Isaac Plains Progressive Rehabilitation and Closure Plan

Isaac Plains Complex | Progressive Rehabilitation and Closure Plan

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1. REHABILITATION PLANNING PART

1.1 Introduction

The Isaac Plains Complex (the Mine, IPC) is operated by Stanmore IP Coal Pty Limited (Stanmore) and consists of the Isaac Plains Mine (IPM), Isaac Plains East (IPE), Isaac Plains East Extension (IPEE) and the Isaac Plains Underground Project (IPU) (not yet started). The Mine operates under Environmental Authority (EA) EPML00932713. In early 2015, the Mine was placed into care and maintenance by the previous owner before it was acquired by Stanmore who restarted operations in early 2016. Expanded operations at IPE were approved in March 2018, with mining operations commencing in July 2018. IP is currently undergoing mining operations at IPE E5 Pit which commenced in 2023.

This *Progressive Rehabilitation and Closure Plan* (PRC plan) has been prepared for the Mine.

2. PROJECT PLANNING

2.1 Baseline Information

2.1.1 Location

The Mine is located in the Bowen Basin in Central Queensland within the Isaac Regional Council Local Government Area (LGA) approximately (~) 140 kilometres (km) southwest of Mackay and 10 km north-east of Moranbah (Figure 1).

LEGEND

- Drainage
- Roads - Major; Minor
- Railway
- Isaac Plains Complex
- Other ML's

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Project Location
Figure 1

2.1.2 Site Topography

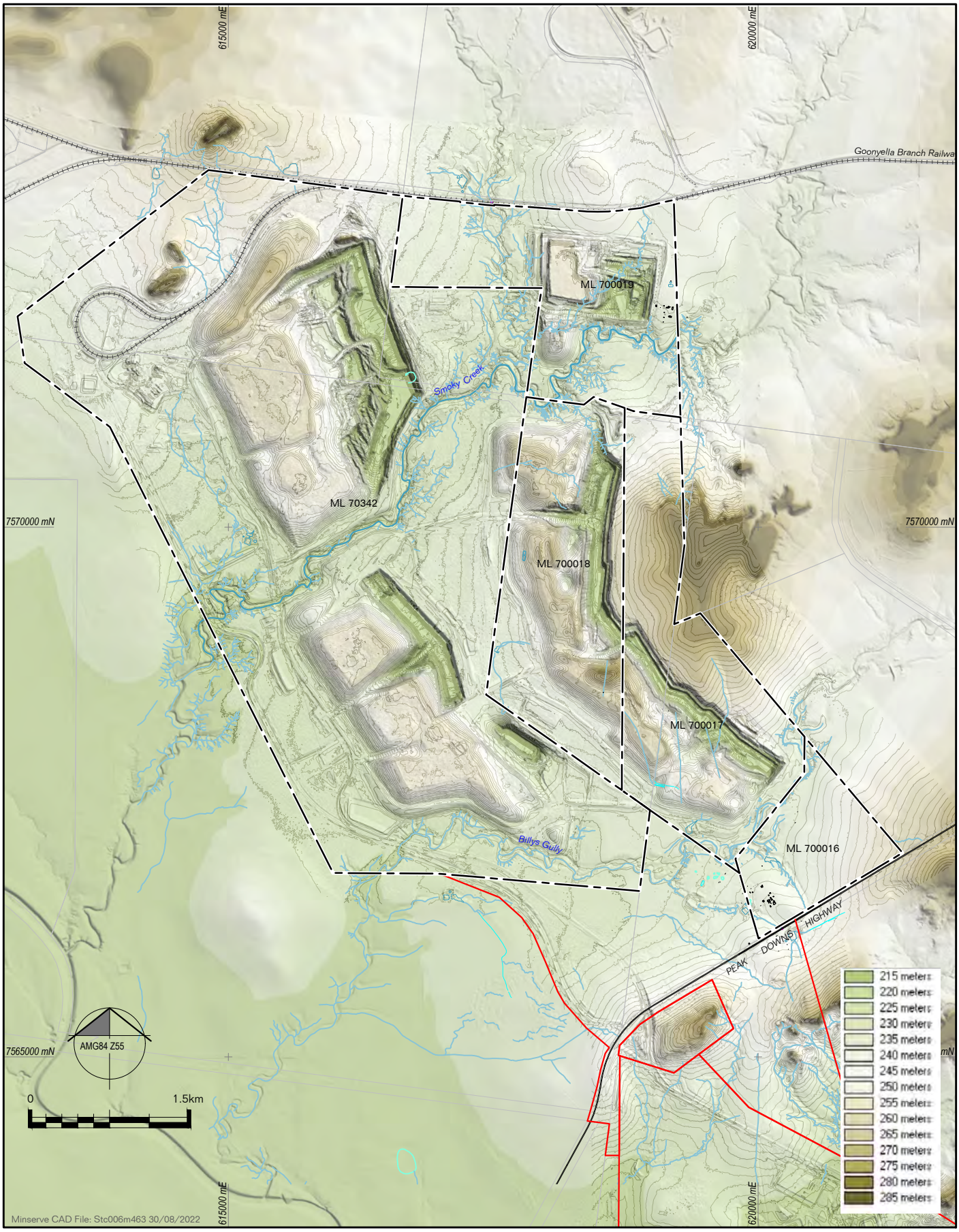
2.1.2.1 Local

The topography of the Mine is relatively flat and averages between 2-3 percent (%). Slopes observed within nearby watercourses (Smoky Creek and Billy's Gully) are steeper. The rail loop (Goonyella Network railway system) traverses around a small mesa at ~ 280 metres (m) Australian Height Datum (AHD).

2.1.2.2 Regional

Catchment elevation varies between 200-300 m AHD. The site drains from north-east to south-west towards the Isaac River. Smoky Creek flows through IPM (ML70342) and Billy's Gully traverses along the southern boundary of the Mine.

Topography of the Mine and region is shown in Figure 2.



LEGEND

- ML
- Drainage
- Roads - Major; Minor
- Railway
- Cadastral Boundary

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Site Topography (Dec 2024)
Figure 2

2.1.3 Climate

Central Queensland commonly experiences high variability in rainfall, evaporation and temperature. The climate in the Bowen Basin is classified as a hot semi-arid (BSh classification) by Köppen Geiger. Typically, these climates have hot summers and cool to warm winters with minimal rainfall.

Local rainfall, evaporation and temperature data, including historical data (2012-2022), has been sourced from the following Bureau of Meteorology (BoM) weather stations:

- Moranbah Water Treatment Plant (site number 034038) — operated 1972 to March 2012 and is located ~ 9 km east of the Mine
- Moranbah Airport (site number 034035) — operational from March 2012 and is located ~ 9 km north-east of the Mine

2.1.3.1 Rain

Rainfall within Central Queensland is unreliable in terms of intensity, duration and location. December, January and February exhibit the highest mean monthly rainfall (above 100 millimetres (mm)). The driest month of the year is September averaging under 10mm of rainfall. The mean annual rainfall for the region is ~ 615 mm. In 2021, mean summer rainfall shows drier conditions compared to averages over the last decade (2012-2022). Average monthly rainfall for both weather stations is given in Table 1.

2.1.3.2 Evaporation

The average annual potential evaporation is estimated to be 2,306 mm, around 3.8 times higher than annual rainfall. The evaporation rate varies seasonally, with October through to March recording the highest evaporation rates (BoM 2022b). Mean monthly evaporation for the Moranbah Water Treatment Plant weather station is given in Table 2. Evaporation data is not available for the Moranbah Airport weather station.

2.1.3.3 Temperatures

The mean annual maximum temperature is around 30.0 degrees Celsius (°C) with the hottest months (greater than (>) 33 °C) being November through to February. The mean annual minimum temperature is around 16.7°C with the coolest months (less than (<) 15 °C) being May through to September. Average monthly and annual minimum and maximum temperature for both weather stations are given in Table 3.

Table 1 Average Monthly and Annual Rainfall

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean rainfall (mm) — Moranbah Water Treatment Plant	103.8	100.7	55.4	36.4	34.5	22.1	18.0	25.0	9.1	35.7	69.3	103.9	614.2
Mean rainfall (mm) — Moranbah Airport	115.7	119.9	73.0	38.8	19.6	22.7	23.7	11.2	11.7	5.0	55.7	54.9	533.7

Table 2 Average Monthly and Annual Evaporation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean rainfall (mm) — Moranbah Water Treatment Plant	248.0	207.2	210.8	171.0	133.3	105.3	114.7	151.9	198.0	248.0	255.0	263.5	2,306.4

Table 3 Average Monthly and Annual Temperature

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean maximum temperature (ºC) — Moranbah Water Treatment Plant	33.8	33.1	32.1	29.5	26.5	23.7	23.7	25.5	29.2	32.3	33.1	34.0	29.7
Mean minimum temperature (ºC) — Moranbah Water Treatment Plant	21.9	21.8	20.2	17.6	14.2	11.1	9.9	11.1	14.1	17.6	19.4	21.1	16.7
Mean maximum temperature (ºC) — Moranbah Airport	35.3	32.3	32.0	30.0	27.2	24.2	24.2	26.9	30.1	32.9	35.1	35.3	30.3
Mean minimum temperature (ºC) — Moranbah Airport	21.5	20.7	19.7	16.4	12.7	9.7	8.1	7.9	12.1	14.9	18.9	20.0	15.2

2.1.3.4 Long-term Projections

a. Rain

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) and BoM produced The State of the Climate 2020 (2020) which says that Australian rainfall is highly variable and is strongly influenced by nearby climate drivers, such as the El Niño southern oscillation (ENSO) which includes El Niño (warm) and La Niña (cold) phases. Long-term trends are evident in Australia despite this natural variability.

Northern Australia and parts of Queensland have been recorded as wetter across all seasons during the northern wet season largely due to increases in rainfall from October to April. The occurrence of intense short-duration extreme rainfall events is responsible for increased rainfall, rather than an increase in the number of storms (CSRIO & BoM 2020).

b. Temperature

The State of the Climate 2020 (CSIRO & BoM 2020) and the Annual Climate Statement 2021 (BoM 2021) says Australia has recorded warming of around 1ºC with most of the warming occurring post-1950s. According to BoM (2021), the warmest years on record in the last decade are 2013, 2014, 2017, 2019 and 2020. With 2019 being the warmest year on record.

It is possible that future drought or further increases in annual local temperatures could impact rehabilitation. This may reduce plant available water and cause vegetation stress.

c. Bushfire

CSIRO and the Queensland Fire and Emergency Service (QFES) developed state-wide bushfire hazard area mapping to support the bushfire hazard provisions of the State Planning Policy (SPP). The mapping allows accurate identification of areas at risk from bushfire and allows greater confidence in design and mitigation strategies, proportional to the mapped risk level.

A bushfire hazard is the potential fire behaviour characterised by weather, fuel loads and topography. Fuel load is living or dead vegetation that accumulates over time. Natural bushfires can start from lightning strikes. Bushfires can start anytime but the greatest risk is in the dry season when rainfall is lowest (September). During the dry season, vegetation and leaf litter can dry out and become fuel for bushfires.

A small area in the south-eastern corner of the Mine is mapped as moderately fire prone while all other areas are not considered a bushfire risk (Queensland Government 2022).

Protection from fire is important during the vegetation establishment phase of rehabilitation. Juvenile plant species may be killed by fire and prolong successful rehabilitation and the meeting of rehabilitation milestones and milestone criteria. The risks to rehabilitation from bushfires have been identified in the risk assessment (Section 7).

2.1.4 Geological Setting

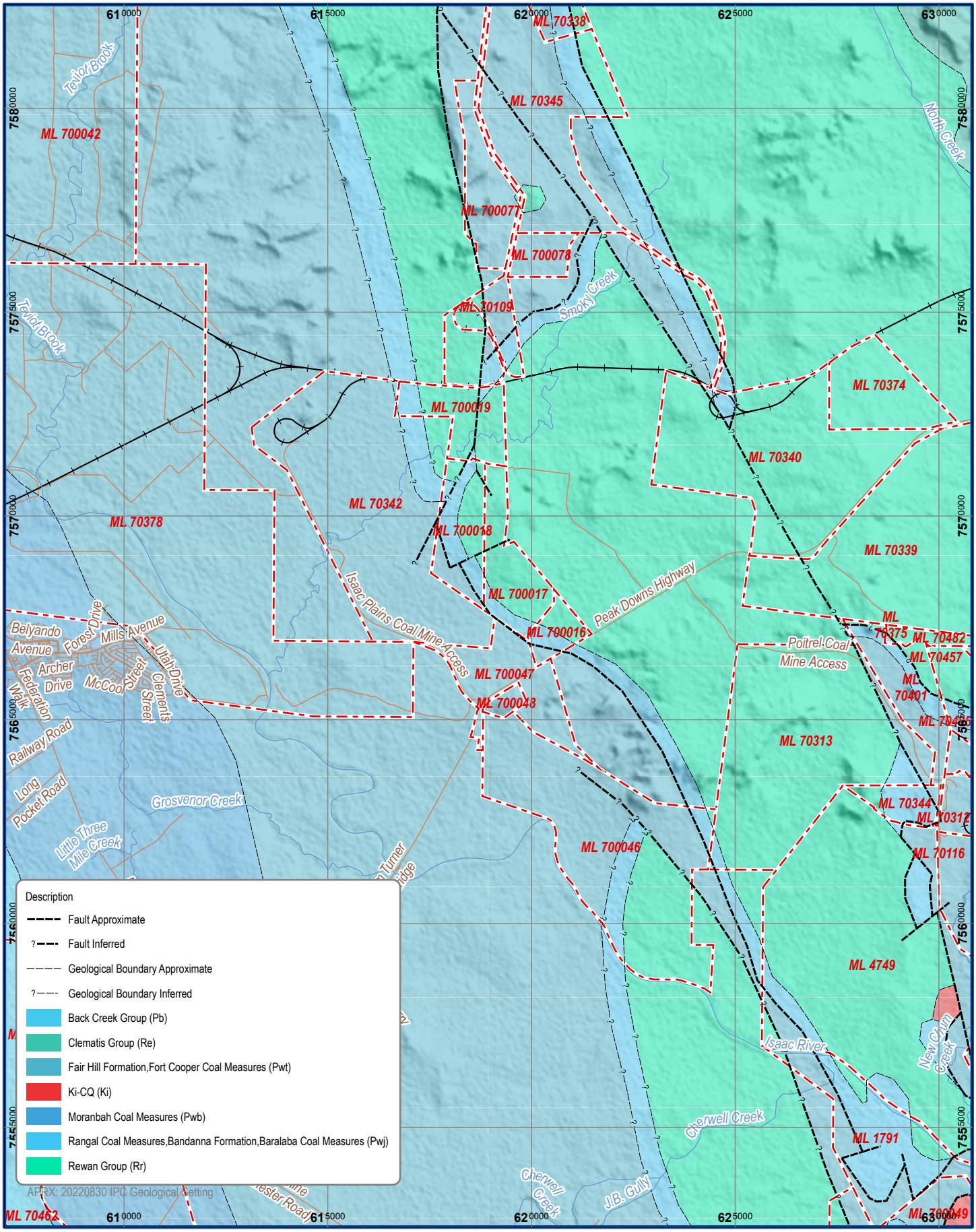
The Mine is in the northern part of the Permian-Triassic Bowen Basin containing principally fluvial and some marine sediments. The Bowen Basin is part of a connected group of Permo-Triassic basins in eastern Australia which includes the Sydney and Gunnedah Basins. Development of the basin in the Early Permian was in the form of a half graben which subsequently became areas of regional crustal sag. Variations in depositional patterns and deformation styles occur along strike suggesting the possibility of north-east trending deep seated crustal transfer faults.

The Bowen Basin has undergone oriented north-east to south-west extensional and compressional events. Structurally, the deposit lies on the western boundary of the deformed Nebo Synclinorium. Complex folding and faulting structures are common throughout the region. Further to the west is the structurally simple Collinsville Shelf.

The stratigraphy comprises three main units:

- Cainozoic sediments, comprising alluvium and soils
- Early Triassic Rewan Group
- Permian period coal measures, comprising Rangal and Fort Cooper Coal Measures

The Mine's economic coal seams are contained in the Late Permian Rangal Coal Measures, which are ~100 m thick. The Permian Rangal Coal Measures are underlain by the Fort Cooper Coal Measures and overlain by the Early Triassic Rewan Group (C&R 2020; Matrix Consulting 2007). The geological setting is shown in Figure 3.



Geological Setting
Figure 3

2.1.5 Site Hydrology and Fluvial Networks

2.1.5.1 Catchment Overview

The Mine is in the Isaac River catchment which falls within the greater Fitzroy Basin just east (~ 33 km) of the Burdekin Basin and Suttor River catchment. The closest main watercourse is the Isaac River that flows north- west to south-east between the Mine and Moranbah. It is a seasonally flowing watercourse which experiences greater surface flow during the wet season (November to April) and shallow subsurface flows during the drier months of May through to October.

The Isaac River catchment is ~22,300 square kilometres (km^2) in comparison to the Fitzroy Basin which is ~142,000 km^2. Water quality in the Isaac River catchment is influenced by land-use within the catchment including grazing and mining operations.

The nearby minor watercourses that branch from Isaac River (Smoky Creek, Smoky Creek Tributary / Chinaman Creek and Billy's Gully) flow directly through the Mine (ML70342). Smoky Creek is ephemeral (i.e. only flowing following heavy rainfall in the catchment) and is a larger watercourse than Billy's Gully. Smoky Creek flows for more than 5 km through the Mine and divides the Mine area in half (north-south).

Billy's Gully is also ephemeral and intercepts the southern part of the Mine for about 3.7 km. Billy's Gully discharges to Isaac River about 3.5 km downstream of the Mine lease boundary. Smoky Creek Tributary / Chinaman Creek is a tributary of Smoky Creek and flows for ~ 1 km within the Mine.

The receiving environment at the Mine consists of the waters of Smoky Creek, Billy's Gully and connected or surrounding waterways within 10 km downstream of the release (C&R 2020).

2.1.5.2 Hydrologic Modelling

During active mining operations, run-off captured from areas that would have previously flowed to the receiving waters of Smoky Creek, Billy's Gully and the Isaac River have been calculated and provided in Table 4.

Table 4 Area Captured within the Mine Water Management System

Catchment	Total catchment area (km^2)	Captured catchment area (km^2)[1]					
		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
Smoky Creek	171	14.6	14.7	15.7	16.1	16.0	16.0
Billy's Creek	171	14.6	14.7	15.7	16.1	16.0	16.0
Isaac River	1,922	18.6	19.2	20.3	21.2	21.1	21.0

1. Catchment area calculated as per the six stages of activities at the Mine including exploration, operations and post closure / decommissioning (WRM 2019).

2.1.5.3 Water Quality

a. Surface Water Environmental Values

The *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP) provides the following surface water environmental values (EVs) associated with the waterways in the vicinity of the Mine:

- Aquatic ecosystem protection

[1] Catchment area calculated as per the six stages of activities at the Mine including exploration, operations and post closure / decommissioning (WRM 2019)

- Irrigation, farm use and stock watering
- Human consumption
- Primary, secondary and visual recreation
- Drinking water
- Industrial use
- Cultural and spiritual values

b. Isaac River

Isaac River's downstream monitoring station (Monitoring Point W2) for 2016 and 2017 are summarised below (WRM 2019):

- Electrical conductivity (EC) — 450-1,110 microsiemens per centimetre (µS/cm)
- pH — neutral to alkaline
- Total suspended solids (TSS) — 130-4,800 milligrams per litre (mg/L)
- Metal toxicants — copper (Cu), silver (Ag), iron (Fe) and aluminium (Al) concentrations exceed ANZG (2018) water quality objectives

c. Smoky Creek

Water quality is monitored in Smoky Creek and Billy's Gully upstream and downstream of the mine. Water quality parameters collected at these sites during 2016-19 are summarised below (WRM 2019):

- EC — 94-541 µS/cm with a median value of 222 µS/cm
- pH — slightly alkaline
- TSS — 60-1,386 µS/cm with a median value of 278 µS/cm
- Metals — Cu, lead (Pb), Ag, nickel (Ni) and Al concentrations exceed ANZG (2018) water quality objectives

There is limited water quality data available for Billy's Gully due to its ephemeral nature.

2.1.6 Groundwater Levels and Properties

2.1.6.1 EVs and Water Quality Objectives

The EPP outlined the EVs for the Isaac River sub-basin of the Fitzroy River system. The EPP separates the applicable EVs into several defined categories with all groundwaters grouped for the entire Isaac sub-basin. The EVs listed for the Isaac groundwaters category includes:

- Aquatic ecosystems — where baseflow supports permanent streams and water holes to some extent (e.g. seasonally or permanently). This interaction can occur in tidal and estuarine zones as well as in freshwater areas
- Irrigation — used to grow crops and pastures for commercial purposes
- Farm supply / use — used to provide stock water supplies
- Primary recreation — supports recreational use which involves direct contact and a high probability of water being swallowed (e.g. diving, swimming, surfing, water skiing and windsurfing)
- Drinking water — used for potable water supply
- Cultural and spiritual values — supports both indigenous and non-indigenous values (e.g. cultural heritage, symbols, landmarks and lifestyles)

2.1.6.2 Hydro Stratigraphic Units

Hydrogeological properties for the Mine area are discussed in the 2020 Annual Groundwater Review (C&R 2021) (Appendix B). The hydro stratigraphic units (HSUs) for the Mine area can be seen in Table 5.

Table 5 Mine HSUs

HSU	Description	Aquifer / aquitard
Quaternary Alluvium / Colluvium	5 —19 m thick, saturated thickness generally 3 m. Consists of upward-fining packages of gravel, sand, silt and clay.	Present
Tertiary Basalt	A network of shallow cooling fractures	Present
Late Permian	Flow hindered by intercalation of sandstone, mudstone and siltstone.	Present

2.1.6.3 Hydrogeological Properties

a. Recharge and Discharge

Alluvial / colluvial groundwater in the Mine area is typically recharged by flows in contemporary waterways during peak flows and floods. Discharge generally occurs via evapotranspiration but may also occur locally through baseline streams during dry periods. Basalt flows in the region are not fully understood but it is assumed that the flows are localised rather than regional. Dominant flows mechanisms are ephemeral by sub-vertical recharge and discharge. The regional recharge and discharge mechanisms of the Late Permian units in the Isaac River region is not well known. As per the overlying features of the Alluvial / Colluvial and Tertiary Basalt units, Late Permian recharge is assumed to be restricted to wet season and wet weather events in the region.

b. Groundwater Bores

There are a number of bores located in the Mine area which are monitored as part of the groundwater monitoring programme. C&R (2021) discusses that the groundwater network at the Mine consists of reference, compliance and observation bores. As mining progresses some bores will be decommissioned and new bores will be developed. The network of monitoring bores at the Mine and surrounds are shown in Table 6.

Table 6 Monitoring Bores in the Mine Area

Monitoring Point	Aquifer Type	Easting (GDA94)	Northing (GDA94)	Surface RL (m AHD)	Monitoring Purpose
IPC reference bores (EA Table 11)					
Burton Coal Bore 2	Rewan Group	620383	7573599	240.8	Compliance bore–Monitoring groundwater trigger levels as per EA C43 and EA C44
Swamp Bore 1 (referred to as Swamp Bore 2 in the EA Table 12)	Rewan Group	621518	7568790	245.9	Compliance bore–Monitoring groundwater trigger levels as per EA C43 and EA C44

Monitoring Point	Aquifer Type	Easting (GDA94)	Northing (GDA94)	Surface RL (m AHD)	Monitoring Purpose
MB1	Rangal Coal Measures	618793	7572214	236.4	To be decommissioned. Used for monitoring groundwater in the target coal seam
MB2	Rangal Coal Measures	619074	7573137	242.7	Monitoring groundwater in the target coal seam
MB4a	Quaternary Colluvium / Tertiary Sediments	620351	7567479	237.6	To be decommissioned. Used for monitoring groundwater in the Quaternary / Tertiary sediments. Insufficient water, replaced by MB4b
MB4b	Quaternary Colluvium / Tertiary Sediments	619740	7567253	233.9	To be decommissioned. Used for monitoring groundwater in the Quaternary / Tertiary sediments
MB8	Rangal Coal Measures	619105	7571149	245.9	To be decommissioned. Used for monitoring groundwater in the target coal seam
MB9	Rangal Coal Measures	620368	7568049	239.5	To be decommissioned. Used for monitoring groundwater in the target coal seam
MB10	Tertiary Basalt	620368	7568046	239.5	To be decommissioned. Used for monitoring groundwater in the Tertiary Basalt
MB11	Tertiary Sediments / Weathered Rewan Group	618832	7571924	232.3	Monitoring groundwater in the Tertiary Sediments / Weathered Rewan Group. Insufficient water (dry)
MB12	Rangal Coal Measures	619210	7572000	239.5	Replacement for MB1 to monitor groundwater in the target coal seam
MB14	Tertiary Basalt	619210	7571132	257.3	Replacement for MB10 to monitor groundwater trigger levels as per EA C44
IPC reference bores (to be commissioned) (Table 11 of the EA)					
MB13	Rangal Coal Measures	619367	7571035	249.7	Replacement for MB8 to monitor groundwater in the target coal seam
MB15	Rangal Coal Measures	620633	7568080	242.9	Replacement for MB9 to monitor groundwater in the target coal seam
MB16	Tertiary Sediments	620670	7568599	245.6	Replacement for MB4b to monitor trigger levels as per EA C44
IPC designated observation bores					

Monitoring Point	Aquifer Type	Easting (GDA94)	Northing (GDA94)	Surface RL (m AHD)	Monitoring Purpose
MB7	Rangal Coal Measures	617537	7569064	237.4	Monitoring groundwater in advance of mine operations
GDEMB01	Quaternary Alluvium	621780	7569179	To be advised (TBA)	Monitoring groundwater-dependent ecosystems
GDEMB02	Quaternary Alluvium	620436	7568168	TBA	Monitoring groundwater-dependent ecosystems
GDEMB03	Quaternary Alluvium	620022	7567230	TBA	Monitoring groundwater-dependent ecosystems
GDEMB04	Quaternary Alluvium	619754	7567165	TBA	Monitoring groundwater-dependent ecosystems

c. Levels and Flows

The flow of Alluvium / Colluvial groundwater in the region is expected to flow southward and south-eastward and possibly through baseflow to streams during dry periods. Groundwater flow in the Tertiary Basalt is expected to be localised rather than regional and only saturated when the water table rises during wet event recharge periods. As per the Alluvium / Colluvial flow the groundwater of the Late Permian is assumed to travel in a south-eastward direction in keeping with the Isaac River drainage at a low flow rate due to sandstone, mudstone and siltstone permeability. As the aquifers associated with the Mine area depend on wet season / rain events for recharge, the water levels are variable.

Permeability of selected aquifers at the Mine were tested using the Bouwer and Rice Slug Test (1976). Results of this testing can be seen in Table 7.

Table 7 Permeability of Aquifers at the Mine

Aquifer	Bore	Standing Water Level (SWL) Metres Below Ground Level (mbGL)	Metres per Day (m/day)
Permian sandstone / siltstone	AC6	27.69	0.001
Leichardt coal seam	C6	27.70	0.010
Permian lithic sandstone	BC	13.38	0.009

d. Chemistry

Data collected from the Mine groundwater monitoring program is reviewed annually to meet condition C40 of the EA and to ensure mining operations are not impacting the groundwater in the surrounding area. The previous review of groundwater monitoring data from 2019-2020 (C&R 2021) describes quality characteristics of the groundwater at the Mine.

The quality of the Alluvium / Colluvium groundwater is variable. EC ranges from below 500 µS/cm to 10,000 µS/cm. Samples are taken from the colluvial sediments as the alluvium groundwater is discrete. The Tertiary Basalt groundwater situated near the Broadlea Mine is considered as relatively good quality with EC ranging from 760 µS/cm and 5,300 µS/cm. Other areas of the basalt aquifer are associated with low yields and poor quality. Late Permian groundwater is identified as sodium chloride-bicarbonate water with concentration increasing southward of the Mine. Late Permian groundwater generally has a high EC ranging from 11,000 µS/cm to 41,000 µS/cm. Results for groundwater monitoring can be seen in Appendix B (Table 6).

2.1.7 Soil Types, Properties and Productivity

2.1.7.1 Soil Types

A desktop assessment of the Queensland Government spatial catalogue (QSC) provides an indication of relevant soil types in the Mine area. Results from the desktop assessment show most of the Mine is mapped as undulating lowland areas with cracking clay soils or weathered clay plains (QSC 2022), stony low hills and bluffs with common rock outcrops.

Fine cracking and smooth podosols with sandy or loamy dark clay can be observed at the southern and eastern parts of the Mine (Kb11). The majority of the mine is situated on soils that are loamy duplex soils with a slightly gravel-strewn surface. These soils are yellow-grey in colour with A and A2 horizons, and an alkaline pedal mottled B horizon (Va51 and Sl21). Surrounding soils are gradational red soils with no A2 horizon and a very large B horizon (My27).

The desktop assessment was ground-truthed for the *Soil and Land Suitability Study* (GTES 2006) (Appendix C). Soil survey results are described in the following sections.

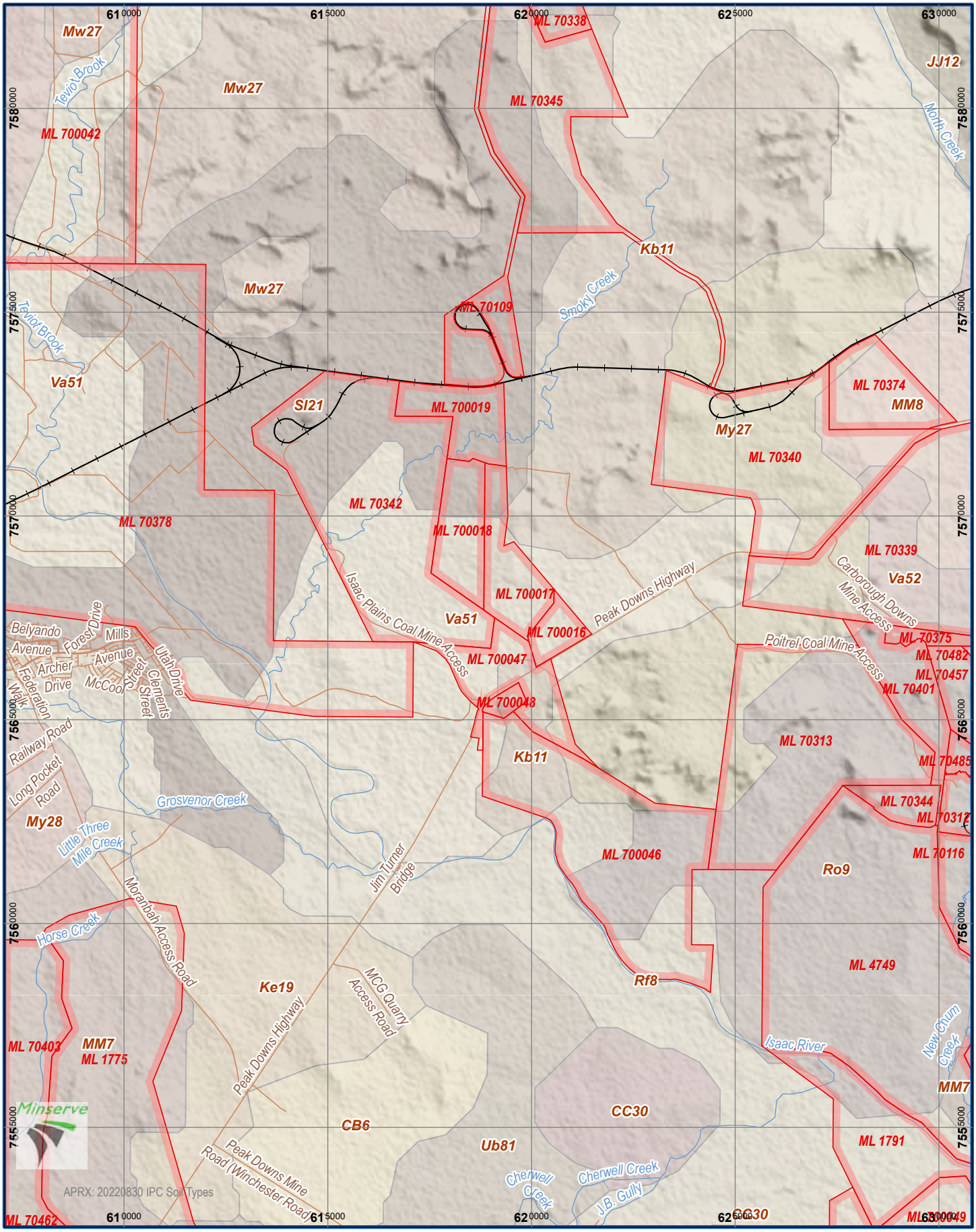
2.1.7.2 Properties

Major soil types found at the Mine area are given in Table 8 and shown in Figure 4. The principal soil types found during the survey were non cracking sandy clays and sandy duplex soils.

Table 8 Major Soil Types Found at the Mine (GTES 2006)

Soil Type	Description	Suitable for Rehabilitation	Concept	Survey Comments
Brown sodosol	Loamy sand topsoil up to 60 cm weak of structure, no intrusions or gravel. Subsoil loams sand and sandy light clay, no inclusions or gravel.	Flat sites only due to high erosion potential. Recommended >25 cm depth.	A1 — Alluvial sandy duplex of mixed Poplar Box and Brigalow.	Associated with alluvia of Cherwell creek and the Isaac River.
Brown sodosol	Sandy crust surface topsoil, silty clay loams up to 40 cm, weak structure. Subsoil silty clay, no intrusions, saline.	Flat areas preferred due to erosion potential. Recommended >25 cm depth.	A3 — Silty clay associated with the Isaac River alluvia with mixed Poplar Box, flooded Coolibah and Brigalow.	Limited to a small area on the Isaac River
Black Vertosol	Cracking self-mulching surface topsoil, medium clay, no gravel. Up to 45 cm. Subsoil medium heavy clay, lenticular structure, saline below 40 cm.	Flat sites preferred due to erosion potential and difficulty establishing initial pasture. Recommended 25 cm depth.	A4 — Alluvial plain of dark cracking clay with Brigalow.	Small area
Brown sodosol	Loamy sand topsoil, no inclusions up to 60 cm. Subsoil sandy clay, no inclusions or gravel, extensive red / grey mottles, moderate consistency and restricted drainage.	Flat sites only due to high erosion potential. Recommended 25 cm depth.	E1 — Poplar Box sandy duplex on undulating plains.	Extensive thought the area

Soil Type	Description	Suitable for Rehabilitation	Concept	Survey Comments
Brown sodosol	Fine sandy loam topsoil, massive structure, no inclusions up to 45 cm. Sandy clay subsoil, weak angular blocky structure. No inclusions or gravel, moderate consistency and restricted drainage.	Flat sites only due to high erosions potential. Recommended 25 cm depth.	E1 — Relic ridgelines above E1 with shallower duplex with Silver Leaf and Narrow Leaf Ironbark with Poplar Box.	Very minor areas in upper positions of the E1 landscape.
Vertosol	Sandy clay topsoil. No carbonate nodules, angular blocky structure, no mottles, up to 30 cm. Medium clay subsoil hard angular blocky structure, no mottles.	Flat sites preferred due to erosion potential. Recommended 25 cm depth.	B1 — Uniform grey / brown clays with areas of gilgai on flat to gently undulating plains with Brigalow.	Occurs on lower lying areas above the alluvial plains.
Red chromosol	Light sandy clay topsoil, weak structure up to 20 cm. Medium clay subsoil, hard, dense massive structure, increasing grey and red mottles down profile. Carbonate nodules.	Flat sites preferred due to erosion potential. Recommended 25 cm depth.	B2 — Sandy uniform clay or thin red / brown duplex soils overlying weathered shale / mudstone with Brigalow on undulating plains. Sandy surface which is often gravelly.	Extensive throughout the area. Dense buffel pastures, land in good condition.
Mixed	Sandy loam reddish brown topsoil, poor structure up to 10 cm. Reddish to yellow brown sandy clay subsoil. Extensive gravels and rock.	Unsuitable. Potential to use as gravel resource.	R1 — Shallow gravely loamy sands to sandy clay loams with extensive outcropping rock.	Minor occurrence to the north of the Mine



Regional Soils Map
Figure 4

2.1.7.3 Productivity

a. Agricultural Land Classification

Guidelines for Agricultural Land Evaluation in Queensland (DSITI & DNRM 2015) provide an agricultural land classification (ALC) class based on soil and landscape characteristics. ALC mapping indicates the Mine site includes class B limited crop land (land that is suitable for a narrow range of crops and sown pastures) and class C1 and C2 pasture land (land suitable only for improved or native pastures due to limitations that preclude continuous cultivation for crop production).

Class B land is considered good quality agricultural land with minor limitations that may affect its use. The land is generally suitable for a wide range of agricultural activities but may require some management practices to address these minor limitations. Class C1 has moderate limitations that significantly affect its use for agriculture. This land is still usable for agriculture but requires more intensive management practices to overcome these limitations. It may be suitable for certain types of crops or livestock but not for others. Class C2 land has limitations that greatly restrict its use for agriculture. This land is generally only suitable for very specific types of agricultural activities or may require significant modification and management to be used effectively. All of the land classes (B, C1-2) mapped for the site are considered suitable as pastures with the benefits gained from the land use outweighing the inputs required to initiate and maintain economic production in the long term.

b. Areas of Regional Interest

Under the *Regional Planning Interests Act 2014* (RPI Act), an approval is needed when a resource activity or regulated activity is proposed in a zone of regional interest. Zones of regional interest are:

- Priority living areas (PLAs)
- Priority agricultural areas (PAAs)
- Strategic cropping areas (SCAs)
- Strategic environmental areas (SEAs)

There are no mapped PLAs, PAAs, SCAs or SEAs within or adjacent to the Mine and no further assessment for these regional interests is needed.

2.1.8 Land Stability

2.1.8.1 Pre-Existing Land Degradation and Erosion

The pre-mining erosion rate has been calculated using the revised universal soil loss equation (RUSLE). An estimate of average soil loss from sheet and rill erosion can be calculated using RUSLE (1).

$$A = R \times K \times LS \times C \times P \qquad (1)$$

Where:

- A = the estimated average annual soil loss in tonnes per hectare per year (t/ha/yr)
- R = the rainfall and runoff erosivity factor which describes the intensity and duration of rainfall within a geographical area
- K = the soil erodibility factor related to soil physical and chemical properties that determine the soil's capacity for soil particle dislodgement
- LS = a dimensionless topography factor determined by slope length and steepness related to the velocity of runoff
- C = the cover and management factor. Cover of any kind can help protect the soil from raindrop impact, slow runoff and reduce kinetic energy

- P = the factor for supporting practices of land management. This factor considers specific erosion control measures

Values for R, K, L and S are obtained from QSC datasets provided by the administering authority.

Sediment deposition is not factored into the equation and subsequently is not an estimate of sediment yield. Furthermore, concentrated flows in gullies and stream channels are not considered. The RUSLE is intended for the prediction of long-term rates of gross hillslope erosion only (including rill and interrill erosion).

The Mine's topography (pre-mining) is relatively flat with few slopes and different soil types recorded (vertosols, sodosols and chromosols). The predicted pre-mining erosion rates are given in Table 9.

Table 9 Pre-Mining Erosion Rates

Statistic	Erosion rate (t/ha/yr)
Minimum	0.09
Maximum	6.71
Median	0.25
Mean	0.84

The maximum erosion rate of 6.71 t/ha/yr is confined to areas within IPE (ML700017), whereas, the minimum erosion rate of 0.09 t/ha/yr is observed on all MLs.

There are few Australian studies that have attempted to quantify erosion rates. The Prediction of Sheet and Rill Erosion Over the Australian Continent, Incorporating Monthly Soil Loss Distribution (Lu et al 2001) is one of these studies. Lu et al (2001) suggests the average Australian rate of erosion is 6.3 t/ha/yr and that a soil loss rate below 0.5 t/ha/yr is classified as low erosion, whereas a soil loss rate above 10 t/ha/yr is classified as high.

The Mine can be considered to have a relatively low pre-mining rate of erosion with a median erosion rate of 0.25 t/ha/yr.

2.1.8.2 Predisposition to Ongoing Stability Issues

Some surrounding areas display erosional issues due to dispersive soils. Previously rehabilitated areas, however, generally show good erosional stability. Rehabilitation methodology will be consistent with current practices and aim to establish adequate groundcover for erosional stability.

2.1.9 Vegetation Communities and Ecological Data

2.1.9.1 Matters of State and National Environmental Significance

The protected matters search tool (PMST) (DCCEEW 2025) identified the following matters of national environmental significance (MNES), under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), as being located within the Mine or surrounding area (5 km buffer radius):

- Four threatened ecological communities (TECs)
- 26 threatened flora or fauna species
- Eight migratory bird species

Current mapping of the Mine indicates the matters of state environmental significance (MSES) occurring within the ML boundaries under the *Vegetation Management Act 1999* (VM Act) are as follows:

- Wildlife habitat (endangered or vulnerable)
- Regulated vegetation (category B)

- Regulated vegetation (category C)
- Regulated vegetation (category R)
- Regulated vegetation (essential habitat)
- Regulated vegetation (intersecting a watercourse)

2.1.9.2 Environmentally Sensitive Areas

Environmentally sensitive area (ESA) mapping of the ML boundaries shows category B areas of Endangered Regional Ecosystems (EREs) – regrowth and remnant (Biodiversity Status) as the only areas of concern. The ESAs are located on ML700016, ML700017 and ML700019 and can be seen in Figure 5.

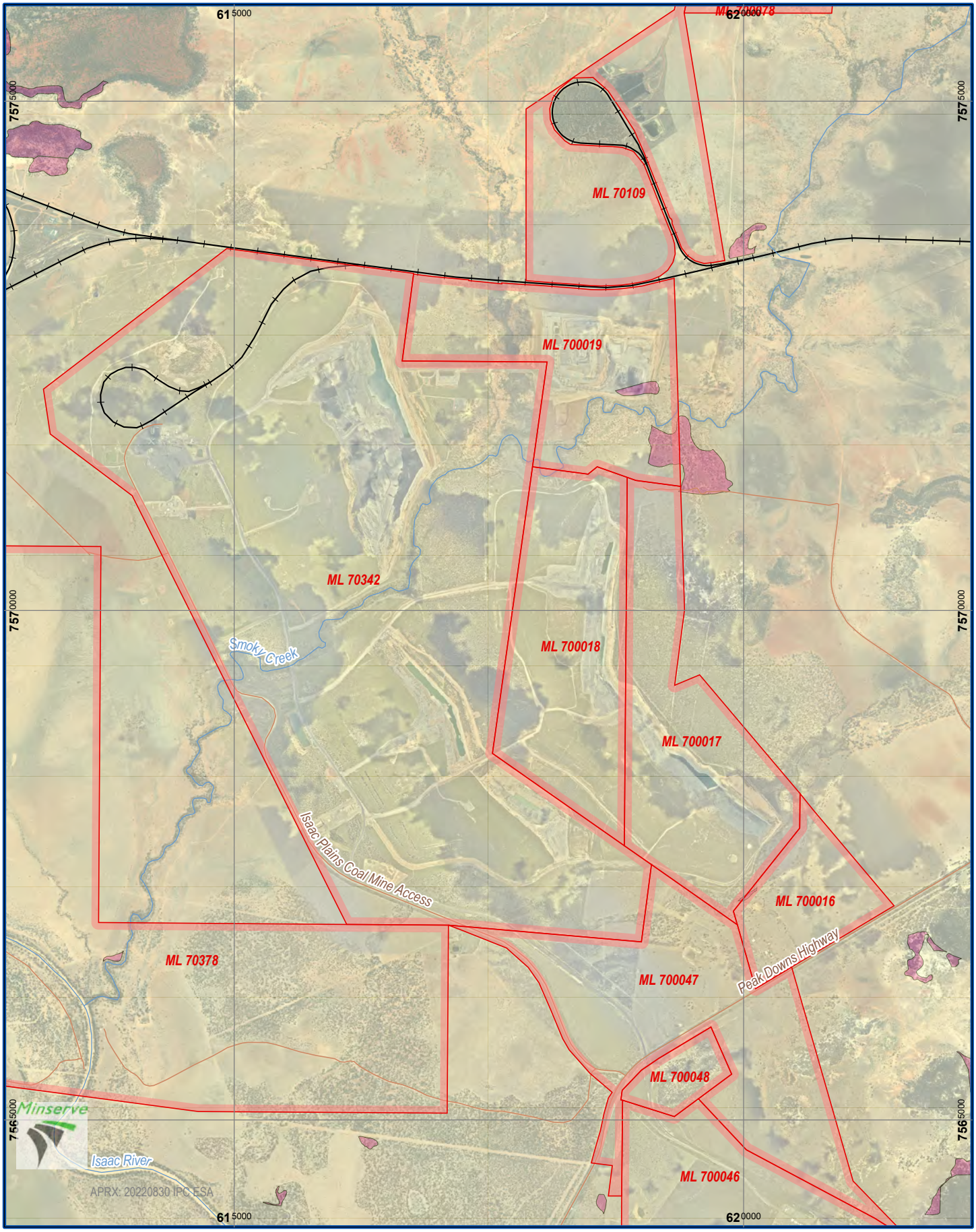
2.1.9.3 Regional Ecosystem

Assessment of RE mapping identified 15 REs that exist within the Mine. Table 10 gives these REs and their corresponding VM Act class and biodiversity status based on the EPBC Act (i.e. least concern, endangered or no concern).

Table 10 RE Descriptions

RE ID	Description	VM Act Class	Biodiversity Status
11.3.1	*Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains	Endangered	Endangered
11.3.2	*Eucalytpus populnea* woodland on alluvial plains	Of concern	Of concern
11.3.25	*Eucalyptus tereticornis* or E. camaldulensis woodland fringing drainage lines	Least concern	Of concern
11.3.7	*Corymbia spp*. Open woodland on alluvial plains	Least concern	Of concern
11.4.9	*Acacia harpophylla* shrubby woodland with Terminalia oblongata on Cainozoic clay plains	Endangered	Endangered
11.5.12	*Corymbia clarksoniana woodland* and other *Corymbia spp*. and *Eucalyptus spp*. on Cainozoic sand plains and/or remnant surfaces	Least concern	No concern
11.5.3	*Eucalyptus populnea +/- E. melanophloia +/- Corymbia clarksoniana* woodland on Cainozoic sand plains and/or remnant surfaces	Least concern	No concern
11.5.9c	*Eucalyptus crebra* and other *Eucalyptus spp*. And *Corymbia spp*. woodland on Cainozoic sand plains and/or remnant surfaces	Least concern	No concern
11.7.2	*Acacia spp*. woodland on Cainozoic lateritic duricrust. Scarp retreat zone	Least concern	No concern
11.8.11	*Dichanthium sericeum* grassland on Cainozoic igneous rocks	Of concern	Of concern
11.8.13	Semi-evergreen vine thicket and microphyll vine forest on Cainozoic igneous rocks	Endangered	Endangered
11.8.5	*Eucalyptus orgadophila* open woodland on Cainozoic igneous rocks	Least concern	No concern
11.9.2	*Eucalyptus melanophloia +/- E. orgadophila* woodland to open woodland on fine-grained sedimentary rocks	Least concern	No concern

RE ID	Description	VM Act Class	Biodiversity Status
11.9.3	*Dichanthium spp., Astrebla spp.* grassland on fine- grained sedimentary rocks	Least concern	No concern
11.9.5	*Acacia harpophylla* and/or *Casuarina cristata* open forest to woodland on fine-grained sedimentary rocks	Endangered	Endangered
11.9.7a	*Eucalyptus populnea, Eremophila mitchellii* shrubby woodland on fine-grained sedimentary rocks	Of concern	Of concern



Waterway
Railway
Road
ML
ESA - Mining Activities

0 0.5 1 1.5 2 2.5
Kilometers

N

stanmore

Environmentally Sensitive Areas
Figure 5

2.1.9.4 Significant Flora

The PMST mapping was used to determine MNES on the MLs and has identified the following significant flora that may occur (Table 11).

Table 11 Significant Flora that Could Occur

Species	Common name	EPBC Status	Presence
Dichanthium queenslandicum	King Blue-grass	Endangered	Likely
Samadera bidwillii	Quassia	Vulnerable	Likely
Eucalyptus raveretiana	Black Ironbox	Vulnerable	Likely
Polianthion minutiflorum		Vulnerable	May occur

2.1.10 Fauna Presence and Populations

Baseline field surveys of the Mine area were completed in 2004 and 2005 (Ecotone 2005) to record fauna species occurring on the associated MLs. Species detected were typical of the native fauna expected to be found in grazing lands adjoining riparian habitat throughout the Isaac Region. The survey detected:

- 27 bird species, including the threatened Squatter Pigeon (*G. scripta scripta*)
- Five mammal species (including two introduced species)
- Three reptile species

2.1.10.1 Significant Fauna

The Squatter Pigeon was observed during the field surveys to the north of Smoky Creek in the Mine area and again two times in the surrounding areas. It is assumed the bird species use the woodland areas adjacent to the study area and the riparian woodland along Smoky Creek for movement in the local area.

MNES mapping found that there were two critically endangered animal species that could occur in the Mine area.

Critically endangered species that may occur in the Mine area include:

- Curlew Sandpiper (*Calidris ferrunginea*)
- White-throated Snapping Turtle (*Elseya albagula*)

Mapping from the PMST indicates that the Curlew Sandpiper and White-throated Snapping Turtle may occur in the MLs.

Table 12 provides a summary of significant fauna that could occur on the MLs associated with the Mine.

Table 12 Significant Fauna that Could Occur

Species	Common name	EPBC Status	Presence
Calidris acuminata	Sharp-tailed Sandpiper	Vulnerable	May occur
Calidris ferruginea	Curlew Sandpiper	Critically Endangered	May occur
Elseya albagula	Southern Snapping Turtle, White- throated Snapping Turtle	Critically Endangered	May occur

Species	Common name	EPBC Status	Presence
Rostratula australis	Australian Painted Snipe	Endangered	May occur
Neochmia ruficauda rufiyaa	Star Finch (Eastern), Star Finch (Southern)	Endangered	Likely
Dasyurus hallucatus	Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu]	Endangered	Likely
Phascolarctos cinereus	Koala	Endangered	Likely
Lerista allanae	Allan's Lerista, Retro Slider	Endangered	May occur
Poephila cincta concha	Southern Black-throated Finch	Endangered	May occur
Denisonia maculata	Ornamental Snake	Vulnerable	Known
Samadera bidwillii	Quassia	Vulnerable	Likely
Erythrotriorchis radiatus	Red Goshawk	Endangered	May occur
Nyctophilus corbeni	Corben's Long-eared Bat, South- eastern Long-eared Bat	Vulnerable	May occur
Furina dunmalli	Dunmall's Snake	Vulnerable	May occur
Falco hypoleucos	Grey Falcon	Vulnerable	Likely
Petauroides volans	Greater Glider	Endangered	Known
Macroderma gigas	Ghost Bat	Vulnerable	May occur
Egernia rugosa	Yakka Skink	Vulnerable	May occur
Rheodytes leukops	Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle, White-eyed River Diver	Endangered	Likely
Geophaps scripta Geosha's	Squatter Pigeon (southern)	Vulnerable	Known
Gallinago hardwickii	Latham's Snipe, Japanese Snipe	Vulnerable	May occur
Stagonopleura guttata	Diamond Firetail	Vulnerable	May occur

2.1.10.10 EPBC Offset Area

Prescribed environmental matters at the Mine will be managed as per conditions H1-H5 of the EA. An assessment of significant residual impacts for IPE and the IPEE project identified that MNES include three vulnerable species under the EPBC Act which are shown in Table 13. The Mount Spencer property area, declared as an environmental offset for both projects, is located in the Isaac Regional Council LGA along the Peak Downs Highway on Lot 4 on Plan SP277438.

Table 13 MNES Impacted by the IPE and IPEE Projects

MNES	Impact area requiring offsets at IPE (ha)	Required offset area at IPE (ha)	Impact area requiring offsets at IPEE (ha)	Required offset area at IPEE (ha)
Koala (*Phascolarctos cinereus*)	125	217	207.8	722
Greater Glider (*Petauroides volans*)	125	290	207.8	482
Squatter Pigeon (Southern) (*Geophaps scripta scripta*)	74	172	117.1 (breeding) 63.6 (foraging)	838

Management objectives for the offset area include:

- To improve the conditions and ecological values of the vegetation communities for associated MNES
- Manage risks to the vulnerable species identified under the EPBC Act
- Strategically graze cattle to reduce and manage understorey fuel loads and native and non-native flora densities
- Reduce the risk of unplanned fire that may cause adverse impacts to the MNES
- Minimise habitat degradation caused by feral pigs, rabbits and horses
- Restrict unauthorised access and prevent alternate land use
- Control invasive weed species to reduce negative impacts on the MNES
- Minimise predation risks by feral cats, wild dogs and foxes

Offset areas are described in the *Isaac Plains East — Offset Area Management Plan: EPBC 2016/7827 and Isaac Plains East Extension — Offset Area Management Plan: EPBC 2019/8548* (Base 2021a; Base 2021b).

2.1.11 Pre-Mining Land Use

The Mine is located within the Bowen Basin and is close to a number of current mining operations. Grazing and mining are the principal industries in the region. Extensive clearing has occurred at the Mine due to previous use for cattle grazing.

2.1.12 Identification of Underlying Landholders

Table 14 gives the tenure and underlying land owners.

Table 14 Lot and Plan Numbers

Tenure	Lot	Plan	Ownership
ML70342	Lot 17	SP261431	Ross William Flohr
ML70342	Lot 4	SP252740	Fitzroy Coal Exploration Pty Ltd
ML70342	Lot 15	SP261431	Margaret Mary Flohr
ML70342	Lot 3	SP192459	Stanmore IP Coal Pty Ltd
ML70342	Lot 3	SP216414	The State of Queensland (represented by the Department of Transport and Main Roads)
ML70342	Unnamed Road	-	Isaac Regional Council
ML700016	Lot 5	GV132	Margaret Mary Flohr

Tenure	Lot	Plan	Ownership
ML700017	Lot 5	GV132	Margaret Mary Flohr
ML700017	Lot 17	SP261431	Ross William Flohr
ML700017	Unnamed Road	-	Isaac Regional Council
ML700018	Lot 17	SP261431	Ross William Flohr
ML700018	Unnamed Road	-	Isaac Regional Council
ML700019	Lot 4	SP252740	Fitzroy Coal Exploration Pty Ltd

2.1.12.1 Native Title

Native title on the freehold and leasehold lands in which the mine is located has been extinguished. However, there are two registered native title claimant groups.

A *Cultural Heritage Agreement* (CHA) was executed on the 21 August 2018 between Stanmore IP Coal Pty Ltd, Stanmore IP South Pty Ltd and the Barada Barna Aboriginal Corporation. The full agreement contains potentially sensitive information and has not been included in this Plan.

2.2 Project Description

2.2.1 Mining Tenements

Mining leases (MLs) associated with the Mine are given in Table 15 and shown in Figure 6.

Table 15 Mining Tenures

Tenure type	Tenure number	Area (hectares (ha))	Description
ML	70342	2,142	IPM, IPU
ML	700016	138	IPE
ML	700017	387	IPE
ML	700018	365	IPE, IPU
ML	700019	357	IPE

L E G E N D

- ML
- Drainage
- Roads - Major; Minor
- Railway
- Cadastral Boundary

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Tenure Boundaries
Figure 6

2.2.2 Environmentally Relevant Activities

Activities that will, or have the potential to, release contaminants into the environment which may cause environmental harm are defined as environmentally relevant activities (ERAs) under the *Environmental Protection Act 1994* (EP Act). In accordance with the *Environmental Protection Regulation 2019* (EP Regulation), the Mine is authorised under a site-specific EA for the mining of black coal.

There are five ERAs authorised under the EA (Table 16). Notifiable activities are given in Table 17.

Table 16 ERAs

ERA number	Description of activity
Schedule 3 13	Mining black coal
Ancillary 31	Mineral processing 2: Processing, in a year, the following quantities of mineral products, other than coke (b) more than 100,000 tonnes (t)
Ancillary 63	Sewage Treatment 1: Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of (b-i) more than 100 but not more than 1,500 EP if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme
Ancillary 38	Surface Coating 1: Anodising, electroplating, enamelling or galvanising using, in a year, the following quantity of surface coating materials (b) more than 100 t but not more than 1,000 t
Ancillary 60	Waste disposal 1: Operating a facility for disposing of, in a year, the following quantity of waste mentioned in subsection (1)(a) (d) more than 200,000 t

Table 17 Notifiable Activities

Item number	Description of activity
7	Chemical storage (other than petroleum products or oil under item 29)
15	Explosive production and storage in above ground tanks
24	Mine wastes: • Storing hazardous mine or exploration wastes, including, for example, tailings dams, overburden or waste rock dumps (WRDs) containing hazardous contaminants • Mining or processing, minerals in a way that exposes faces, or releases groundwater, containing hazardous contaminants
29	Petroleum product or oil storage

2.2.3 Primary Mine Features / Infrastructure

The Mine consists of six primary pits located on ML70342: N1, N2, S1, S2, S3 and E5. N1, N2 and E5 are located north of Smoky Creek which bisects the Mine while S1, S2 and S3 are located south of Smoky Creek. The four remaining MLs are located directly east of ML70342 and are known as IPE.

Key infrastructure at the Mine includes:

- Mine industrial areas (MIA) including laydowns, buildings, administration, carparks, cleared and concreted areas
- Coal handling and preparation plant (CHPP), overland conveyor, run-of-mine (ROM) pad and hardstand
- Haul roads, roads and tracks
- Power infrastructure and pipelines
- Rail loop and train loading facility

- Tailings storage facility (TSF)
- Water management structures including dams and drains

Primary features and key infrastructure are shown in Figure 7.

2.2.3.2 Regulated Structures

Regulated structures on the mine include:

- Smoky Creek N1 Levee
- Smoky Creek S1 Levee

There are no regulated dams at the Mine.

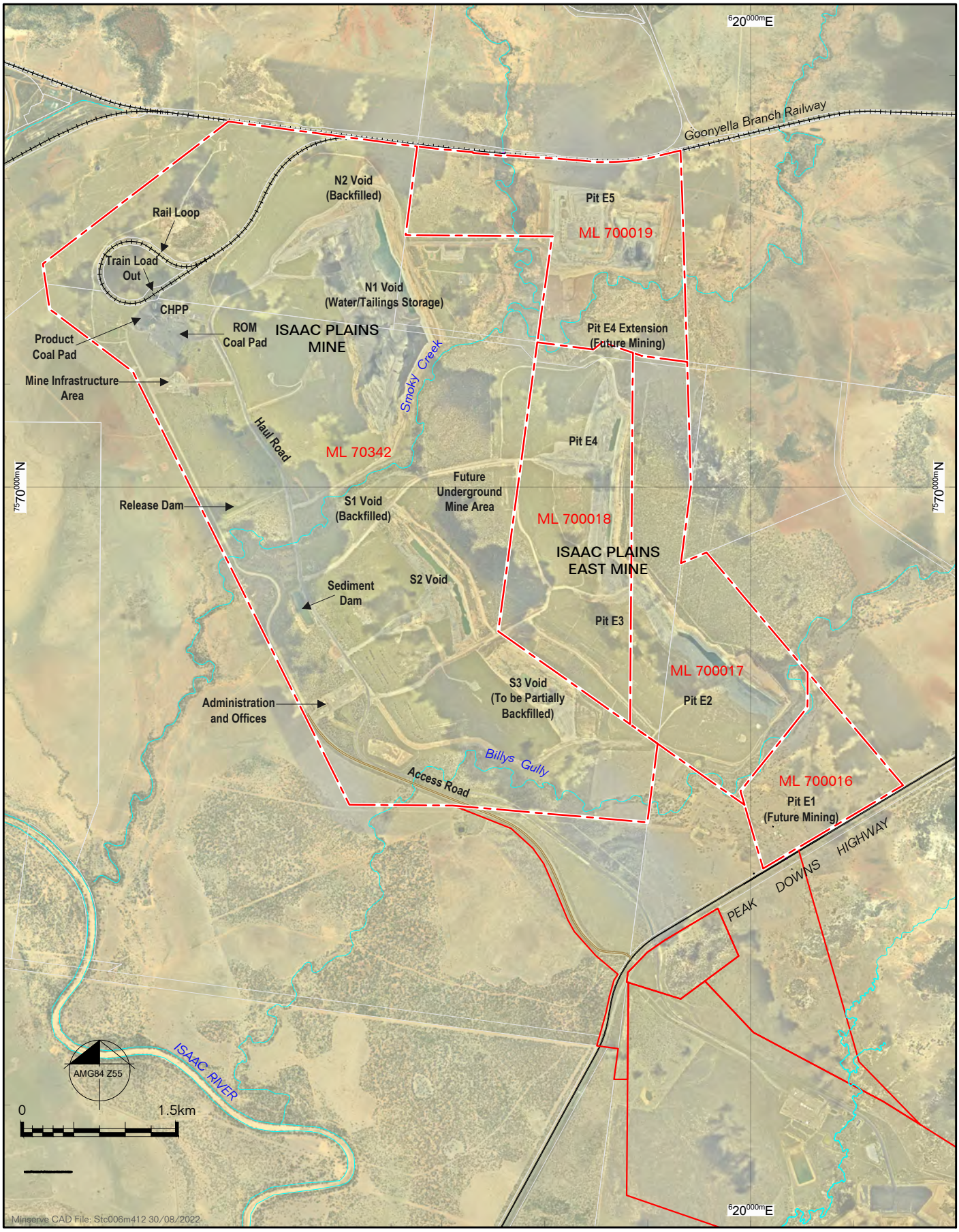
2.2.4 Type of Mining Operation

2.2.4.3 Open Cut

The Mine has operated since 2006 as an open cut truck and shovel operation producing coking coal for exportation. Overburden was removed by a combination of drilling, blasting, dragline, dozing, excavation and haul methods. Overburden material from open cut areas has been placed in out-of-pit dumps and previously exhausted pits.

2.2.4.4 Underground

IPU is proposed on the existing MLs and received approval in 2019 by the Queensland Government. IPU will involve the development of an underground bord and pillar mine. IPU is located to the east of the IPM open cut pits and extends beneath the northern end of the IPE open cut pits.



LEGEND

- ML
- Drainage
- Roads - Major; Minor
- Railway
- Cadastral Boundary

stanmore

Isaac Plains Complex
General Layout
Figure 7

2.2.5 Proposed Duration of Operation

Open cut mining within the new IPEE Pit E5 is ongoing with completion in 2032. Underground mining is scheduled to start in 2026 and be completed in 2036, and E1 and the E4 extension are planned for the future.

2.3 Design for Closure

In accordance with the PRC plan guideline, transitional PRC plans are not required to demonstrate how aspects of the mine site have been designed for existing or approved disturbance. However, any expansion to an existing site must demonstrate how it has been designed for closure.

Mining operations at the Mine are contained to operational pit E5. Both open cut and underground mining are planned prior to closure. Details on how the open cut and underground mining expansions have been designed for closure is described in the following sections.

This design for closure section includes information available for future approved works at the Mine.

2.3.1 IPEE

Mining in new IPEE Pit E5 is ongoing and mining is planned for new open cut pit E1 as well as an extension to pit E4 (IPEE). The E4 extension is referred to as E4N or E5S in some documentation. E5 is also referred to as E5N in some studies.

All pits are approved as per Table 17 of the EA. The E4 extension is south of Smoky Creek while E5 is a new pit north of Smoky Creek. E1 is south of E2 pit on the southern side of Billy's Gully (Figure 7).

2.3.1.5 Location of Mine Features and Infrastructure

a. Protection of EV's and the Receiving Environment

The EV's for IPEE are associated with IPC and discussed in section 2.1.6. Planning for IPEE has considered the protection of the EV's and mitigation measures have been discussed in the IPEE Surface Water Impact Assessment (WRM 2019) (Appendix D) and the Groundwater Dependent Ecosystem Management and Monitoring Plan (3d Environmental 2020) (Appendix E). The Mine's water management system includes detailed control measures to protect the receiving environment from mine affected water which can be seen in Appendix D. Details of the GDE associated with the IPEE project and mitigation measures for protection are provided in section 6.1.1.

b. Surrounding Land Uses and Proximity to Sensitive Receptors

The surrounding land use is predominantly coal mining with areas of cattle grazing. Sensitive receptors are limited to homesteads to the north of E5 pit and adjacent to E1 pit. The homestead at E1 will be vacated prior to the start of E1 pit as per agreements between Stanmore and the land owner.

c. Proximity to the Active Mining Area

The E4 extension and E5 are in close proximity to existing mining areas. The E4 extension is south of Smoky Creek while E5 is a new pit north of Smoky Creek. E1 is south of E2 pit on the southern side of Billy's Gully. Access to E5 and the E4 extension will be via two Smoky Creek tributary crossings which have yet to be constructed. Access to E1 pit will be via a creek crossing over Billy's Gully within the already approved Commonwealth disturbance boundary. Coal haulage will use the haul road to the south of E2 pit and follow the existing haul roads back to the CHPP.

d. Gradient of Disturbed Land

The average gradient of the area is less than 1%. Disturbed land will be graded to manage surface runoff. The water management system includes the construction of a drainage system that diverts clean water runoff from undisturbed areas away from disturbed areas.

e. Local and Regional Topography

The topography of E4, E5 and E1 is similar to the Mine in general being relatively flat. Regional topography is given in 2.1.2.

f. Surface Water and Groundwater Features

Appendix D outlines potential impacts to surface water resources including management and mitigation measures. This includes the construction of flood protection levees to the north and south and a clean water diversion on the eastern side of IPEE. The flood protection levees have been designed as regulated structures during operations but will be integrated into the rehabilitated final landform when no longer required.

Klohn Crippen Berger (KCB) (2020) (Appendix F) investigated potential impacts to groundwater from IPEE. They concluded that IPEE will not impact surface waters or alluvial aquifers because:

- There is limited alluvium present in the vicinity of the project mining area, and the identified alluvium is not in hydraulic connection with the regional groundwater system
- There is no groundwater contribution to surface water flows in creeks within the mining area and its surrounds
- There are no groundwater users predicted to be affected by groundwater depressurisation and therefore no significant impacts on groundwater users are predicted
- Potential GDEs are interpreted to be sourcing water from shallow, perched ephemeral groundwater associated with Billy's Gully. This groundwater is not in hydraulic connection with the regional groundwater system and therefore no significant impacts on these receptors are predicted
- The zone of predicted cumulative depressurisation does not include any groundwater users or other features impacted by IOPEE
- There is a very low potential for groundwater contamination as a result of the Project

g. Geotechnical Conditions

The geotechnical conditions for IPEE will be similar to existing operations. Geological information is available in section 2.1.4.

h. Competing Water and Land Uses

The surrounding land use is predominantly coal mining with areas of cattle grazing. IPEE will not compete for water resources with other land uses and the majority of disturbed land will be returned to a grazing PMLU.

i. Visual Impact

The E4 extension and E5 voids will not be visible from the Peak Downs Highway and are surrounded by existing mining voids. There is not expected to be any change to the visual amenity of the area.

j. Size, Shape and Design of Mine Features and Infrastructure

IPEE will use existing IPC infrastructure for coal processing. Pit dimensions are shown in Figure 8.

k. Mining Methods

Mining will be undertaken as a conventional dragline/truck and shovel operation. This is consistent with the existing IPC operation and will provide similar conditions for rehabilitation at the end of mining.

2.3.2 IPU

2.3.2.6 Location of Mine Features and Infrastructure

a. Protection of EV's and the Receiving Environment

The protection of EV's is given in the IPU Groundwater Report (KCB 2019).

b. Surrounding Land Uses and Proximity to Sensitive Receptors

The surrounding land use is predominantly coal mining with areas of cattle grazing. The IPU is located between IPM and IPE and will be farther away from sensitive receptors than existing operations.

c. Proximity to the Active Mining Area

The IPU area is located between IPM and IPE with access to the underground being from the S2 pit highwall.

d. Gradient of Disturbed Land

The average gradient of the IPU area is less than 1%.

e. Local and Regional Topography

The topography of IPU is similar to the Mine in general being relatively flat. Regional topography is given in 2.1.2.

f. Surface Water and Groundwater Features

IPU will use existing infrastructure at IPC for processing coal and the storage of rejects associated with coal processing. Some surface infrastructure will be required but is within previously disturbed areas of S2 pit. This means there is limited potential for contamination from new surface infrastructure areas. The storage of hydrocarbon and chemicals will continue to be managed in accordance with the existing IPC management practices, including the use of bunding and immediate clean-up of spills which will prevent the contamination of the groundwater regime.

Given the limited activities proposed and the controls that will be adopted, IPU has a very limited potential to give rise to groundwater contamination as a result of hydrocarbon and chemical contamination.

g. Geotechnical Conditions

A geotechnical assessment of the IPU was undertaken by Blackrock Mining Solutions Pty Ltd (Blackrock) (Appendix H). The assessment identified preferred parameters to provide adequate stability for bord and pillar mining operations. This includes minimising surface subsidence which may impact rehabilitation.

h. Competing Water and Land Uses

IPU will not compete with surrounding land uses for water or land. The surrounding land use is predominantly coal mining with areas of cattle grazing. Areas of potential subsidence will be returned to a grazing PMLU. Water extraction will be limited to dewatering of the coal seam during operations. As per section 2.1.6 the quality of water associated with the coal seam does not allow for stock watering or other agricultural uses.

i. Visual Impact

The area includes minimal aboveground infrastructure. The visual impact of subsidence at surface level will be minimal and only observable from close range. The IPU area will not be visible from the Peak Downs Highway.

j. Size, Shape and Design of Mine Features and Infrastructure

IPU will use existing IPC infrastructure for coal processing. New infrastructure will be limited to:

- ROM coal conveyor
- ROM coal stockpile
- Bord and pillar MIA
- Ancillary infrastructure including gas drainage, water management, powerline, ventilation and access roads

The ROM coal conveyor, stockpile and bord and pillar MIA are located within the existing S2 pit limiting additional disturbance. Existing access roads will be used where practicable. The powerline route runs through the potential subsidence area of IPU.

k. Mining Methods

IPU is a bord and pillar operation with sufficient roadway and pillar strength to ensure that there will be no caving, and the underground workings will be safe and stable. Consequently, this mining methodology will not result in significant surface subsidence above the underground workings.

2.4 Rehabilitation / Improvement Planning

Progressive rehabilitation must be maximised by starting and completing rehabilitation as soon as practicable after land becomes available. Land is considered available for rehabilitation unless a reason in section 126D(5) of the EP Act is met.

Land is considered available for rehabilitation when:

- The land is no longer being mined
- The land is no longer being used for operating infrastructure or machinery for mining including dams or water storages
- The land is not needed for mining of a probable or proved ore reserve
- The land contains permanent infrastructure remaining for a PMLU

2.4.1 Relevant Activities and Progressive Rehabilitation

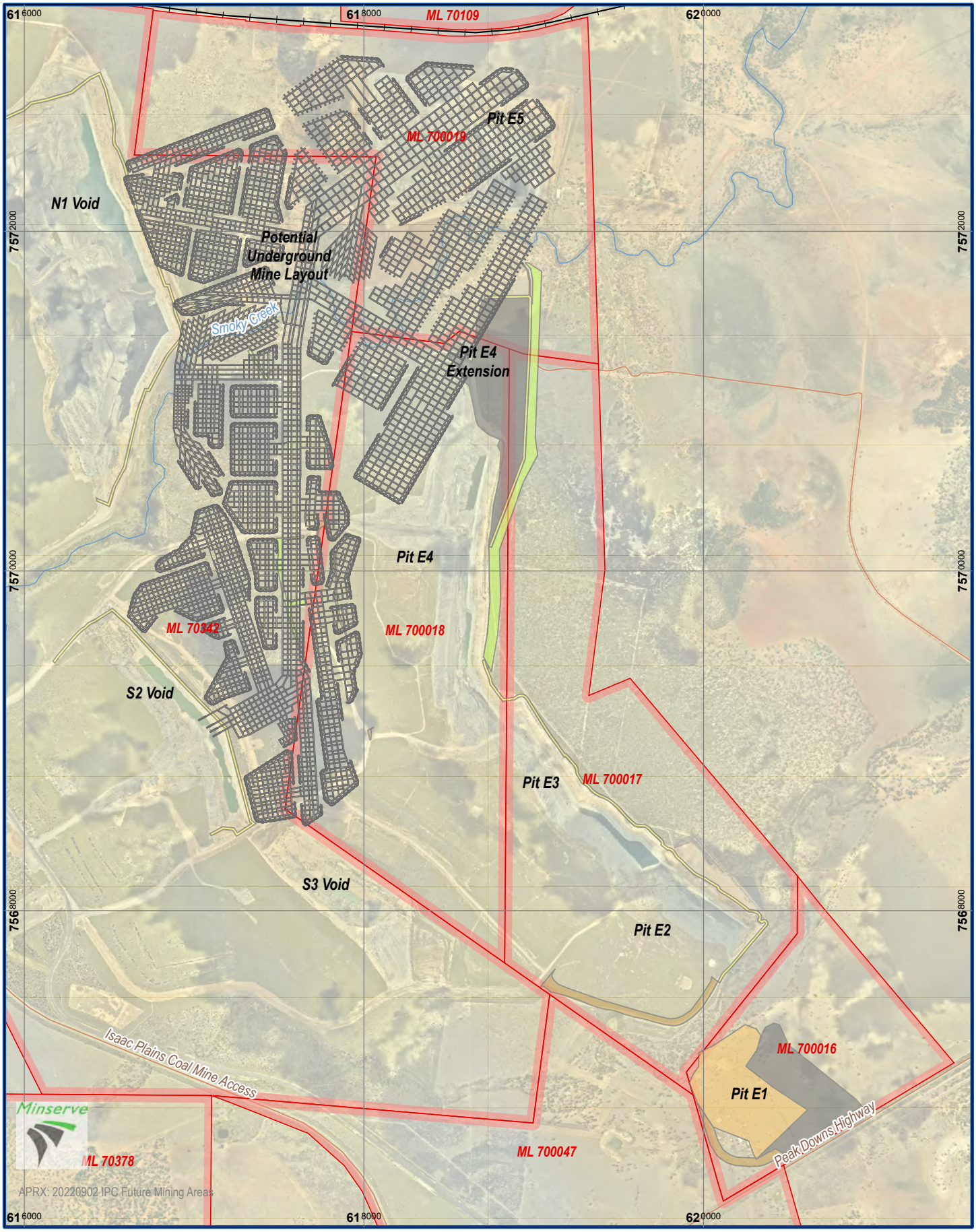
The relevant activities that require rehabilitation and the predicted duration, size and extent, and whether each relevant activity can be progressively rehabilitated is described in Table 18.

Table 18 Progressive Rehabilitation/Improvement of Relevant Activities

Relevant activity	Predicted duration	Size (ha)	Availability for progressive rehabilitation
WRDs	2026-2048	505.09	Available progressively as areas are mined out or not required for overburden dumping.
Topsoil stockpiles	2063-2048	91.7	Available progressively as topsoil stockpiles are depleted during rehabilitation works.
ROM and product stockpiles	2037-2048	15.5	Available for rehabilitation once all mining and processing activities are complete.
Mine infrastructure and rail loop	2037-2048	28.3	Available for rehabilitation once all mining and processing activities are complete.
Roads, laydowns and cleared areas	2025-2053	234.8	Available for rehabilitation once all mining and processing activities are complete.
Water storage and management structures	2027-2048	28.4	Available for rehabilitation once all mining and processing activities are complete.

Relevant activity	Predicted duration	Size (ha)	Availability for progressive rehabilitation
Tailings and co-disposal	2037-2053	31.4	Available for rehabilitation once tailings material has adequately dried and is safe for equipment usage during rehabilitation works.
Exploration	2023	23.4	Previously rehabilitated.
Subsidence areas	2033-2038	308.5	Available at the completion of underground mining in 2036.
Completed rehabilitation	2023	907.3	Previously rehabilitated.
Gas infrastructure	2023-2038	10.3	Gas infrastructure is located on the MLs but is not the property of the Proponent.
Retained infrastructure	2023-2038	46.3	Available for transfer to the future landholder once all mining and processing activities are complete.
Pit voids	2023-2038	329.1	• S2 is required for access to IPU until 2035 • E2 and E3 are available for improvement works from 2025 • N1 is required for tailings storage until 2038 • E1 not yet constructed and will be available for improvement works in year 2033 • E4 extension will commence in 2023 with the area available for improvements works in 2030 • E5 will be available for improvement works in year 2028

Figure 8 shows the future mining areas for the Mine.



Waterway
Railway
Road
ML
IPUG Underground Layout
Opencut Mining
CDA
Overburden Dump
Levee
Pit

N

0 200 400 600 800 1,000
Meters

stanmore

Proposed Future Mining Areas
Figure 8

2.4.2 Existing Rehabilitation

Progressive rehabilitation has been completed over a series of campaigns spanning several years starting in 2007, as land has become available for rehabilitation. A total of ~ 907 ha of rehabilitation has been completed at the Mine. A summary is given in Table 19 and examples shown in Plate 1. The locations of completed rehabilitation works at the Mine is shown in Figure 9. To date, rehabilitation has primarily focused on the waste rock dumps.

Rehabilitated areas are subject to ongoing monitoring and maintenance, in accordance with the Rehabilitation Plan and Rehabilitation Monitoring Program. No applications for progressive certification of rehabilitated areas have been submitted for the Project.

All rehabilitation within the Project's ML has been completed per the methodology described in Section 6. Generally, this included the following steps:

1. The open area was contoured to the required shape
2. Ripping was undertaken to break up compacted surface layers and key in the topsoil
3. Local topsoil was spread across the contoured landform to an average 150mm thickness
4. Seeds of selected pasture grasses and legumes (appropriate to the desired post mining land use) sown
5. Weed management undertaken in accordance with landholders' protocols and Local and State Government guidelines
6. Annual monitoring of revegetation areas

Rehabilitation inspection and monitoring occurs each year across the site and includes inspections of rehabilitated areas. The annual rehabilitation inspection is the first step in assessing the success of rehabilitation monitoring results for each area, and are currently reported in separate sections of the Annual Rehabilitation Inspection Report. An annual collation and summary of all monitoring information and subsequent assessment against completion criteria, is used to assess the trajectory of each area towards achieving acceptable rehabilitation outcomes.

Table 19 Existing Rehabilitation

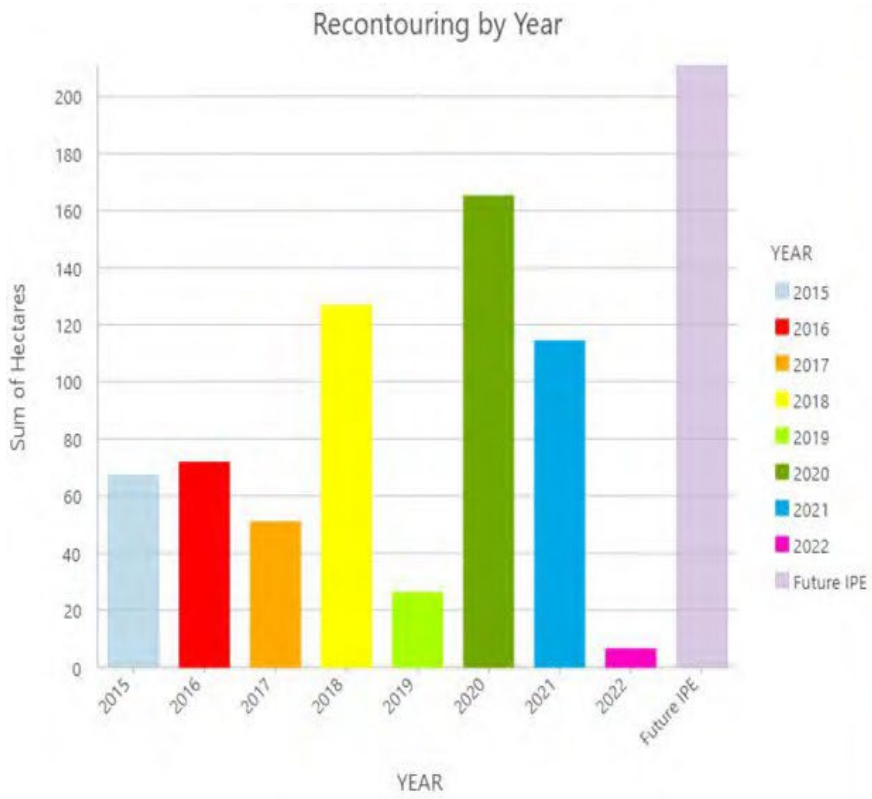
Location	Methodology	Year commenced (approximate)
N2 pit area		
N2 pit	• Reshaping • Topsoiling • Rip and seed	2020
N1 pit area		
N1 west	• Reshaping • Topsoiling • Rip and seed	2016

Location	Methodology	Year commenced (approximate)
N1 south	• Reshaping • Topsoiling • Rip and seed	2018
N1 north	• Reshaping • Topsoiling • Rip and seed	2020
N1 east	• Reshaping • Topsoiling • Rip and seed	2020
S1 pit area		
S1	• Reshaping • Topsoiling • Rip and seed	2018-2020
S2 pit area		
S2 north	• Reshaping • Topsoiling • Rip and seed	2016
S2 south	• Reshaping • Topsoiling • Rip and seed	2021
S2 east	• Reshaping • Topsoiling • Rip and seed	2019-2020
S2 west	• Reshaping • Topsoiling	2017

Location	Methodology	Year commenced (approximate)
	• Rip and seed	
S3 pit area		
S3 west	• Reshaping • Topsoiling • Rip and seed	2016 and 2018
S3 south	• Reshaping • Topsoiling • Rip and seed	2017-2019
S3 central	• Reshaping • Topsoiling • Rip and seed	2020
S3 east	• Reshaping • Topsoiling • Rip and seed	2021
BG levee	• Topsoiled • Seeded • Fertilized	2019
E2 pit area		
E2 south	• Reshaping • Topsoiling • Rip and seed	2021-2022
E4 pit area		
E4 north	• Reshaping • Topsoiling • Rip and seed	2021

Location	Methodology	Year commenced (approximate)
E5 pit area		
E5	• Reshaping • Topsoiling	2024

Plate 1 Existing Rehabilitation



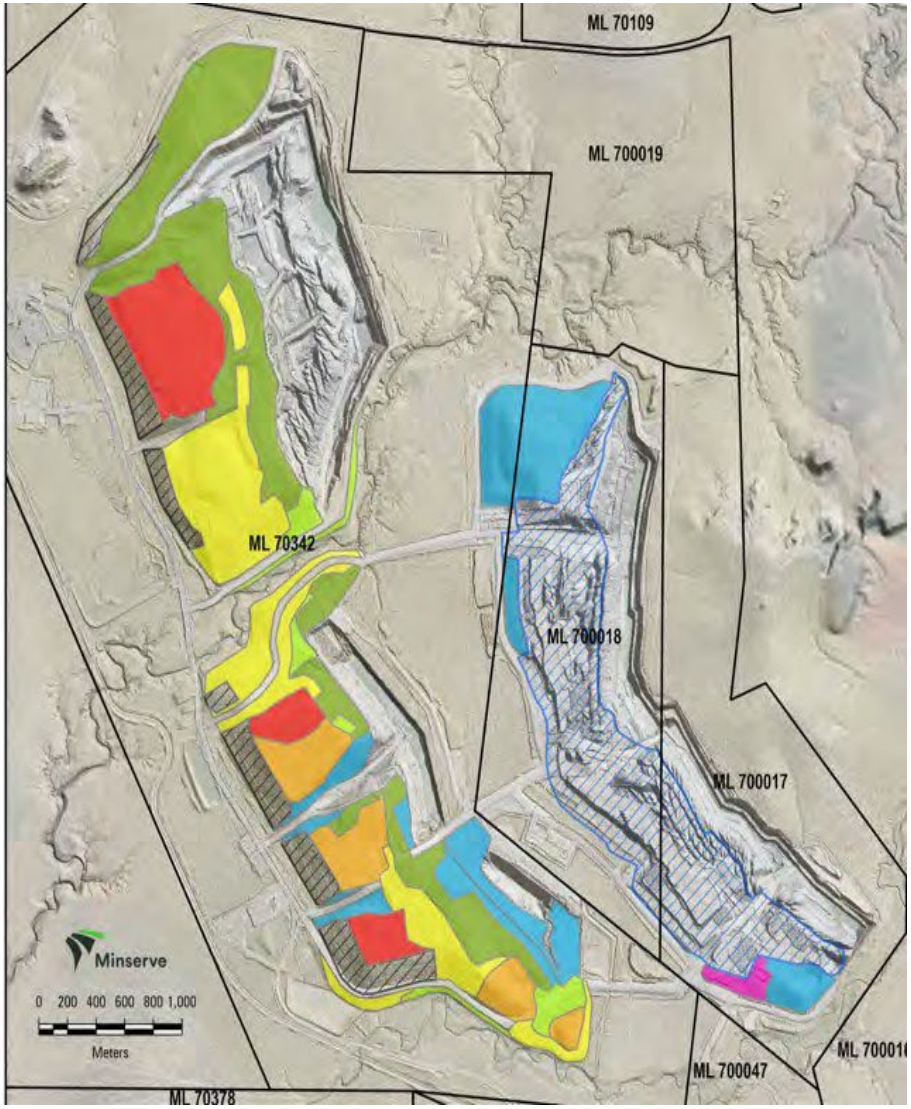


Figure 9 Completed Rehabilitation Works at the Mine

3. COMMUNITY CONSULTATION

3.1 Community Consultation Register

To comply with section 126C(1)(c)(iii) of the EP Act Stanmore has completed a register to provide a record of consultation and engagement outcomes. Community consultation that has been done to date is given in Table 20.

Table 20 Community Consultation Register

Consultation date(s)	Community member(s)	Description of consultation type (workshop, quarterly meetings, etc)	Information provided to the community	Issues raised / discussed by the community	How the issues have been considered	Decisions / outcomes of engagement	Commitments made by Stanmore IP Coal Pty Ltd
13-Oct-2005	Landholder of Wotonga Station	Meeting	Required easement for a raw water pipeline from Stanmore's offtake point on the Sunwater pipeline to Stanmore's Raw Water Dam (RWD).	Risk caused by mining activities	Review an agreement that has been in place since 2006.	Signed agreement	Stanmore's obligation on termination. Vacate the licensed area promptly and remove the pipeline and any other of its infrastructure, fixtures, vehicles, plan, equipment, machinery, tools and mater. Restore any disturbance of the licensed area.
12-Nov-2012	Moranbah Cumulative Impacts Group	Meeting	Moranbah cumulative impacts group seeks clarity on cumulative dust issues and long-term view for sustainability.	Cumulative dust issues	Moranbah Cumulative Impacts Group developed a vision for Moranbah to be a resilient and prosperous town with a good reputation	Action defined to address knowledge gap and gather information, effectively communicate and develop a best practice	Stanmore is committed to fulfilling its EA obligations and have implemented measures to mitigate its dust risk to comply with the EA.

Consultation date(s)	Community member(s)	Description of consultation type (workshop, quarterly meetings, etc)	Information provided to the community	Issues raised / discussed by the community	How the issues have been considered	Decisions / outcomes of engagement	Commitments made by Stanmore IP Coal Pty Ltd
					as an attractive place to live and work.	for dust management.	
20-Jul-2017	Landholder of Wotonga Station	Meeting	Acquisition of mining leases for Isaac Plains East.	The SUR area overlaps with lot 5 on Crown Plan GV132 (SUR Land).	Variation of the IPE agreement on the terms of the deed.	Signed agreement	Stanmore will honour the agreement made with the landowner.
19-Apr-2018	Landholder of Wotonga Station	Letter	Retention of dams post mine closure.	Stanmore provides a statement from relevant landholders for the retention of dams post mine closure.	The landholder will retain the dams post mine closure.	Signed agreement	Stanmore to deliver the dams to the landholder at closure of the mine.
9-May-2019	Moranbah teachers tour of Isaac Plains Mine Site	Meeting	Site tour of Isaac Plains Coal Mine as part of Community	Lack of understanding of mining within the community.	Site tour is open to all Moranbah teachers, school staff and their partners.	Successful site tour	Continued support for the community
18-Sep-2019	Landholder – Mal Burston	Letter	Land and House Vacate Notice	Expansion of Isaac Coal Mine and Isaac Plains East Project mine leases	Relocation of land occupiers	Signed agreement	Ongoing consultation

Consultation date(s)	Community member(s)	Description of consultation type (workshop, quarterly meetings, etc)	Information provided to the community	Issues raised / discussed by the community	How the issues have been considered	Decisions / outcomes of engagement	Commitments made by Stanmore IP Coal Pty Ltd
				ML70342 and ML700019			
02-Jun-2020	Mt Spencer landholder	Meeting	Access agreement	Granting Stanmore exclusive access to offset investigation area of for a period of 12 months for the purposes of carrying out ecological studies to determine if the land is suitable for use for offsets.	Part of Lot 4 on SP 277438 comprising an approximate area of 3000 hectares and divided into Target Area 1 (of approximately 1000 hectares) and target area 3 (of approximately 1000 hectares)	Signed agreement	Amount payable in the agreement
21-Sep-2020	Moranbah teachers tour of Isaac Plains Mine Site	Meeting	Site tour of Isaac Plains Coal Mine as part of Community	Mine site familiarisation of new teaching	Site tour is open to all Moranbah new teachers in the region.	Successful site tour	Continued support for the community
17-Jun-2021	Landholder Wotonga Station	Meeting	Landholder given site tour to see Pit 2 rehabilitation achieved with the dragline. The brolga bath depression area was explained, and	Crossing of the dragline through stock area. Rehabilitation not meeting the intended	Progression of rehabilitation in line with EA. Removal of stock from area through which the dragline will cross.	Agreement to walk dragline through landholder property and landholder understanding of Stanmore	Commitment to rehab.

Consultation date(s)	Community member(s)	Description of consultation type (workshop, quarterly meetings, etc)	Information provided to the community	Issues raised / discussed by the community	How the issues have been considered	Decisions / outcomes of engagement	Commitments made by Stanmore IP Coal Pty Ltd
			the type of rehab was discussed aiming for grazing as the final use. Discussed dragline walk route from Isaac Plains to Isaac Downs.	final land use objective.		commitment to returning the land to grazing post mine.	
28-May-2022	Rehabilitation Commissioner and team.	Meeting	Site tour of Isaac Plains Coal Mine rehabilitation area and discuss challenges and success of	Rehabilitation challenges	Stanmore explains it's strategies in addressing the challenges.	Successful site tour	Commitment to rehab.
3-Jun-2022	Department of Environment and Science	Meeting	Site tour of Isaac Plains Coal Mine and understand general site challenges and concerns.	General site concerns.	Site familiarisation and discussion with senior management team of Isaac Plains Complex.	Successful site tour	Continued support for the community
16-Aug-2022	Isaac Regional Council	Meeting	Progressive Rehabilitation and site visit of the rehabilitated spaces.	Challenges and opportunities in the rehabilitated spaces.	Site tour and discussion with senior management team of Isaac Plain Complex	Successful site tour	Practice of the Progressive Rehabilitation and Closure Plan (PRCP)
1-Sep-2022	Landholder	Meeting	Landholder explained	Expectation around final	Explanation provided as per	Consensus reached for	Establish an area for the rehabilitation trial and

Consultation date(s)	Community member(s)	Description of consultation type (workshop, quarterly meetings, etc)	Information provided to the community	Issues raised / discussed by the community	How the issues have been considered	Decisions / outcomes of engagement	Commitments made by Stanmore IP Coal Pty Ltd
	Wotonga Station		rehabilitation milestones, permitted residual voids and inquiry into grazing trial on established rehabilitation areas.	void landforms and requirements for grazing trials.	EA EPML00932713 regarding final voids and clarity sought from the stakeholder regarding rehab trial.	rehabilitation trial and the landholder acknowledged Stanmore progress with rehabilitation.	provide necessary infrastructure. Continue rehabilitation as per the EA.
22-Sep-2022	Isaac Regional Council	Letter	Isaac Plains Mine rehabilitation history and Stanmore's objectives for Progressive Rehabilitation and Closure Plan (PRCP) pursuant to the Environmental Authority (EA) EPML00932713.	Progressive Rehabilitation objective to surrender land in condition similar to those that existed prior to disturbance and supporting Post Mine Land Use (PMLU)	The PRCP describes how progressive rehabilitation of disturbed land will occur and specifies future (post-mining) land uses and the condition the land must be in before the operation's Environmental Authority may be surrendered.	Information	Stanmore's commitment to its compliance obligations
23-Sep-2022	Barada Barna Aboriginal Corporation	Letter	Rehabilitation history and Stanmore's objectives for Progressive Rehabilitation and Closure Plan	Progressive Rehabilitation objective to surrender land in condition similar to those that	The PRCP describes how progressive rehabilitation of disturbed land will occur and specifies future	Information	Stanmore's commitment to its compliance obligations

Consultation date(s)	Community member(s)	Description of consultation type (workshop, quarterly meetings, etc)	Information provided to the community	Issues raised / discussed by the community	How the issues have been considered	Decisions / outcomes of engagement	Commitments made by Stanmore IP Coal Pty Ltd
			(PRCP) pursuant to the Environmental Authority (EA) EPML00932713.	existed prior to disturbance and supporting Post Mine Land Use (PMLU)	(post- mining) land uses and the condition the land must be in before the operation's Environmental Authority may be surrendered.		

3.2 Community Consultation Plan

To comply with section 126C(1)(c)(iv) of the EP Act, Stanmore has created a community consultation plan to detail how consultation will be carried out in relation to closure planning. Stanmore's *Community and Stakeholder Engagement Plan* (CSEP) seeks to involve the community during the planning, construction, operation and decommissioning of projects in accordance with Queensland SIA Guideline (2018), the Australian Government's *Handbook on Community Engagement and Development for the Mining Industry* and the PRC plan guideline.

3.2.1 Objectives

The CSEP's objectives are:

- To identify stakeholder groups that could be affected or may have an interest in Stanmore operations and projects
- To identify the interests, and concerns, and needs of the stakeholder groups
- To ensure opportunities is provided for engagement between stakeholders and the operation or project
- To maintain a framework for strong and cooperative relationships with local communities and stakeholders;
- To provide a compliant mechanism to allow affected communities and other stakeholders to register complaints, queries or comments and have them addressed in a timely manner by Stanmore
- To ensure operations planning and delivery are informed by stakeholder views
- To ensure engagement supports adaptive management of social impacts

3.2.2 Identified Community Members

The key stakeholder groups addressed by the CSEP are shown in Table 21. Key landowners in the Mine area are shown in Figure 10.

Table 21 Key Community Members

Key Stakeholders	Groups
State government	• Office of the Coordinator-General- Coordinated Project Delivery Division (CPDD) • Department of Transport and Main Roads • Department of Women, Aboriginal and Torres Strait Islander Partnerships and Multiculturalism • Department of Housing and Public Works • Department of Trade, Employment and Training • Department of the Environment, Tourism, Science and Innovation • Department of Natural Resources and Mines, Manufacturing, and Regional and Rural Development • Queensland Ambulance Service
Local government	• Isaac Regional Council • Mackay Regional Council
Local and public service providers	• Moranbah State High School • Moranbah State Primary School • Moranbah State East Primary School • Moranbah Police Station • Moranbah Hospital • Ambulance services • Moranbah and District Support Services • Moranbah Men's Shed

Key Stakeholders	Groups
	• Mackay, Whitsunday Isaac Suicide Prevention Network • Simply Sunshine Childcare Centre • Moranbah Early Leaning Centre
Local and regional employment and training providers	• Coalfield Training Excellence Centre (CTEC) • Principal mine contractor • Local training providers (MREAL etc) • Local employment providers (Work Pac etc)
Housing and accommodation providers	• Isaac Affordable Housing Trust • Emergency and Long-Term Accommodation (ELAM) Moranbah • Real estate agencies in Moranbah • Worker Accommodation Village Providers (Civeo etc) • Other accommodation providers who are providing housing services and programs of relevance to the SIMP
Industry groups and businesses	• Moranbah Traders Association • CFMEU Mining and Energy • Mackay-based Resource Industry Network (RIN) • Various local business owners • Major infrastructure providers (e.g. Rail, Port, Energy) • Overlapping and adjacent resource tenement holders

Key Stakeholders	Groups
Local and regional commerce and community development organisations	• Moranbah and District Support Service Association Inc • Dysart Community Support Group Association Inc • Moranbah Community and Youth Hub management committee • Nebo Community Development Group • Mackay, Whitsunday, Isaac Suicide Prevention Network • Other organisations who are providing services and programs of relevance to the SIMP • Natural resource management organisations
Aboriginal and Torres Strait Islander peoples	• Barada Barna Aboriginal Corporation • Barada Barna people • Gangali Narra Widi Aboriginal Corporation (GNWAC) • Widi People • Wiri People • Jannga People • Indigenous businesses • Indigenous training providers
Local communities	• Landholders in and surrounding Stanmore operating sites and projects • Residents including Moranbah, Dysart, Coppabella, Nebo and other residents in Isaac LGA with an interest in Stanmore operations
Workforce	• Stanmore employees

Key Stakeholders	Groups
	• Major contractor employees • Unions

3.2.3 How the Community will be Engaged / Information Released for Community Consultation

Stanmore have and will continue to use a range of strategies to engage with the community regarding operations at the Mine. Methods of engagements by interest group can be seen in Table 22.

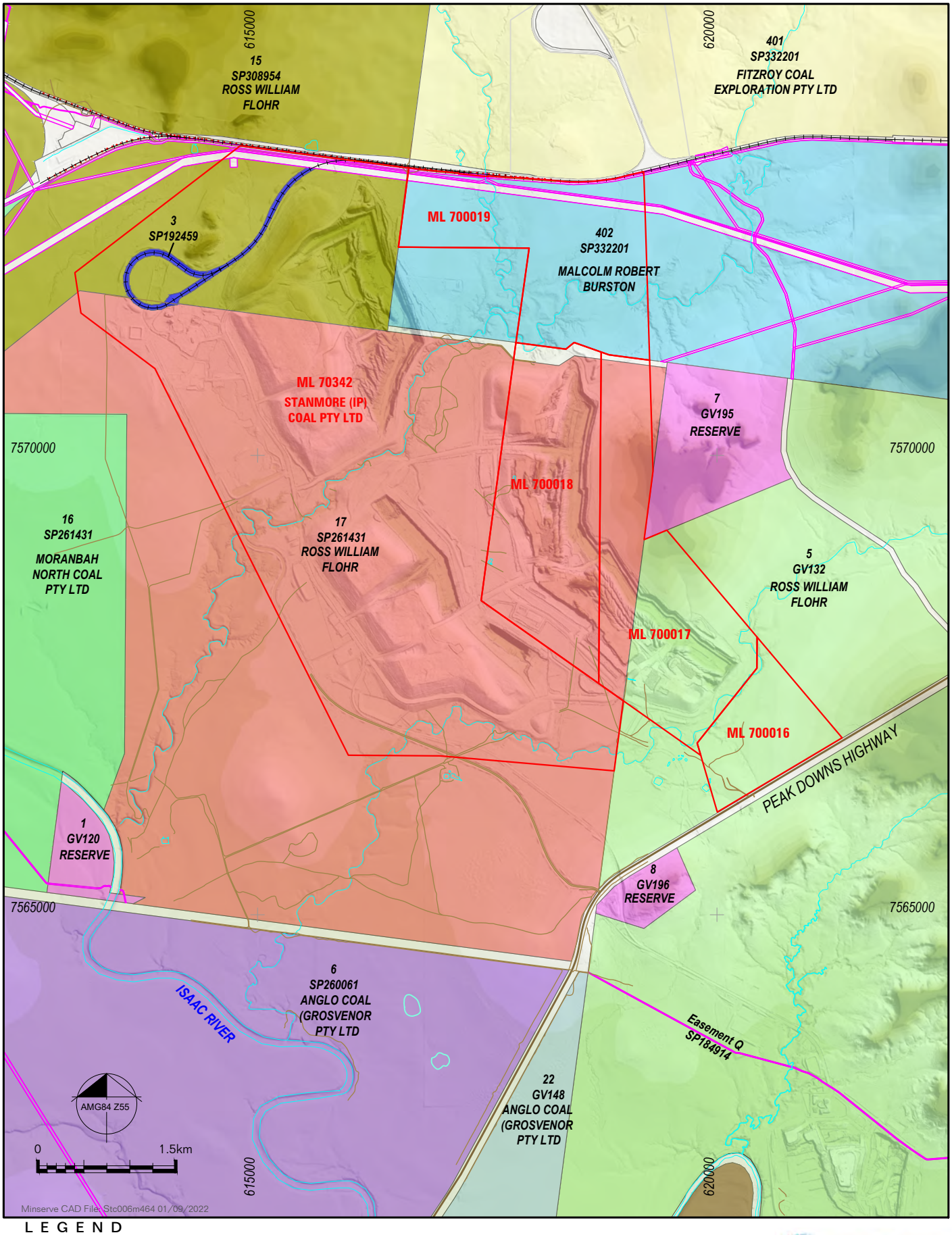
Table 22 Key Stakeholder Engagement Mechanisms

Stakeholder group	Primary interest	Engagement mechanisms
Federal agencies	Environmental protection and monitoring	Direct correspondence (letters, emails, phone calls) Briefing/individual meetings
State agencies	Sustainable resource development Approval processes Pressure on regional infrastructure Employment and business opportunities Education and training opportunities Housing availability and affordability Safety and emergency response Capacity of health and education services Impact on road networks	Website Direct correspondence (letters, emails, phone calls) Briefing/individual meetings Biannual newsletter Fact sheets to announce project changes and updates Project officer dedicated as community contact point
Local governments	Employment and business opportunities Education and training opportunities Housing availability and affordability Safety and emergency response Community funds and benefits Approvals process Capacity of social services and infrastructure Water supply Local road network Traffic impacts and roads Constituent complaints Timely and accurate revised Project information	Website Direct correspondence (letters, emails, phone calls) Project officer dedicated as community contact point Quarterly newsletter Fact sheets to announce project changes and updates Participation in local business forums Presentations to local service providers where requested Briefing/individual meeting

Stakeholder group	Primary interest	Engagement mechanisms
Social and public services providers	Capacity of social services and infrastructure Employment and business opportunities Education and training opportunities Safety and emergency response Community funds and benefits Traffic impacts and roads Timely and accurate revised Project information	Website Direct correspondence (letters, emails, phone calls) Project officer dedicated as community contact point Fact sheets to announce project changes and updates Briefing/individual meeting
Local and regional employment and training providers	Employment and business opportunities Education and training opportunities Project timeframes and updates Traffic impacts and roads Constituent complaints	Presentations to employment and training bodies Project officer dedicated as community contact point Dedicated project phone number or email address Website Fact sheets to announce project changes and updates
Housing and accommodation providers	Housing availability and affordability Capacity of social services and infrastructure Project timeframes and updates	Presentations to housing providers Project officer dedicated as community contact point Dedicated project phone number or email address Website Quarterly newsletters Fact sheets to announce project changes and updates Briefing/individual meeting
Industry groups and businesses	Supply chain opportunities Tender requirements Project timeframes and updates Labour requirements for SMR Operations Impacts on their operations	Presentations to business representative bodies Project officer dedicated as community contact point Dedicated project phone number or email address Website Newspaper advertisements Quarterly newsletters Fact sheets to announce project changes and updates
Local and regional commerce and community development organisations	Employment and business opportunities Education and training opportunities Access to community Investment	Quarterly newsletter Project officer dedicated as community contact point Dedicated project phone number or email address

Stakeholder group	Primary interest	Engagement mechanisms
	Fund and Community Sponsorship and Donation Program Housing affordability Community safety Timely and accurate revised Project information' Environmental issues and management	Website Regular community information sessions Participation in local events Complaint mechanism Community Investment Fund supporting materials
Aboriginal and Torres Strait Islander peoples	Employment and business opportunities Education and training opportunities Labour requirements for SMR Operations Supply chain opportunities Community funds and benefits Timely and accurate revised Project information Cultural heritage management Any native title agreement requirements	Presentation to Aboriginal representative bodies Relationship committee nominated as contact point with routine meetings scheduled. Dedicated key contact phone number and email address Website Newspaper advertisements Quarterly newsletters Regular community information sessions Participation in local events Complaint mechanism Community Investment Fund supporting materials Fact sheets to announce project changes and updates
Local communities including local and adjoining landholders	Job and business opportunities Education and training opportunities Community funds and benefits Community cohesion and social values Dust, noise and light emissions House affordability and availability Access to social services Traffic and congestion Mine site environmental management Rehabilitation Groundwater and surface water management Changes to farming practice Accessibility	Regular community information sessions Project officer dedicated as community contact point Quarterly community newsletter Dedicated project phone number and email address Participation in local events Complaint mechanism Community Investment Fund supporting materials Website Media releases and social networks (such as Facebook)
Workforce	Work shifts and schedules	Company newsletter

Stakeholder group	Primary interest	Engagement mechanisms
	Impact on families Transport and commuting arrangements Codes of conduct for behaviour Housing and accommodation options Service provision in nearby towns Road safety	Website – intranet Human resource management Team Onsite notice boards Induction processes and training Toolbox talks and safety messages Senior Management Team meetings (senior staff) General Management meetings (general managers) Regular informal social events Employee grievance mechanism



L E G E N D

- IPM MLs
- Drainage
- Roads - Major; Minor
- Railway
- Cadastral Boundary
- Easement Boundary

stanmore

Land Ownership and Easements

Figure 10

3.2.4 Proposed Consultation Frequency

The engagement program is outlined in Table 23. Stanmore will adapt stakeholder engagement activities to reflect local concerns as they arise.

Table 23 Community and Stakeholder Engagement Key Action Summary

Actions	Responsibility	Associated stakeholders/ partners	Timeframes	Monitoring responsibility	Monitoring frequency	Reporting requirements
Maintain a Project officer dedicated as a community contact point	GM G&S	N/A	Ongoing during construction and operation	N/A	N/A	N/A
Continue to engage with local and surrounding landholders to monitor impacts	Site GM's	Landholders	Ongoing during construction and operation	GM G&S	Bi-annually during construction and operation	Annual implementation report during construction and operation
Continue in identifying issues, disseminating information throughout the life of SMR Operations and providing a forum for discussion	GM Isaac Complex	Local community Relevant government agencies	Ongoing during construction and operation	GM G&S	Bi-annually during construction and operation	Annual implementation report during construction and operation
Provide various communication channels (eg signage, advertisements in local papers, construction materials) about	ID Project Manager	N/A	Ongoing during construction	GM G&S	Bi-annually during construction and operation	Annual implementation report during construction

Actions	Responsibility	Associated stakeholders/ partners	Timeframes	Monitoring responsibility	Monitoring frequency	Reporting requirements
changes to local access, potential road hazards and expected traffic volumes during construction						
Continue to engage with local service providers including schools, health and other social services regarding when blasting and other Project related activities which have any potential to impact on the community have been scheduled	GM Isaac Complex	Service providers	Ongoing during construction and operation	GM G&S	Bi-annually during construction and operation	Annual implementation report during construction and operation
Facilitate open and transparent engagement with local communities	Principal External Engagement	N/A	Ongoing during construction and operation	GM G&S	Bi-annually during construction and operation	Annual implementation report during construction and operation

Actions	Responsibility	Associated stakeholders/ partners	Timeframes	Monitoring responsibility	Monitoring frequency	Reporting requirements
Establish, publicise, and maintain a readily accessible community complaints and resolution process	Principal External Engagement	Local community	Ongoing during construction and operation	GM G&S	Bi-annually during construction and operation	Annual implementation report during construction and operation
Bi-annual publication and dissemination of Project Community Updates	ID Project Manager	N/A	Quarterly during construction and operation	GM G&S	Bi-annually during construction and operation	Annual implementation report during construction and operation
Establish and maintain long-term respectful relations with the Barada Barna including managing cultural heritage in accordance with the Cultural Heritage Management Plan and meeting the requirements of any native title agreement	Principal External Engagement	Barada Barna people	Ongoing during construction and operation	GM G&S	Bi-annually during construction and operation	Annual implementation report during construction and operation

Actions	Responsibility	Associated stakeholders/ partners	Timeframes	Monitoring responsibility	Monitoring frequency	Reporting requirements
Regular engagement with the Isaac Regional Council in the monitoring of SIMP implementation	Principal External Engagement	Isaac Regional Council (IRC)	Ongoing during construction and operation	GM G&S	Bi-annually during construction and operation	Annual implementation report during construction and operation
Engage with the community through inviting applications to the Stanmore Community Fund	Principal Sustainability	Community organisation	Ongoing during construction and operation	GM G&S	Bi-annually during construction and operation	Annual implementation report during construction and operation

3.2.5 How Feedback and Complaints will be Considered

Concerns and issues raised during consultation are to be recorded and responded to in a timely and consistent manner in accordance with regulatory standards and company policy. The following are key guiding principles employed by Stanmore in responding to issues or concerns raised by local stakeholders:

- Timeliness – complaints will be addressed in a timely and efficient manner
- Sensitivity – Ensure that feelings and perspectives of parties involved are respected
- Fairness and impartiality – parties involved will be afforded substantive and procedural fairness in the resolution process
- Confidentiality – only parties directly involved in the complaint or those involved in decision making about outcomes will have access to information about the complaint

A Community Contact number for the purpose of receiving complaints and enquiries from stakeholders in relation to Stanmore operations will be provided. This Community Contact number will be provided to:

- Isaac Regional Council and Mackay Regional Council
- Police officers in Moranbah, Dysart, and Nebo
- Landholders in the vicinity of Stanmore operations and its infrastructure
- Contractors and subcontractors
- The public through the company's website

All incoming calls will be logged into the stakeholder database.

4. POST-MINING LAND USE

Mining is a temporary use of land. The majority of the Mine will be returned to grazing, which is consistent with EA conditions regarding rehabilitation, i.e. condition F4.

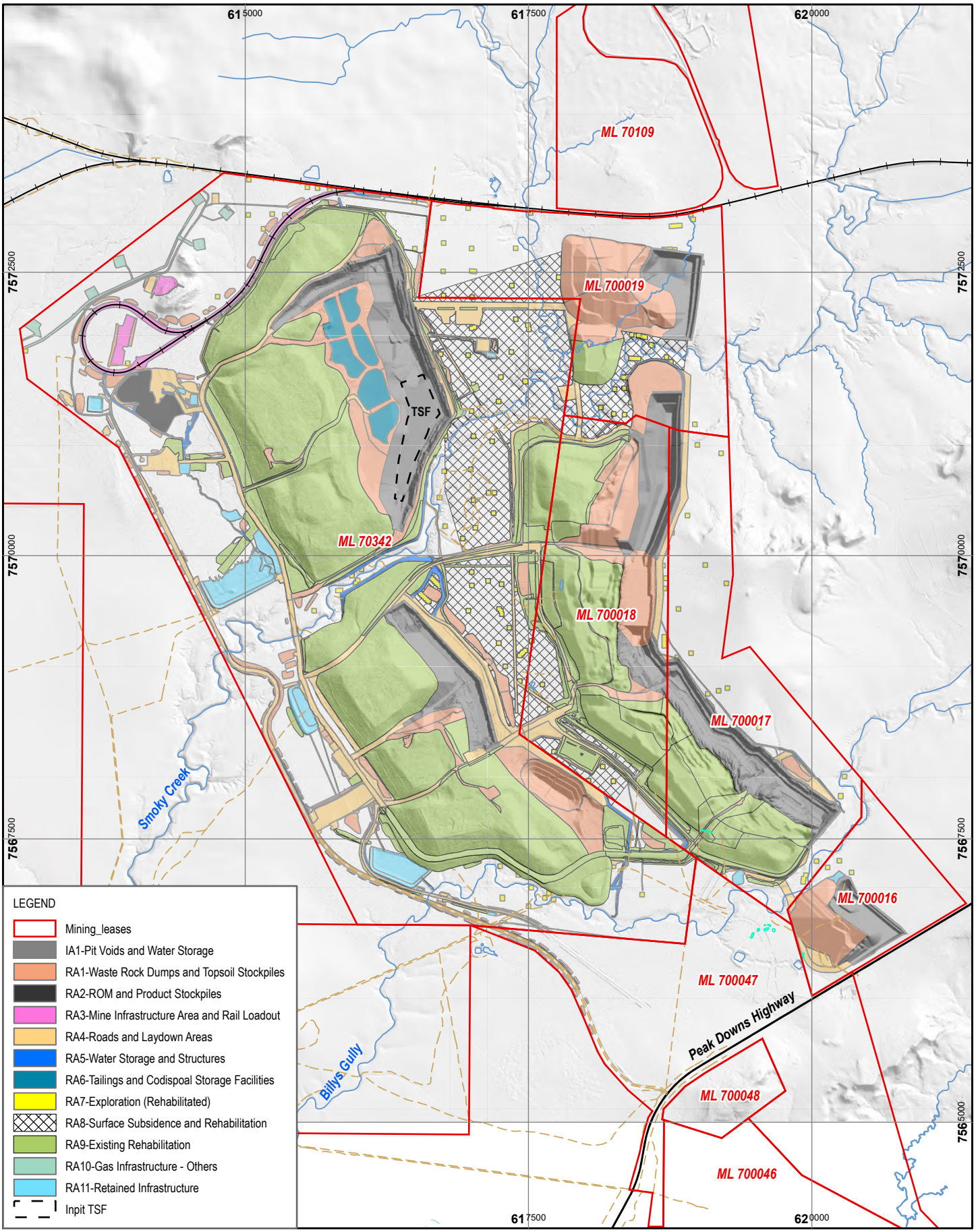
The process to achieve this is discussed in section 7 and Appendix A. The mine domains and rehabilitation areas are shown in Table 24 and Figure 11.

Table 24 PMLU and Rehabilitation Areas

Mine domain	PMLU	Rehabilitation area	Area (ha)
Waste rock dumps and topsoil stockpiles	Grazing	RA1	310.6
ROM and product stockpiles	Grazing	RA2	15.6
Mine infrastructure area and rail loop	Grazing	RA3	28.3
Roads, laydowns and cleared areas	Grazing	RA4	224.2
Water storage and management structures	Grazing	RA5	21.6
Tailings and co-disposal	Grazing	RA6	31.4

Mine domain	PMLU	Rehabilitation area	Area (ha)
Historic Exploration	Grazing	RA7	22.3
Subsidence areas	Grazing	RA8	308.4
Existing rehabilitation	Grazing	RA9	977.2
Gas infrastructure	Grazing	RA10	10.3
Retained infrastructure	Water storage[1]	RA11	46.3
Pit Voids and Water Storage	N/A	IA1	382.4

1. Water storage supporting the grazing PMLU



N

0 500 1,000 1,500 2,000 2,500

Meters

stanmore

Rehabilitation Areas
Figure 11

4.1 Consistency with the Outcome of Community Consultation

The PMLU is consistent with the outcome of community consultation because:

- There is a preference for pasture grazing as it is consistent with the previous land use and will be suitable for final landowner use
- Retained infrastructure for water storage is beneficial for the final land use

How underlying landholders and other stakeholders views have been addressed:

- Grazing trials arranged with details confirmed through consultation with the concerning landowner to confirm rehabilitation success
- Dams will be retained for landholder use post mining as agreed
- The PMLU of grazing will create a stable land use for the area in keeping with sustainability goals for the region
- Rehabilitation will be completed in line with the PRC plan schedule

4.2 Consistency with Local, State and Commonwealth Requirements

The following review of the local and state requirements demonstrate that pasture grazing is consistent with the strategies and plan outlined herein.

4.2.1 State Requirements

4.2.1.1 Mackay, Isaac and Whitsunday Regional Plan

The Mackay, Isaac and Whitsunday Regional Plan (DLGP 2012) includes the following specific policies for PMLUs:

- Identified valuable mineral and extractive resource areas within the region are protected from development that might adversely affect current or future extraction
- The operation of extraction and processing activities does not compromise:
  - Human health
  - Current and future resource use opportunities
  - Regional landscape values
  - Ecosystem function and services
  - Must minimise its impact on primary production
- Once extraction ceases, former resource areas are rehabilitated to facilitate multiple end-uses, ensuring continuing contribution to the economic, community and EVs of the region
- Innovative practices are encouraged, including local processing and value-adding activities, to maximise eco-efficiencies.

4.2.2 Local Government Requirements

4.2.2.2 2035 Community Strategic Plan

Our 2035 Community Strategic Plan (the strategic plan), IRCs commitment to the long-term future of the region. It is the blueprint for the future, which outlines how IRC will work towards enabling strong, vibrant, diverse, and sustainable communities for our people over the next 20 years.

Inevitable social, economic and political changes mean that IRC to explore new ways of capitalising on opportunities and addressing challenges, to make sure the region reaches its full potential.

The aim of the strategic plan is to provide clear goals and direction towards improving the future of the Isaac region through growth in four key themes:

- Community — strong and diverse communities that support all to live, work and raise families
- Economy — continue to be Queensland's number one performing regional economy based upon a thriving, resilient and diverse mix of industry sectors
- Infrastructure — effective and sustainable infrastructure that supports the needs of the region's communities and its economic sectors
- Environment — appropriate and sustainable balance between environment, economy and community to make sure our natural resources are sustainably managed and protected

The strategic plan is consistent with a PMLU of pasture grazing and water storage supporting grazing because:

- Expansions to the Mine will add to the industries that consistently place IRC in the top gross domestic product (GDP) performing LGA's in Queensland, whilst allowing for transition to a future land use that will retain community employment
- When rehabilitated the Mine will transition to pasture grazing and continue to support the region's communities and its economic sectors as an agribusiness
- The rehabilitation option chosen aligns with the strategic plan as it reflects the previous land use in the area and maximises the productive outcome for the land

4.2.2.3 Isaac Regional Council Planning Scheme

The *Isaac Regional Council Planning Scheme 2021 - v.1.1* (IRC 2021) provides a framework for managing growth, plan for a sustainable future and guide the way land is used and developed in the Isaac Region.

The Mine site is located in the rural zone of the *Isaac Regional Council Planning Scheme 2021 - v.1.1* (IRC 2021). The post mining land use of grazing is compatible with surrounding land uses and the purpose of the rural zone.

4.2.3 State and Commonwealth Legislation

State and Commonwealth legislation that may be relevant to the PMLU and region is summarised in Table 25 including how the legislation relates to the Mine.

Table 25 State and Commonwealth Legislation

Legislation	Objective	General application	How it relates to the Mine
Planning Act 2016	The principal objective of this Act is to achieve ecological sustainability.	Where land is included on a mining lease (ML) pursuant to the *Mineral Resources Act 1989*, closure and rehabilitation activities done under an EA do not require a planning approval from the local government.	The PMLU does not require local government approval.
Local Government Act 2009	The purpose of this Act is to provide for the way a Local government is constituted and the nature and extent of its responsibilities and powers. Local laws are made under the Act.	Local laws may apply to the owner of land as defined under the *Mineral Resources Act 1989.*	The *Planning Act 2016* only applies if a built structure that is entered onto the Queensland Heritage Register is found. Therefore, it does not apply to development in the ML authorised under the *Mineral Resources Act 1989*.
EP Act 1994	To protect the environment while allowing development that improves the total quality of life and ecologically sustainable development.	General environmental 'duty of care' to be observed to guarantee that any potential environmental impact from the Mine is minimised.	Duty of care is demonstrated for rehabilitation by assessing the potential impacts to EVs as part of the PRC Plan in accordance with the PRC Plan guideline.
State Development and Public Works Organisation Act 1971	To provide state planning and organisational legislation that aids in the delivery of ecologically sustainable development.	Commitments during mine planning of the expansion projects may impact on closure and rehabilitation of the Mine.	Duty of care is demonstrated for rehabilitation by assessing the potential impacts to EVs as part of the PRC Plan in accordance with the PRC Plan guideline.
Transport Infrastructure Act 1994	The overall objective of the Act is to provide a regime that allows for and encourages effective integrated planning and efficient management of a system of transport infrastructure.	Approval from the Department of Transport and Main Roads (DTMR) is needed under the *Transport Infrastructure Act 1994* if Mine	The Mine does not propose any modification to State Controlled Roads. Consequently, approvals for works under s33 of the Act is not needed.

Legislation	Objective	General application	How it relates to the Mine
		operations interfere with a State Controlled Road.	
Aboriginal Cultural Heritage Act 2003 which give rise to Duty of Care Guidelines, 2004	Provide effective recognition, protection and conservation of Aboriginal cultural heritage.	All practical measures need to be taken to make sure closure activities do not harm Aboriginal cultural heritage, ie demonstrate 'cultural heritage duty of care'.	The *Aboriginal Cultural Heritage Act 2003* requires that, when carrying out an activity, all reasonable and practicable measures are taken to make sure that the activity does not harm Aboriginal cultural heritage. This is referred to as the cultural heritage duty of care. Stanmore has a cultural heritage management plan (CHMP) with the Barada Barna People to manage the risk of harm to Aboriginal cultural heritage by activities associated with the Mine.
Land Act 1994	Relates to the administration and management of non-freehold land and deeds of grant in trust and the creation of freehold land, for related purposes.	Regulates the opening and closing of road reserves and land dealings relating to changes in land tenure.	The *Land Act 1994* provides a framework for the allocation of State land as leasehold, freehold or other tenure and provides for its management. The Act further regulates the grant, lease and permitting of Unallocated State Land and reserves and roads. No action is needed to satisfy this Act.
Stock Route Management Act 2002	The main purpose of this Act is to provide for stock route network management.	Regulates the management and use of stock routes.	The Mine does not intersect existing stock routes. Consequently, no agreements to alter stock routes or reserves are needed.

Legislation	Objective	General application	How it relates to the Mine
Water Act 2000 (and Water Resource (Fitzroy Basin) Plan, 2011 Fitzroy Basin Resource Operations Plan, 2011)	Provide for the sustainable management of water and other resources and the establishment and operation of water authorities and for other purposes.	Utilisation of groundwater and rehabilitation of bore holes.	Stanmore IP Coal Pty Ltd have a make good agreement for the use of Burton Coal Bore 1. The bore is located on land owned by Fitzroy Coal Exploration Pty Ltd.
Nature Conservation Act 1992	To provide a framework for the protection of state listed threatened species	Rehabilitation strategies may need to include any State listed threatened species or communities that occur in the ML.	There are no requirements to return any State listed threatened species or communities required under the EA.
Vegetation Management Act 1999	Regulates clearing of vegetation to guarantee appropriate management and conservation.	Mine to comply with State and regional vegetation management plans and policies and comply with vegetation management practices on leased and freehold land.	Clearing native vegetation is exempt from requiring a clearing permit when it is conducted within a ML. No works are proposed outside of the ML. As such no development approvals are needed.

4.3 Post-Mining Land Use Suitability

Grazing and water storage are considered to be the most suitable PMLU for the Project for the following reasons:

- There are no regulatory constraints that apply to grazing or water storage in this area and it is consistent with the existing land outcome documents for the Project, including the EA and Rehabilitation Management Plan (RMP) (C&R 2019) (Appendix H)
- These PMLUs will be achievable with available rehabilitation methods, as evidenced by rehabilitation already completed and/or underway to date
- Whilst there are some localised areas of the Project which have greater slopes, these will be certified as safe and stable and are best placed within the larger grazing PMLU area. This is to avoid the need to re-disturb large areas of existing rehabilitation already established in adherence to current EA conditions. As needed, exclusion fencing will be installed, to ensure no humans or livestock are at risk of injury
- Achievement of these PMLUs is cost effective and can provide economic, social, and environmental benefits
- These PMLUs are compatible with the surrounding area, and the pre-mining land use
- These PMLUs are realistically achievable at the Project and will ensure the land is safe, structurally stable beyond certification of the rehabilitation, and non-polluting.

4.4 Milestone and Completion Criteria

Milestone and completion criteria are given in Table 26. Criteria have been developed based on criteria given in the EA and the RMP (C&R 2019) (Appendix H) which are both LODs. Some criteria have been updated as they were not suitable for milestone criteria i.e. not SMART criteria.

The final milestone criteria will act as the completion criteria as per the PRC plan guideline.

Table 26 Completion Criteria

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
RM1	Infrastructure Decommissioning and Removal		
		RM1a. All services, excluding retained infrastructure, are disconnected and decommissioned.	All services not being transferred to the future landholder must be disconnected before infrastructure is decommissioned and removed.
		RM1b. All buildings, excluding retained infrastructure, are demolished and/or removed offsite.	Buildings and infrastructure not being transferred to the future landholder must be removed.
		RM1c. All road materials (bitumen and gravel), excluding retained infrastructure, are removed.	Roads not being transferred to the future landholder must be rehabilitated.
		RM1d. All pipelines, excluding retained infrastructure, are drained and removed.	Pipelines not being transferred to the future landholder must be removed.
		RM1e. All waste removed from site unless authorised by the EA for disposal onsite.	All waste to be removed and/or disposed of at an appropriate licensed facility or onsite, where authorised.
		RM1f. All exploration drill holes rehabilitated in accordance with the eligibility criteria and standard conditions for exploration and mineral development projects – V2 (DEHP – 2016)[2].	Any remaining drill holes, sumps, exploration tracks and gridlines must be rehabilitated to the PMLU.

2 Department of Environment and Heritage Protection (2016) Guideline – Requirement for site specific and amendment applications – underground water rights under the *Environmental Protection Act 1994*.

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
		RM1g. Infrastructure required for the ongoing health and safety of operators such as road safety bunds are to be retained until deemed safe to remove in accordance with the *Coal Mining Safety and Health Act 1999*.	To ensure safety of site personnel whilst care and maintenance activities occur.
		RM1h. All dams dewatered and desilted as per AQP recommendation.	Non-retained water infrastructure will be decommissioned and rehabilitated. Retained water infrastructure will be drained and desilted prior to relinquishment (as per AQP recommendation).
		RM1i. Watercourse crossings and culverts, excluding retained infrastructure, removed.	Non-retained watercourse crossings and culverts will be removed and rehabilitated.
		RM1j. All machinery and equipment, not required for rehabilitation works removed from rehabilitation area.	All machinery and equipment not required for rehabilitation works must be removed from the site.
		RM1k. Infrastructure to be retained for use by underlying landholder, deemed fit for purpose and accepted by signed agreement from the underlying landholder.	Infrastructure not being transferred to the landholder must be removed. Infrastructure to be retained must be accepted by landholder in writing.
		RM1l. An AQP has certified the achievement of RM1a) to k).	Certification by AQP necessary for achievement of RM1 (items a through k) to ensure successful completion.
RM2	Remediation of Contaminated Land		
		RM2a. Preliminary and intrusive contaminated land investigations carried out by an AQP to assess potentially contaminated mine domain areas.	A site investigation under the EP Act must be undertaken to assess potential contaminated mine domain areas as required in relation to contaminated land to make sure that the land is suitable for the PMLU.

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
		RM2b. Depending on the result of RM2. a) Suitably Qualified Person (SQP) determines applicability of relevant requirements of Chapter 7, part 8 of the *Environmental Protection Act 1994* (Qld) (EP Act) to the identified contaminated land areas.	A site investigation report / site management plan (or similar) may be required under the EP Act to identify any further work required for contaminated land areas.
		RM2c. Contaminated and hazardous material either remediated in-situ or removed/transported to an approved landfill for disposal and waste tracking information recorded and submitted.	Contaminated material must be treated or removed and disposed of in accordance with relevant legislation.
		RM2d. Validation testing confirms that contaminated and hazardous materials have been removed or remediated successfully.	Validation testing is required to ensure contaminated and hazardous materials have been properly identified and removed or remediated.
		RM2e. SQP certifies the achievement of criteria RM2. b) to RM2. d) retained until achievement of RM7.	A SQP must provide certification to make sure that all contaminated materials have been remediated or removed and disposed of in accordance with relevant legislation, ensuring RM2. b) to RM2. d) are retained until RM7 (achievement of surface requirements) achieved.
RM3	Landform Development and Reshaping/Re-profiling		
		RM3a. Final landform drainage installed as designed by AQP to allow effective removal of surface water from vegetated slopes.	To mitigate the risk of structural stability of landform not being achieved, it is necessary to install drainage features for areas impacted by operations to allow effective removal of surface water from vegetated slopes.
		RM3b. All major earthworks completed, slopes and general reshaping and pushing/ trimming are completed in accordance with the design specification provided by an AQP.	Landform development and reshaping/re-profiling necessitates major earthworks. Major earthworks must be completed in accordance with design specification/s provided by the AQP.

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
		RM3c. The Smoky Creek N1 and S1 levees are incorporated into the final rehabilitated landform with established vegetation and selective placement of non-erosive materials and/or rock mulch protection as per AQP advice to ensure landform stability to sustain flood stress of up to PMF event.	Levee-specific criteria included as existing levees (flood protection landforms) are part of RA1.
		RM3d. All flood protection landforms (e.g. levees or landforms) provide immunity to at least the 0.1% AEP flood event plus 0.5m freeboard.	Similar to RM3b, flood protection landforms (inclusive of levees and landforms generally) must provide immunity to at least the 0.1% AEP flood event (plus 0.5m freeboard), informed by the post-mining flood scenario modelling completed which showed that final voids would not be inundated under the conditions of a 0.1% AEP flood.
		RM3e. S3 void to be partially backfilled above the long-term groundwater level.	Partial backfilling will enable the walls of the void to be rehabilitated to a grazing PMLU, per EA requirements.
		RM3f. The rehabilitated landform reshaped to: i. For RA1 and RA6, ≤15% for the external slope and ≤30% for internally draining slopes. ii. For RA2, RA3, RA4, RA5, RA7, RA8, RA9, RA10 ≤15%	The final landform will be shaped to ≤ 15% external slope angle and ≤ 30% for internally draining slopes. The final landform is consistent with EA conditions.
		RM3g. All landforms are shaped to be water shedding.	Landforms will be shaped to be water shedding in accordance with the EA.
		RM3h. Erosion and sediment control systems are designed by an AQP, installed, and fit for purpose	Temporary or permanent drainage or other erosion and sediment controls are required to minimise areas of concentrated flow and manage surface water runoff.
		RM3i. Final landform drainage installed as designed by AQP to reduce ponding of surface water from vegetated slopes.	To mitigate the risk of structural stability of landform not being achieved, it is necessary to install drainage features for areas impacted by

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
			operations to allow natural water flows across the rehabilitated site.
		RM3j. Seepage and surface runoff from rehabilitation areas is directed to the sediment dams through appropriate permanent, low maintenance and stable drainage systems, as agreed by the underlying landholder.	To ensure there is no runoff from mine affected areas entering surrounding undisturbed areas and is appropriately captured onsite.
		RM3k. Final rehabilitated landforms (RA1, RA5, RA6, RA9, RA11) including back-filled pits, N2, S1 and S3 voids other than residual voids assessed as geotechnically stable by an AQP with a factor of safety (FOS) of 1.5.	Assessment must be completed by an AQP that the final landform is geotechnically stable with a FOS of 1.5.
		RM3l. Final rehabilitated overburden dumps in which the base of the spoil is not inundated have critical FOS values ≥ 1.5, and the base of spoil with risk of inundation have FOS between 1.3 - 1.5.	Determination that the final rehabilitated overburden dumps are geotechnically stable, as informed by geotechnical assessment.
		RM3m. Disturbed natural watercourse bed and banks returned to a natural condition with profile similar to the pre-disturbance condition.	In achieving the PMLU, disturbed watercourse bed and banks must be returned to natural condition / pre-disturbance profile.
		RM3n. Any areas of subsidence with measurable ponding of overland flow, resulting from the Isaac Plains Underground Project, are ripped and reshaped as required to ensure free drainage.	The criteria reflects condition F20 of the EA, ensuring subsidence resulting from underground mining does not capture overland flow. The criteria ensures that overland flow is maintained throughout rehabilitation works.
		RM3o. Water storages are safe for stock access and have vegetated banks.	Retained water storages must support the grazing PMLU and need to have consideration towards reshaping / reprofiling to ensure stable landform.
		RM3p. An AQP has certified the achievement of RM3 a) to o).	Requirement for AQP certification of RM3 a) to o) to ensure milestone criteria achieved and documented.

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
RM4	Installation of cover system		
		RM4a. Tailings have consolidated and are considered safe by an AQP for installing the cover system.	The cover system must effectively mitigate the potential for migration of contaminants from tailings storage areas to the receiving environment and be deemed safe by an AQP.
		RM4b. An AQP to determine appropriate detailed cover design for installation.	The cover system must be designed by an AQP and effectively mitigate the potential for migration of contaminants to the receiving environment.
		RM4c. An AQP certify installation of cover system as designed per RM4.b).	The cover system must be installed as per the certified design.
		RM4d. Following installation of a cover system in accordance with RM4.a), the cover system achieves the following criteria: i. Surface is water-shedding and achieves net drainage flux less than 10% of average annual rainfall and demonstrated by modelling that the cover design is capable to minimising average net percolation to below 10% annual rainfall. ii. Growth media has been approved by an AQP and ameliorated and/or fertilised if necessary to support the target vegetation species. iii. Sampling of the ameliorated and/or fertilised growth media confirms the soil properties are suitable for the vegetation species as per **Appendix 1 – Pasture grazing seeding mix** unless alternative species recommended by an AQP.	The cover design will provide a stable landform, provide a growth medium for establishing vegetation, and achieve net percolation rates of better than 10% consistent with the accepted performance of an enhanced store and release cover (5-10% net percolation) (INAP 2017). AQP review and the inclusion of modelling as the method of measuring performance has been provided to ensure this milestone criteria is achieved.

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
		RM4e. The installed cover is erosional and geotechnically stable and supports the marginal grazing PMLU.	The cover system must display erosional stability, be geotechnically stable and support the grazing PMLU.
		RM4f. An independent AQP has certified the achievement of RM4. a) – RM4. e).	Requirement for AQP certification of RM4. a) – RM4. e) to ensure milestone criteria achieved and documented.
RM5	Surface preparation		
		RM5a. An assessment of growth media has been completed by an AQP to confirm growth media and suitability for PMLU and target vegetation establishment.	Growth media, defined as all soil and soil-like material that will support the final vegetation cover (including topsoil and subsoil where these are applied independently) must be assessed by an AQP to be appropriate for the PMLU and target vegetation. This will increase likelihood of vegetative success.
		RM5b. Application rate of ameliorants such as fertiliser, gypsum/or organic matter and physical treatment plan determined by an AQP based on the assessment required by **RM5a** and implemented.	Ameliorants may be required based on the growth media health and suitability, as determined by an AQP.
		RM5c. Records demonstrate topsoil placement has achieved a minimum target depth of 150 mm.	Documentation of topsoil placement to minimum target depth of 150 mm must be maintained and kept. This depth will provide enough depth for ripping and vegetation growth.
		RM5d. Deep ripping of compacted areas as per the requirements of the soil material assessment, including along the contour slopes.	Deep ripping of heavily compacted areas will break up compacted soil to encourage with water infiltration and vegetation establishment.
		RM5e. Filling and ripping of surface cracks greater than 20cm wide to a depth as required in areas impacted by subsidence, prior to topsoil application.	Crack filling required before application of topsoil (and subsequent revegetation).

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
		RM5f. Following amelioration, representative soil testing confirms: i. pH (1:5) 5.6–8.4 ii. Saturation Extract EC (Ece) ≤ 10 dS/m from 0-0.6 m depth iii. Exchangeable sodium percentage (ESP) ≤6% (0-0.1 m depth) or ≤23% (at 0.5 m depth) (Placement of growth media to a minimum depth of 150 millimetres (mm), with additional growth media added as needed to high-risk areas where informed by an AQP).	Areas of excessive erosion or subsidence must be remediated to allow for topsoiling, seeding or other works. Criteria aligned to QMRC Rehabilitated Mined Land Suitability for Beef Cattle Grazing in the Bowen Basin: Technical Paper and is appropriate for the site.
		RM5g. Remediate any erosion or subsidence by, but not limited to, addition of rock and/or log cover to assist erosion resistance of eventual vegetative groundcover.	Addition of rock and/or log cover to strengthen resistance to erosion, encouraging erosional stability which will be able to support the PMLU.
		RM5h. Construction of seal from surface into the underground workings complies with regulation 325 of the Queensland Coal Mining Safety and Health Regulations 2020 (CMSHR) and Registered Professional Engineer of Queensland (RPEQ) design.	Construction will consider design criteria, strength of materials, placements of seals, placement and number of sampling tubes, tying in hatches and service pipes. The Underground Mine Manager will review the quality control of the installed product, validate the engineering integrity of the seal via an engineering review and regularly review the relevant Safety and Health Management System documentation as per the guidance issued by the Chief Inspector of Coal Mines.
		RM5i. The surface and groundwater monitoring is underway (at least one year of sampling undertaken).	Surface and groundwater monitoring to be undertaken to ensure potential contamination is detected as early as possible and can be acted upon as appropriate.
		RM5j. An AQP to certify achievement of RM5.a) to i). For areas affected by subsidence, AQP confirms following: iv. Surface deflection within range of 20-60mm above UG area, except in modified Duncan panels. v. Modified Duncan panels surface deflection within range of 100 -150mm.	Requirement for AQP certification of RM5.a) to i) to ensure milestone criteria achieved and documented. Additional requirements provided for areas affected by subsidence to ensure landform stability.

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
		vi. The cessation of subsidence. vii. Depression/ponding areas are free draining and require no further drainage works.	
RM6	Revegetation		
		RM6a. Complete seeding in accordance with target species of 3P (perennial, palatable and productive) with a selection of species and at a rate consistent with **Appendix 1– Pasture grazing seed mix**.	Recommended seeding rates as given in the Revegetation Plan.
		RM6b. The seed application required by RM6a must include minimum of 4 palatable perennial pasture species and include up to 50% native species.	Fertilisation is required due to low fertility as per the soil and capping material assessment.
		RM6c. Complete seeding of topsoil surfaces for areas impacted by subsidence using a seed mix and a rate consistent with **Appendix 1 - Pasture grazing seed mix**.	The seed mix and sow rate will be tailored based on monitoring to ensure the best chances of germination success / vegetation cover.
		RM6d. An AQP has certified the achievement of RM6.a) to RM6.c).	Requirement for AQP certification of RM6.a) to RM6.c) to ensure milestone criteria achieved and documented.
RM7	Achievement of surface requirements		
		RM7a. Rehabilitated areas demonstrate achievement of the following criteria: i. Minimum 70% established and persistent vegetative ground cover, comprising 50% palatable perennial pasture species. ii. Presence of rocks, logs or other effective erosion control cover is limited to 30% of total groundcover.	Achievement of criteria is important to demonstrate completion of surface requirements (RM7). i. This criterion is SMART and includes measurable parameters. Vegetation and foliage criteria as per the proposed final completion criteria. ii. SMART criterion, involving measurable erosion control cover parameters.

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
		iii. Achievement of following as per Guidelines for Agricultural Land Evaluation in Queensland: • Land class 4 – RA1, RA6 • Land class 3 – RA2, RA3, RA4, RA5, RA7, RA8, RA9, RA10 iv. Weed presence is less than 10% of total vegetative groundcover confirmed by an AQP in annual monitoring. v. Subsided areas do not have residual ponding, and overland flows and surface runoff drain freely from these areas.	iii. This criteria aligns with the EA and will support achievement of appropriate land classes within relevant RAs. iv. SMART criterion, involving measurable goal for weed presence, as confirmed by AQP during annual monitoring. v. To ensure no residual ponding is evident and runoff freely drains to sediment dams.
Soil quality and erosion			
		RM7b. Representative soil testing of the growth media confirms: i. pH (1:5) 5.6–8.4 ii. Saturation Extract EC (Ece) ≤ 10 dS/m from 0-0.6 m depth iii. Exchangeable sodium percentage (ESP) ≤6% (0-0.1 m depth) or ≤23% (at 0.5 m depth) iv. Evidence of nutrient and organic matter cycling is occurring (through presence of organic carbon and nitrogen in the soil profile for a period of 3 years).	It can be assumed that the soil is suitable to support the PMLU if the established vegetation meets appropriate criteria. Key growth media parameters are included as additional references. Criteria aligned to QMRC Rehabilitated Mined Land Suitability for Beef Cattle Grazing in the Bowen Basin: Technical Paper and is appropriate for the site.
		RM7c. Erosional stability must meet the following: i. No evidence of erosion classified as 'moderate' or 'severe' as defined by **Appendix 2: Erosion classification framework**. ii. Any erosion present will not compromise the achievement of a PMLU to a stable condition.	To ensure stable landform, no active erosion or evidence of erosion (per the criteria) may be present within the site.

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
		iii. The final landform design demonstrates that rates of erosion are <5 t/ha/yr. iv. Evidence of scouring, overtopping, sedimentation or destabilisation in or associated with erosion and sediment control and engineered drainage structures, limited to minor classification as per **Appendix 2: Erosion classification framework**.	
Surface water quality			
		RM7d. Surface water runoff from rehabilitation areas collected at appropriate location/s determined by an AQP for monitoring surface water runoff quality when surface flows occur and when it is safe to do so.	Rainfall runoff / or seepage must be of acceptable characteristics for the receiving environment that does not cause environmental harm.
		RM7e. Surface water runoff monitoring in accordance with RM7.e) shows surface water runoff is non-polluting to receiving waters and complies with the following: i. pH 6.5-8.5 pH units ii. EC ≤720 µS/cm iii. Turbidity ≤50 NTU iv. Sulfate ≤25 mg/L	Rainfall runoff / or seepage must be of acceptable characteristics for the receiving environment that does not cause environmental harm.
		RM7f. Water sampling of water storages (RA11) for quality monitoring purposes undertaken quarterly and achieve **Appendix 4: Surface water quality limits** for native wildlife and/or livestock ingestion for a minimum of 5 years.	Surface water quality must meet criteria parameters to avoid environmental harm.
		RM7g. AQP certifies achievement of RM7.a) to RM7.f).	Requirement for AQP certification of RM7.a) to RM7.f) to ensure milestone criteria achieved and documented.

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
RM8	Achievement of post-mining land use to a stable condition		
Contaminated Land			
		RM8a. If deemed necessary by the SQP under RM2, Contaminated Land Investigation Document (CLID) completed in accordance with the EP Act, including: i. Site Suitability Statement confirming the suitability of the property (all lot/plans within the mining lease area) for the PMLUs. ii. Site Investigation Report and, where required, a Validation Report and/or a draft Site Management Plan provided. iii. Removal of land from Environmental Management Land Register (EMR)/ Contaminated Land Register (CLR).	If necessary, as deemed by the SQP, a CLID will need to be undertaken in accordance with the EP Act requirements. This will work towards the site being non-polluting.
		RM8b. The final rehabilitated landforms are structurally stable by achievement of following: i. For RA1 and RA6, ≤15% for the external slope and ≤30% for internally draining slopes. ii. For RA2, RA3, RA4, RA5, RA7, RA8, RA9, RA10 ≤15%.	Achievement of criteria important to demonstrate achievement of post-mining land use to a stable condition (RM8). The final landform will be shaped to ≤ 15% external slope angle and ≤ 30% for internally draining slopes. The final landform will be shaped to ≤ 15% external slope angle. The final landform is consistent with EA conditions.
		RM8c. Final rehabilitated landforms, including back-filled pits (N2 and S1 voids) but excluding residual voids, are assessed as geotechnically stable by an AQP with a FOS of 1.5	Assessment must be completed by an AQP that the final rehabilitated landform is geotechnically stable.

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
		RM8d. Overburden dumps in which the base of the spoil is not inundated have critical FOS values ≥ 1.5, and the base of spoil with risk of inundation have FOS between 1.3 - 1.5.	Assessment must be completed by an AQP that the final rehabilitated landform (overburden dumps) are geotechnically stable.
		RM8e. No tunnel erosion or fissures present in areas subject to subsidence.	In ensuring landform stability, no tunnel erosion or fissures to be present within areas subject to subsidence.
		RM8f. Bed and banks of subsidence drainage structures are stable.	In achieving the PMLU to stable condition, subsidence drainage structure bed and banks must be deemed stable.
		RM8g. No bed and bank erosion within watercourses as a result of or associated with subsidence or subsidence management.	In ensuring landform stability, no tunnel erosion or fissures to be present within areas subject to subsidence.
		RM8h. No cracking or destabilisation present in bed or banks of watercourses as a result of subsidence or subsidence management.	In achieving the PMLU, disturbed watercourse bed and banks must be returned to natural condition / pre-disturbance profile with no cracking or destabilisation present.
		RM8i. Subsidence areas that may be subject to flooding are designed to withstand flood stresses compromising structural or erosional stability.	Areas of subsidence that may be subject to flooding are designed (i.e. through flood protection landforms such as levees and landforms generally) to withstand flood stresses.
		RM8j. Vegetation shows preferred pasture species (3P grasses) diversity ≥ 4.	Important in ensuring PMLU success and revegetation in accordance with final completion criteria.
		RM8k. Minimum 70% established and persistent vegetative ground cover, comprising 50% palatable perennial pasture species.	This criterion is SMART and includes measurable parameters. Vegetation and foliage criteria as per the proposed final completion criteria.
		RM8l. Presence of rocks, logs or other effective erosion control cover is limited to 30% of total vegetative groundcover.	SMART criterion, involving measurable erosion control cover parameters.

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
		RM8m. Achievement of following as per Guidelines for Agricultural Land Evaluation in Queensland: Land class 4 – RA1, RA6 (Marginal grazing) Land class 3 – RA2, RA3, RA4, RA5, RA7, RA8, RA9, RA10 (grazing)	This criteria aligns with the EA and will support achievement of appropriate land classes within relevant RAs.
		RM8n. Weed presence is less than 10% of total vegetative groundcover.	SMART criterion, involving measurable goal for weed presence, as confirmed by AQP during annual monitoring.
		RM8o. Restricted invasive plants (as defined in the *Biosecurity Act 2014* Qld) comprise ≤5% of vegetation groundcover.	SMART criterion, involving measurable goal to restrict invasive plants, whereby they may only comprise ≤5% of vegetation groundcover.
		RM8p. Infrastructure to be transitioned to a landholder will be deemed fit for purpose and accepted, by signed agreement, with the landholder.	Infrastructure being transferred to a landholder must be fit for purpose and accepted by landholder in writing.
		RM8q. Rehabilitation is resilient to fire and grazing pressures.	Resiliency to fire and grazing pressures is important in achieving timely revegetation and PMLU success in accordance with the PRC Plan Schedule.
Soil Quality, Erosion and Retained Infrastructure			
		RM8r. Growth media quality meets the parameters outlined in **RM7.b).**	Per RM7b. it can be assumed that the soil is suitable to support the PMLU if the established vegetation meets appropriate criteria. Key growth media parameters are included as additional references. Criteria aligned to QMRC Rehabilitated Mined Land Suitability for Beef Cattle Grazing in

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
			the Bowen Basin: Technical Paper and is appropriate for the site.
		RM8s. No evidence of erosion classified as 'moderate' or 'severe' as defined by **Appendix 2: Erosion classification framework.**	To ensure stable landform, no active erosion or evidence of erosion (per the criteria) may be present within the site.
		RM8t. The final landform design demonstrates that rates of erosion are <5 t/ha/yr.	To ensure stable landform, erosion rates must be <5 t/ha/yr.
		RM8u. Evidence of scouring, overtopping, sedimentation or destabilisation in or associated with erosion and sediment control and engineered drainage structures, limited to minor classification as per **Appendix 2: Erosion classification framework.**	To ensure stable landform, no active erosion or evidence of erosion (per the criteria) may be present within the site.
		RM8v. Any erosion present will not compromise the achievement of a PMLU to a stable condition.	To ensure stable landform and PMLU success, no active erosion or evidence of erosion may be present within the site which could compromise the integrity of the PMLU.
		RM8w. Water storages (RA11) contain suitable water quality for native wildlife and/or livestock ingestion and achieve the water quality criteria outlined in **Appendix 4 – Surface water quality limits**.	Water quality must meet water quality criteria outlined in Appendix 4 and also ensure no adverse impacts to native wildlife and livestock occur via ingestion.
		RM8x. Water storages are safe for native animals and stock access and have vegetated banks.	Safe and stable landforms around water storages will enable native animals and livestock to safely access watering points.
		RM8y. An independent AQP certifies achievement of RM8. a) to RM8. x).	Requirement for AQP certification of RM8. a) to RM8. x) to ensure milestone criteria achieved and documented.

4.4.1 Bunding

Post-mining, permanent abandonment bunding will be constructed at the Mine. The design and dimensions are based on both the *Safety Bund Walls Around Abandoned Open Pit Mines* from the Western Australian Department of Industry and Resources (DIR) (1997) and the Department of Minerals and Energy (DME) *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (1995) being:

- Constructed from non-weathered dumped rockfill where possible
- A minimum of 2 m in height
- A minimum base width of 5 m
- Not greater than 1 in 1.5 batters

The bund will be set back in accordance with a calculated geotechnical FoS of ≥1.5 or a minimum distance of 15 m from the pit crest to ensure safety of personnel. As noted in the geotechnical report in Appendix H, exclusion bunds or fences would need to be set far enough back from the existing crest to allow for crest retreat.

Drainage slots would be cut into the bund and spaced at regular intervals and low points to allow the discharge of surface water during rainfall events. Discharge spillways would then be installed following the inflow of water into the pit from diversion drains. The distance between these spillways along the bund should be spaced in regular intervals or based on discharged volumes.

All bunding to be certified by an AQP to ensure the safety of personnel.

4.4.2 Fencing

Stock fencing is required to restrict access of animals and people to the residual void. Fencing will be installed at a suitable distance from the safety bunding to allow access for inspection and maintenance of both structures.

The fence will consist of a four-strand barbed stock fence.

5. NON-USE MANAGEMENT AREAS

5.1 Legislative Requirements

In accordance with sections 126C (1)(d), (g) and (h) of the EP Act, for each proposed non-use management area, the rehabilitation planning part of the PRC Plan must:

- State the reasons the applicant considers the area cannot be rehabilitated to a stable condition
- Include copies of reports or other evidence relied on by the applicant for each proposed non-use management area
- State the extent to which the proposed non-use management area is consistent with the outcome of consultation with the community in developing the plan
- State the extent to which the non-use management area is consistent with any strategies or plans for the land of a local government, the State or the Commonwealth

Pursuant to section 754 (3) of the EP Act and section 6.3.2 of the PRC plan guideline, a NUMA will be taken to be pre-approved if a land outcome, the same or substantially similar to a NUMA, is contained in a LOD. LODs are defined in section 750 of the EP Act.

Where a NUMA has been pre-approved and is being translated into the PRC Plan, the EA holder is not required to:

- Justify the proposed NUMA
- Provide evidence to support the justification of the NUMA
- Go through the Public Interest Evaluation process
- Comply with the prohibition of voids located within a flood plain having to be rehabilitated to a stable condition

The Mine has seven approved residual voids under the EA (LOD):

- N1
- S2
- E1
- E2/E3/E4
- E5

Condition F6 of the EA stipulates that only the residual voids detailed in Table 17 of the EA are permitted at the approved place and that each residual void must comply with its design requirements in the table. Void design is shown in Table 27.

Table 27 Residual Void Design (EA table 17)

Void identification	Void high wall - competent rock	Void high wall incompetent rock slope	Void low wall	Void low wall incompetent rock slope	Void maximum surface area (ha)	Void maximum depth (m)	Void volume (Mm^3) (+/- 2.5%)
N1	275% (70˚)	Not applicable	Not applicable	73% (36˚)	99	110	41
S2	275% (70˚)	Not applicable	Not applicable	73% (36˚)	42	90	20
E1	275% (70˚)	100% (45˚)	73% (36˚) – 100% (45˚)	Not applicable	20	80	7
E2/E3/E4	275% (70˚)	100% (45˚)	73% (36˚) – 100% (45˚)	Not applicable	133	140	90
E5	275% (70˚)	100% (45˚)	73% (36˚) – 100% (45˚)	Not applicable	24	80	8

5.2 Description of the NUMAs

The NUMAs are described in the following sections. All NUMAs have been assessed as groundwater sinks as per section 6.3.3. The total NUMA area is inclusive of the final bunds. Final bunds are considered part of the void as they cannot support a PMLU. This means that the total surface area assigned to the NUMAs is slightly larger than the actual void area as defined by the EA. It is important to note that the total void surface area is compliant with Table 17 of the EA.

5.2.1 N1

The N1 NUMA includes the northern section of the void with the southern void area to be utilised for tailings storage. Overburden dump and coarse rejects disposal areas to the west will be rehabilitated to a grazing PMLU. Stabilisation works will be completed on the northern end wall and the NUMA will be managed in accordance with the criteria outlined in section 5.5.

5.2.2 S2

The S2 NUMA includes the residual highwall, low wall spoil and void ramp. Overburden dumps to the west and south will be rehabilitated to a grazing PMLU. The highwall will be required for portal entry while the ramp and some sections of low wall will be required for ancillary infrastructure during the operation of IPU. Stabilisation works will be required on the low wall to increase the FoS as per 6.3.3.

5.2.3 E1

The E1 NUMA is not yet constructed. It will include residual highwall, low wall and end wall. Out of pit dumps on the low wall side will be reshaped, topsoiled and seeded to a grazing PMLU.

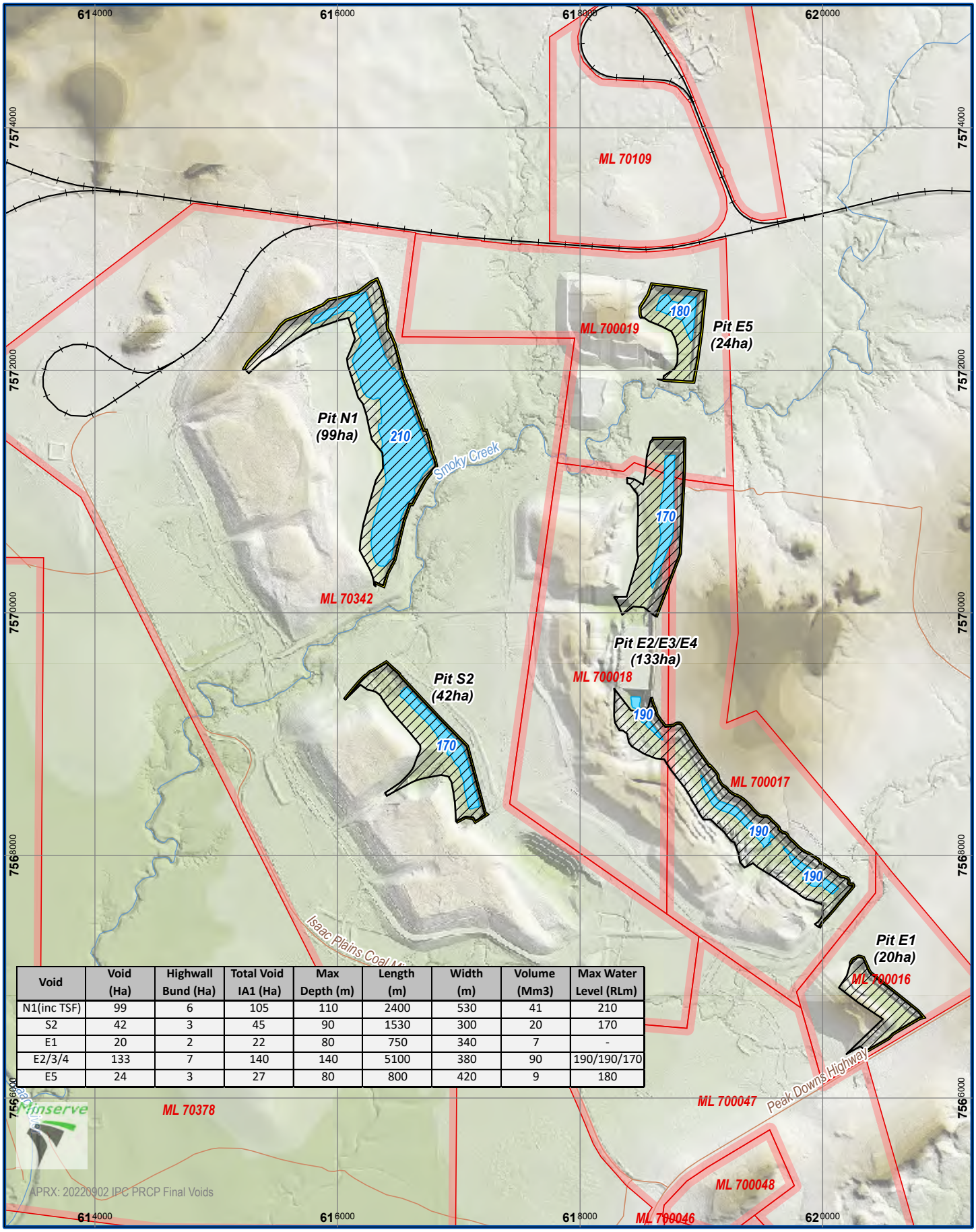
5.2.4 E2/E3/E4

The E2/E3/E4 NUMAs are a series of three pits on the eastern extent of the Mine. E4 pit includes a planned northern extension. The NUMAs include the highwall, low wall and end wall (E2 and E4 only). Out of pit dumps on the low wall side will be reshaped, topsoiled and seeded to a grazing PMLU.

5.2.5 E5

Pit E5 is currently an operational open cut pit. It will include residual highwall, low wall and end wall. Out of pit dumps on the low wall side will be reshaped, topsoiled and seeded to a grazing PMLU.

The location and dimensions of the NUMAs are shown in Figure 12.



Void	Void (Ha)	Highwall Bund (Ha)	Total Void IA1 (Ha)	Max Depth (m)	Length (m)	Width (m)	Volume (Mm3)	Max Water Level (RLm)
N1(inc TSF)	99	6	105	110	2400	530	41	210
S2	42	3	45	90	1530	300	20	170
E1	20	2	22	80	750	340	7	-
E2/3/4	133	7	140	140	5100	380	90	190/190/170
E5	24	3	27	80	800	420	9	180

ML
Waterway
Railway
Road

NUMA
Final Voids
Levee
Final Water Level RLm AHD

N

0 500 1,000 1,500 2,000 2,500
Meters

stanmore

Locations of NUMA Final Voids and Water Storage
Figure 12

5.3 Consistency with the Outcome of Community Consultation

The outcome of residual voids remaining in the landscape at IPC has been well known and communicated throughout the Mine's life. Original approvals allowed for residual voids and mine planning and operation progressed on this assumption. Consultation with community members included the retention of final voids.

5.4 Consistency with Local, State and Commonwealth Requirements

The following review of the local and state government requirements demonstrate that the proposed NUMAs are not inconsistent with the strategies and plan outlined herein.

5.4.1 State Requirements

5.4.1.1 Mackay, Isaac and Whitsunday Regional Plan

The *Mackay, Isaac and Whitsunday Regional Plan* (DLGP 2012) includes the following specific policies for PMLUs:

- Identified valuable mineral and extractive resource areas within the region are protected from development that might adversely affect current or future extraction
- The operation of extraction and processing activities does not compromise:
  - Human health
  - Current and future resource use opportunities
  - Regional landscape values
  - Ecosystem function and services
  - Must minimise its impact on primary production
- Once extraction ceases, former resource areas are rehabilitated to facilitate multiple end-uses, ensuring continuing contribution to the economic, community and EVs of the region
- Innovative practices are encouraged, including local processing and value-adding activities, to maximise eco-efficiencies

The Mackay, Isaac and Whitsunday Regional Plan is consistent with the nomination of NUMAs because:

- The mining voids are remnants of the economic extraction of coal ensuring no potential resource was sterilised
- Void water may be used for coal washing and other industrial activities in the short term which provides an asset and reduces the use of raw water
- The NUMAs do not have an impact to the surrounding environment outside of their own footprint
- The retention of NUMAs does not impact the overall PMLU of grazing as the area occupied by the NUMAs is minor compared to the overall area available for grazing. This minimises the impact to primary production
- Retention of NUMAs does not exclude the area from future land uses which may become apparent with advances in technology

5.4.2 Local Government Requirements

5.4.2.1 2035 Community Strategic Plan

IRC 2035, Our Community Strategic Plan (the strategic plan), is IRCs commitment to the long-term future of the region. It is the blueprint for the future, which outlines how IRC will work towards enabling strong, vibrant, diverse, and sustainable communities for our people over the next 20 years.

Inevitable social, economic and political changes mean that IRC will explore new ways of capitalising on opportunities and addressing challenges, to make sure the region reaches its full potential.

The aim of the strategic plan is to provide clear goals and direction towards improving the future of the Isaac region through growth in four key themes:

- Community — strong and diverse communities that support all to live, work and raise families
- Economy — continue to be Queensland's number one performing regional economy based upon a thriving, resilient and diverse mix of industry sectors
- Infrastructure — effective and sustainable infrastructure that supports the needs of the region's communities and its economic sectors
- Environment — appropriate and sustainable balance between environment, economy and community to make sure our natural resources are sustainably managed and protected

The strategic plan is consistent with the retention of NUMAs because:

- The NUMAs are still able to supply void water for the purposes of coal washing and other industrial uses in the short term which provides an asset to support the region's communities and its economic sectors
- The use of pit water reduces the use of raw water for industrial processes representing a positive environmental benefit

5.4.2.2 Isaac Regional Council Planning Scheme

The *Isaac Regional Council Planning Scheme 2021 - v.1.1* (Isaac Regional Planning Scheme) (IRC 2021) provides a framework for managing growth, plan for a sustainable future and guide the way land is used and developed in the Isaac Region.

The Mine site is located in the rural zone of the Isaac Regional Planning Scheme. The retention of NUMAs is consistent with the purpose of the rural zone as it is compatible with existing and future rural uses and will not impact on the viability of rural uses .

5.4.3 State and Commonwealth Legislation

State and Commonwealth legislation that may be relevant to the NUMAs and region is summarised in Table 28 including how the legislation relates to the Mine.

Table 28 State and Commonwealth Legislation

Legislation	Objective	General application	How it relates to the Mine
Planning Act 2016	The principal objective of this Act is to achieve ecological sustainability.	Where land is included on a mining lease (ML) pursuant to the *Mineral Resources Act 1989*, closure and rehabilitation activities done under an EA do not require a planning approval from the local government.	The NUMAs do not require local government approval.
Local Government Act 2009	The purpose of this Act is to provide for the way a Local government is constituted and the nature and extent of its responsibilities and powers. Local laws are made under the Act.	Local laws may apply to the owner of land as defined under the *Mineral Resources Act 1989*.	The *Planning Act 2016* only applies if a built structure that is entered onto the Queensland Heritage Register is found. Therefore, the Planning Act does not apply to development in the ML authorised under the *Mineral Resources Act 1989*.
EP Act 1994	To protect the environment while allowing development that improves the total quality of life and ecologically sustainable development.	General environmental 'duty of care' to be observed to guarantee that any potential environmental impact from the Project is minimised.	The potential impacts to EVs due to the retention of NUMAs (water storages) were assessed as part of the original EA application. Duty of care is demonstrated for rehabilitation by preparing the PRC plan in accordance with the PRC plan guideline.
State Development and Public Works Organisation Act 1971	To provide state planning and organisational legislation that aids in the delivery of ecologically sustainable development.	Commitments during the environmental impact statement (EIS) phase may impact on closure and rehabilitation of the Project.	The potential impacts to EVs due to the retention of NUMAs (water storages) were assessed as part of the original EA application. Duty of care is demonstrated for rehabilitation by preparing the PRC

Legislation	Objective	General application	How it relates to the Mine
			plan in accordance with the PRC plan guideline.
Transport Infrastructure Act 1994	The overall objective of the Act is to provide a regime that allows for and encourages effective integrated planning and efficient management of a system of transport infrastructure.	Approval from the Department of Transport and Main Roads (DTMR) is needed under the *Transport Infrastructure Act 1994* if the Project interferes with a State Controlled Road.	The Mine does not propose any modification to State Controlled Roads. Consequently, approvals for works under s33 of the Act is not needed.
Aboriginal Cultural Heritage Act 2003 which give rise to Duty of Care Guidelines, 2004	Provide effective recognition, protection and conservation of Aboriginal cultural heritage.	All practical measures need to be taken to make sure closure activities do not harm Aboriginal cultural heritage, i.e. demonstrate 'cultural heritage duty of care'.	The *Aboriginal Cultural Heritage Act 2003* requires that, when carrying out an activity, all reasonable and practicable measures are taken to make sure that the activity does not harm Aboriginal cultural heritage. This is referred to as the cultural heritage duty of care. The Mine has a cultural heritage management plan (CHMP) with the Barada Barna People to manage the risk of harm to Aboriginal cultural heritage.
Land Act 1994	Relates to the administration and management of non-freehold land and deeds of grant in trust and the creation of freehold land, for related purposes.	Regulates the opening and closing of road reserves and land dealings relating to changes in land tenure.	The *Land Act 1994* provides a framework for the allocation of State land as leasehold, freehold or other tenure and provides for its management. The Act further regulates the grant, lease and permitting of Unallocated State Land and reserves and roads. No action is needed to satisfy this Act.
Stock Route Management Act 2002	The main purpose of this Act is to provide for stock route network management.	Regulates the management and use of stock routes.	The Mine does not intersect existing stock routes.

Legislation	Objective	General application	How it relates to the Mine
			Consequently, no agreements to alter stock routes or reserves are needed.
Water Act 2000 (and Water Resource (Fitzroy Basin) Plan, 2011 Fitzroy Basin Resource Operations Plan, 2011)	Provide for the sustainable management of water and other resources and the establishment and operation of water authorities and for other purposes.	Utilisation of groundwater and rehabilitation of bore holes.	Stanmore IP Coal Pty Ltd have a make good agreement for the use of Burton Coal Bore 1. The bore is located on land owned by Fitzroy Coal Exploration Pty Ltd. This is to have no impact on NUMAs at the Mine.
Nature Conservation Act 1992	To provide a framework for the protection of state listed threatened species	Rehabilitation strategies may need to include any State listed threatened species or communities that occur in the ML.	There are no requirements to return any State listed threatened species or communities required under the EA.

5.5 NUMA Completion Criteria

Table 29 outlines the milestone criteria to be applied to the NUMAs. Criteria have been developed based on criteria given in the EA and the RMP (2019) which are both LODs. Some criteria have been updated as they were not suitable for milestone criteria i.e. not SMART criteria.

The final milestone criteria will act as the completion criteria as per the PRC guideline.

Table 29 NUMA Milestone Criteria

Milestone reference	Management milestone	Milestone criteria	Justification of criteria
MM1	Achievement of structural stability		
		MM1a. Highwall and end wall landforms (where not backfilled) must: i. Prevent the ingress of floodwater into the void; ii. Be geotechnically stable.	Consistent with the EA (LOD), ensuring that drainage measures and structures have been suitably established and are directing overland flow away from highwall edge and landforms are geotechnically stable.
		MM1b. The following slope geometry achieved for highwall and end wall (where not backfilled):	Batter angles are consistent with the EA (LOD).

Milestone reference	Management milestone	Milestone criteria	Justification of criteria
		i. Competent (unweathered) rock slopes are overall 275% (70°) with 35 m high batters; and 10m wide bench at the base of each batter; ii. Non-competent (weathered) rock slopes are overall 100% (45°) and 10 m wide bench at the base of weathering; iii. The uppermost layer of soil and extremely weathered rock are battered back to overall 27° (50%) and protected from surface runoff to minimise gullying; iv. Low-wall void slopes battered to a maximum overall angle of 100% (45°) in incompetent rock.	
		MM1c. Following slope geometry achieved for low wall spoil: i. Slopes battered to an overall angle of 73% (36°) or angle of repose in incompetent rock.	Batter angles are consistent with the EA (LOD).
		MM1d. Walls / slopes assessed as stable by an AQP (geotechnical engineer) (FoS ≥1.2 or ≥1.5 for E1 pit).	Assessment must be undertaken by an AQP (geotechnical engineer) that the residual voids walls and slopes are geotechnically stable.
		MM1e. Residual voids are not subject to inundation from floodwaters up to and including the 0.1% AEP.	Post-mining flood scenario modelling showed that final voids would not be inundated under the conditions of a 0.1% AEP flood.
		MM1f. The risk associated with a probable maximum flood (PMF) event with respect to residual voids must also be considered in final landform design.	Requirement for risk consideration / assessment with regards to PMF event in residual voids as part of final landform design to ensure safe, stable, and non-polluting requirements are met.
		MM1g. AQP assesses that the existing smoky creek N1 and S1 levees incorporated into the final landform provide flood protection to N1 pit and S2 pit at the minimum 0.1% AEP level + 0.5m freeboard.	Levee-specific criteria included as existing levees (flood protection landforms) are part of RA1. These are to be assessed by an AQP to ensure incorporation in final landform is appropriate for flood protection.
		MM1h. Levees and abandonment bunds have appropriate scour protection to sustain flood velocities of minimum 0.1% AEP and	To ensure stable landform, appropriate scour protection must be in place. Further, a risk

Milestone reference	Management milestone	Milestone criteria	Justification of criteria
		consider PMF flood stress as advised by AQP based on a risk assessment completed in accordance with **PRCP Condition 4**.	register must be maintained and reviewed every three years, identifying risks to not achieving sufficient improvement for NUMAs and how any risks are being managed or minimised.
		MM1i. The location of the voids and associated safety bunds does not cause instability or degradation to the land outside the NUMA.	To ensure a stable and non-polluting landform (both within the NUMA and surrounding areas).
		MM1j. Residual voids must not overtop.	To ensure a stable and non-polluting landform.
		MM1k. An AQP demonstrates with monitoring of water quality, water level within void and modelling data, that the residual void/s act as groundwater sinks post-closure.	All final voids have been modelled as groundwater sinks with migration of potential contaminants to the receiving environment unlikely. Nonetheless, water quality and level monitoring and modelling to be completed by AQP as evidence that residual voids remain as groundwater sinks.
		MM1l. An AQP certifies achievement of MM1.a) to MM1.i) and MM1.k).	Requirement for AQP certification of MM1.a) to MM1.i) and MM1.k) to ensure milestone criteria achieved and documented.
MM2	Installation of cover system (in-pit tailings)		
		MM2a. Tailings have consolidated and are considered safe by an AQP for installing the cover system.	AQP to determine when appropriate and safe to install the cover system.
		MM2b. An AQP to determine appropriate detailed cover design for installation, including non-acid forming (NAF) spoil placed in a minimum 1m thick layer over consolidated tailings.	The cover system must be designed by an AQP and effectively mitigate the potential for migration of contaminants from tailings storage areas to the receiving environment.
		MM2c. An AQP certify installation of cover system as designed per MM2.b).	Certification must be given that the cover system has been installed as per the certified design and is effective in mitigating the potential for migration of contaminants

Milestone reference	Management milestone	Milestone criteria	Justification of criteria
			from tailings storage areas to the receiving environment.
		MM2d. Installed cover displays erosional and geotechnical stability.	Cover system must display erosional and geotechnical stability to ensure safe, stable and non-polluting landform.
		MM2e. Installed cover is effective in mitigating the potential for interaction of contaminants from tailings storage areas with the surrounding environment, up until when the natural water level rises in the N1 void to create a water cap.	The cover system must be effective in mitigating the potential for migration of contaminants from tailings storage areas to the receiving environment up until the water cap (in the N1 void) is created. The integrity of the cover is critical in ensuring a safe, stable and non-polluting landform.
		MM2f. An independent AQP certifies achievement of MM2.b) to MM2.e).	Requirement for AQP certification of MM2.b) to MM2.e) to ensure milestone criteria achieved and documented.
MM3	Achievement of surface requirements / access controls		
		MM3a. Safety bund setback distance is in accordance with calculated geotechnical FoS of ≥1.5 and achieves a minimum distance of 15 m.	A safety bund is required to restrict the access of vehicles, animals and people to the residual void. It should be located a sufficient distance from areas of potential instability adjacent to the void.
		MM3b. The safety bund is constructed around the perimeter of the final void to prevent access to the residual void, in accordance with engineering requirements including: i. Constructed from non-weathered dumped rockfill where possible; ii. A minimum 2m in height; iii. A minimum of 5m base width;	Bund specifications as per the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME 1995) and *Safety Bund Walls Around Abandoned Open Pit Mines* (DIR 1997).

Milestone reference	Management milestone	Milestone criteria	Justification of criteria
		iv. Not greater than 1 in 1.5 batters.	
		MM3c. Fencing installed at nominated offset from safety bund (nominally a four-strand barbed stock fence).	Stock fencing is required to restrict access of animals and people to the residual void.
		MM3d. Safety signage (design in accordance with Australian Standard) is erected at 100m intervals along the fence.	Safety signage is required to warn people of the safety risks associated with residual voids.
		MM3e. No public access to highwall or end wall areas.	Public access to highwall and end wall areas must be restricted for safety.
		MM3f. An AQP certifies achievement of MM3.a) to MM3.e).	Requirement for AQP certification of MM3.a) to MM3.e) to ensure milestone criteria achieved and documented.
MM4	Achievement of sufficient improvement		
		MM4a. The highwall landform has been constructed in accordance with the final design by an AQP.	To ensure landform stability, highwall must be constructed per final design by AQP.
		MM4b. Appropriate safety infrastructure at the geotechnical set-back distance has been installed to prevent access to the NUMA.	Safety infrastructure is required to restrict the access of vehicles, animals and people to the NUMA.
		MM4c. Annual monitoring shows exclusion fences and bunds present remain effective.	Safety bund and fencing are required to restrict the access of vehicles, animals and people to the NUMA.
		MM4d. The residual void is safe to humans and livestock.	Residual void must be safe and stable, with access restricted to ensure safety of humans and livestock.
		MM4e. The final void is geotechnically stable including: i. Walls / Slopes assessed as stable by an AQP (geotechnical engineer) (FoS ≥1.2 or ≥1.5 for E1 pit)	Certification must be given by a suitably qualified geotechnical engineer that the residual void walls and slopes are geotechnically stable and are consistent with

Milestone reference	Management milestone	Milestone criteria	Justification of criteria
		ii. Drainage measures and structures have been appropriately established and are directing overland flow away from the highwall edge iii. Erosion and sediment control measures have been installed and are operating as per design	the EA (LOD). Drainage, and erosion and sediment control structures must be implemented and functioning as per design.
		MM4f. The residual void meets the criteria set out in **Appendix 7: Final Void Dimensions**.	Residual void must meet area (inclusive of safety bunds) and maximum void depth criteria per Appendix 7, ensuring a safe and stable landform.
		MM4g. Risk from the void is as low as reasonably practical (ALARP) in accordance with the latest version of AS/NZS ISO 31000:2009 Risk Management and certified by an AQP.	The residual risk from the void must be ALARP as certified by an AQP.
		MM4h. Residual voids are monitored for water level six monthly, for 10 years in conjunction with **PRCP Condition 15** to demonstrate residual void sink behaviour.	Ongoing water monitoring to be completed for 10 years as evidence that residual voids show groundwater sink behaviour.
		MM4i. The water level and quality in the void continually show that it does not and will not cause environmental harm to the receiving environment, and continue to act as a sink, as demonstrated by groundwater modelling and monitoring of groundwater level and quality. **Note:** here **PRCP Condition 12** groundwater quality results applicable to demonstrate 'no harm' criteria and **PRCP Condition 15** and **MM4.h)** applicable for residual void sink behaviour).	All final voids have been modelled as groundwater sinks with migration of potential contaminants to the receiving environment unlikely. Nonetheless, water quality and level monitoring and modelling to be completed as evidence that residual voids remain as groundwater sinks. Residual voids must be managed in a way that complies with best practice standards and strategies and minimises risks to the environment.
		MM4j. Voids retain minimum 0.1% AEP flood immunity, supported by flood modelling re-run at end of life and calibrated against the final landform.	Post-mining flood scenario modelling showed that final voids would not be inundated under the conditions of a 0.1% AEP flood, however modelling must be re-run at end of life to ensure a safe, stable and non-polluting final landform.

Milestone reference	Management milestone	Milestone criteria	Justification of criteria
		MM4k. Erosion of the landform within the NUMA area will not negatively impact on the stability of any adjacent rehabilitation areas, or their ability to sustain their PMLU.	Erosion and sediment control within the NUMA area must not affect stability of adjacent rehabilitation areas, thereby potentially compromising their ability to sustain their PMLU. This is important for ensuring rehabilitation success of PMLU areas.
		MM4l. An independent AQP certifies achievement of MM4.a) to MM4.k).	Requirement for AQP certification of MM4.a) to MM4.k) to ensure milestone criteria achieved and documented.

6. REHABILITATION MANAGEMENT METHODOLOGY

6.1 General Rehabilitation Practices

Rehabilitation methodology for IPC is discussed below. Information has been sourced from the RMP (Appendix I).

6.1.1 Hydrogeology

A hydrogeological assessment was prepared for the Mine and is provided in Appendix F. The hydrogeological assessment was updated in 2024, to include an update to the 2020 numerical groundwater model, re-simulating the post-closure landform, and reflect additional data collected (Appendix O). The occurrences and properties of groundwater at the Mine can be read in section 2.1.6.

6.1.1.1 Groundwater Dependent Ecosystems

An assessment to determine the presence of groundwater dependant ecosystems (GDE) at IPEE was completed in March 2020 (3d Environmental). The report identified the riparian vegetation associated with the alluvial flood plain of Billy's Gully qualified as a GDE. Table 30 describes the possible impacts to the GDE as a result of the activities proposed in the area.

Table 30 Potential Impacts to Billy's Gully GDE System (3d environmental, 2020)

Impact mechanism	Mitigation measures	Mitigated risk
A total or partial loss or reduction in the volume or pressure of the aquifer being utilised by GDEs.	• monitoring of groundwater and vegetation communities to detect changes in aquifer pressure and application of mitigation strategies	Low
A change in the magnitude and timing of volume fluctuations in the aquifer being utilised by GDEs.	• water management system • erosion and sediment control • monitoring groundwater and vegetation communities to detect changes in aquifer pressure • engineering solutions are provided for construction of the haul road crossing on Billy's Gully to ensure the lateral connectivity of the perched groundwater table is not disrupted	Low
Changes to the interaction between surface flows and aquifers being utilised by a GDE.	• water management system • erosion and sediment control plan • monitoring of groundwater and vegetation communities to detect changes in aquifer pressure and application of mitigation strategies	Low
Change in chemical composition of an aquifer detrimentally impacting the health of a GDE.	• water management system • erosion and sediment control plan	Low

Impact mechanism	Mitigation measures	Mitigated risk
	• monitoring of groundwater and vegetation communities to detect changes in aquifer pressure and application of mitigation strategies	

6.1.1.2 Groundwater Modelling

A three-dimensional (3D) numerical groundwater model was developed by KCB in 2019 for IPU (Appendix F). The numerical model was used to predict the effects of activities at the Mine (including IPU and surrounding mines/projects) during operational periods and post closure. Results of the numerical model relating to IPU are discussed further in section 6.4.2. The Groundwater Monitoring and Management Plan developed by KCB (2019) provides the conceptual hydrogeological cross section shown in Figure 13.

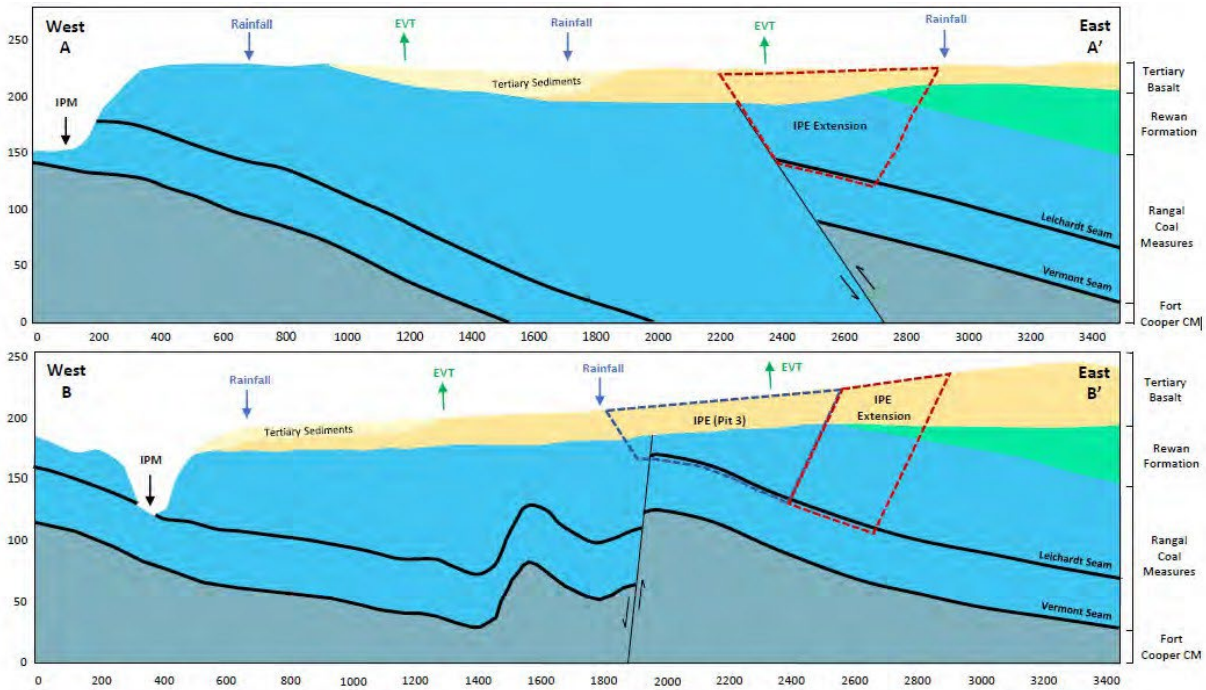


Figure 13 Conceptual Hydrogeological Cross Section (KCB 2019)

An updated groundwater model simulation representing the proposed post-closure landform has been undertaken in 2024. Prior to undertaking the new simulation, a re-calibration of the numerical model was conducted to current conditions based on available groundwater monitoring records. The new model considers and represents the properties of the backfilled spoil. The spoil is represented with a hydraulic conductivity of 5 m/d. The groundwater modelling has been revised using the proposed final landform which is consistent with the surface water modelling. The predicted long-term void water levels (in terms of recovery) have been determined through the groundwater modelling, allowing recovery of the voids during the closure period and applying evaporation to the void water level. It is assumed that there is no surface water runoff into the voids. The lack of runoff into the pit in the model results in a conservative prediction, with recovery occurring slower than that of reality.

The updated modelling has considered the underground workings, and the associated material parameters in the predictive scenario of mine development as well as post-closure groundwater recovery.

6.1.1.3 Post-Closure Groundwater Levels

Post-closure groundwater flow is influenced by the groundwater level recovery following the mining operations. The rate of groundwater level recovery and the final equilibrated groundwater level is influenced

by groundwater flow to the pit voids, rainfall, runoff, and evaporation from the pit lake surface. Underground dewatering conducted as part of mining activities caused a localised drawdown in the groundwater level within the vicinity of the workings.

Groundwater generally flows towards the pit voids, aiding in recovery across the Mine site. Modelling indicates it will take about 700 years for the final void water levels to stabilise. Pit N1, which has a lower elevation, will stabilise first within 300 years of closure.

The predicted cumulative impact on groundwater levels from all of the Mine voids suggests some flow between the voids until an equilibrium is reached, but no flow is expected away from the site (Figure 14).

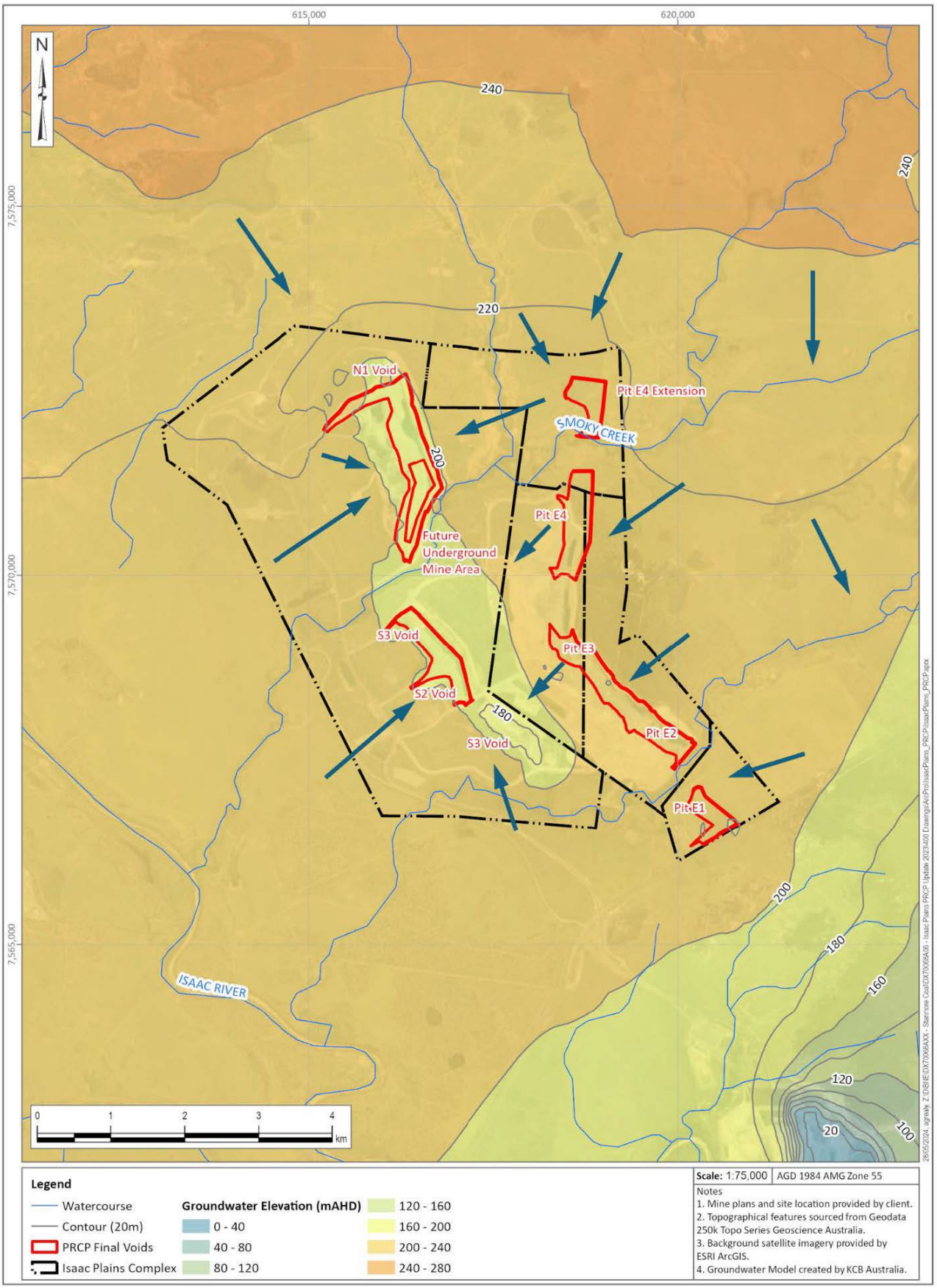


Figure 14 Post-Closure Water Table (1,000 years) and groundwater flow directions (KCB 2024)

6.1.1.4 Pit Void Steady-State Water Levels

The updated groundwater model predicts a range of final steady-state pit void water level elevations across the various pit voids. The elevations are summarised in Table 31. Final pit voids are expected to remain as sinks through the post-closure period. The trigger elevation acts as the "spill point" for each pit void. If the groundwater level rises above this elevation, water will discharge from the pit void into the downstream environment. Conversely, if the groundwater level falls below the trigger elevation, localised groundwater will flow towards the pit void.

Table 31 Post-Closure Steady-State Pit Void Water Levels (KCB 2024)

Pit Void	Equilibrated Post-Closure Void Water Elevation (mAHD)	Pit Void Source / Sink Trigger Elevation	Source / Sink Void Characteristic
N1	197.5	217.0	Sink
S2	190.8	213.8	Sink
E2/E3	204.9 & 203.7	232.0	Sink
E4	201.1	229.6	Sink
5	202.1	228.5	Sink
E1	203.8	217	Sink

Figure 15 identifies that the N1 void has one of the lowest pit lake elevations of all the pit voids following post-closure quasi steady-state equilibrium of groundwater levels, therefore, there will be a hydraulic gradient towards the N1 void. N1 is one of the first to recover as it is receiving water from the other voids.

An increasing groundwater inflow into the N1 void over time indicates that the hydraulic gradient between the pit lakes of the surrounding voids and the N1 void is increasing over the duration of the post-closure groundwater level recovery.

The transfer of water between the pit voids is not considered to have any discernible impacts of groundwater receptors in proximity of the Mine as the equilibrated pit void water elevations are below the source / sink trigger elevation, therefore groundwater migration away from the Mine is not predicated.

Predicted post-closure equilibrium conditions have similar timeframes as predicted in the 2020 *Groundwater Report (IPEE)* (Appendix F).

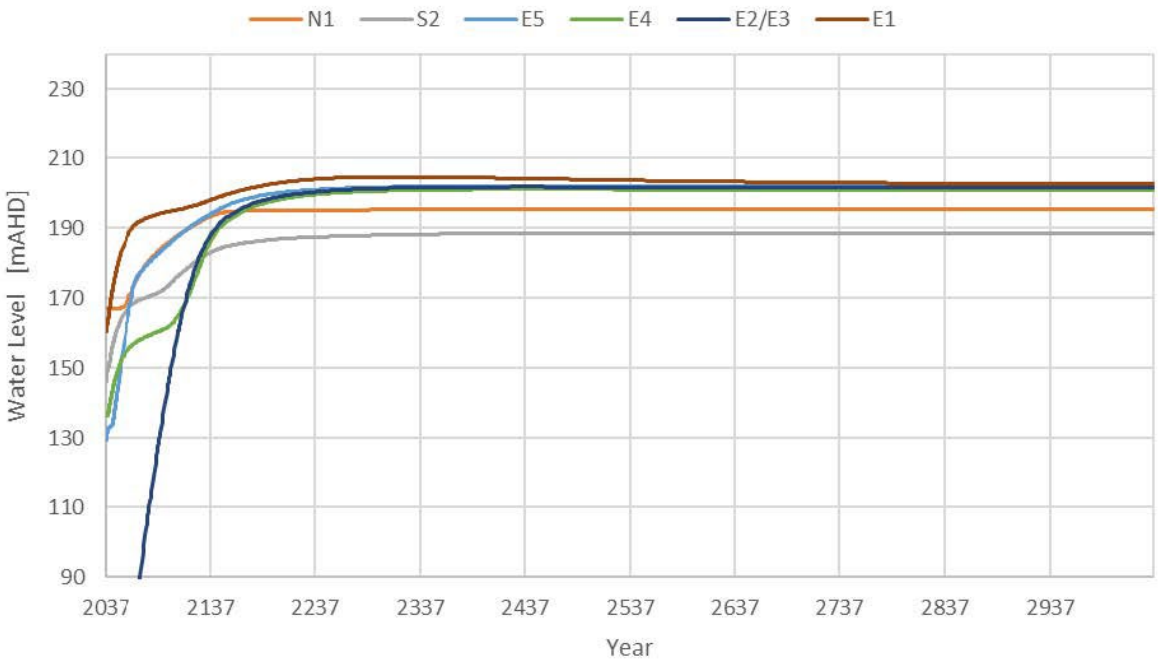


Figure 15 Final Void Water Levels Post-Closure

6.1.1.5 Post-Closure Groundwater Quality

The surface water impact assessment (WRM 2019) predicated the long-term salinity for each of the voids. The main contributor to changes in groundwater quality will be the evaporative concentration driven by evaporation from the pit voids.

The NUMA voids are expected to act as long-term groundwater sinks, not sources, therefore, it's unlikely that saline evapo-concentrated water in the closure voids will affect the groundwater quality in the surrounding areas.

6.1.1.6 Potential Impacts on Environmental Values

The groundwater in the hydrostratigraphic units underlying the Mine are generally of poor quality, with low yields and high salinity. This limits its beneficial uses, as evidenced by the few water supply bores near the Mine. One landholder bore was identified as a potential water supply source but has since been abandoned.

A bore census (KCB 2020) confirmed that there are no water supply bores in the Quaternary alluvium due to limited yields and/or high salinity, further indicating the unsuitability of this groundwater for vegetation. The Broadlea Bore field, located northeast of the IPC, targets the Tertiary basalt aquifer. The Mine is not expected to depressurise the Tertiary basalt during operations, and therefore, not impact during closure.

Most potential GDEs mapped near the IPC are classified as 'low confidence,' with some 'moderate confidence' GDEs, as discussed in Section 6.1.1.1. Some 'high confidence' Terrestrial GDEs (TGDEs) are mapped along the Isaac River, west of the Mine site. 'Moderate potential' TGDEs are mapped along Billy's Gully and Smoky Creek. These potential GDEs are unlikely to rely on the groundwater system due to the high salinity of the Tertiary sediments and alluvium, and are more likely to source soil moisture and surface water during flow periods. Therefore, the closure of the Mine is unlikely to have any noticeable impact on these potential GDEs.

6.1.1.7 Groundwater Contamination

Potential contaminants from the Mine to the groundwater in the area are shown in Table 32.

Table 32 Potential Contaminants to Groundwater from the Mine

Sources	Potential contaminants
Overburden dump and coal stockpile	Run-off containing suspended solids and dissolved salts
Pits	Suspended solids and dissolved solids
Infrastructure	Petroleum hydrocarbons, detergents, degreasers, run off containing suspended solids
Sewage treatment plant	*Escherichia coli*, nutrients and treatment chemicals
Tailings Storage facility	pH, As and Cu

6.1.1.8 Relationship with PRCP Schedule

Appendix F includes a source/sink trigger assessment based on long term water balance modelling. Pit water levels and source/sink trigger values are given in Table 31.

All final voids have been modelled as groundwater sinks with migration of potential contaminants to the receiving environment unlikely. The N1 final void will store tailings below the groundwater trigger limit for potential groundwater contamination (192 mRL). Removal of infrastructure and remediation of contaminated land will remove potential contaminants from rehabilitated areas.

No further groundwater considerations are necessary for the proposed rehabilitation methodology. Relevant rehabilitation/improvement areas are **RA2, RA3, RA4, RA6** and **IA1**.

Relevant milestones are **RM2, RM4, RM8** and **MM4**.

6.1.2 Voids in Flood Plains

6.1.2.1 Legislative Requirements

Section 3.4 of the PRC plan guideline outlines the information requirements for transitional PRC plans relating to voids in flood plains. This section states:

Where a land outcome document has a pre-approved land outcome for a void with a location specified, flood plain modelling is not required. If a void has been identified as a NUMA in a land outcome document but the location is not identified, the applicant is required to carry out flood plain modelling in accordance with this section of the guideline. While the provision in the EP Act relating to voids located within a floodplain having to rehabilitate to a stable condition does not apply, the PRC plan must include how the proposed location of the void minimises risks to the environment. Therefore, the flood plain modelling is required to support the assessment of the proposed location of the void.

The location of the voids has been given in the EA which is a LOD meaning flood plain modelling is not required. However, this section also states that flood plain modelling is required to show how the proposed location of the void minimises risk to the environment.

6.1.2.2 Void Flood Plain Modelling

Hydraulic modelling completed for IPEE by WRM (2019) (Appendix D) demonstrates that all seven approved residual voids at IPE will be located outside of the 0.1% annual exceedance probability (AEP) flood event zone.

Further information regarding flood modelling at the Mine is provided in section 6.1.3 of this PRC Plan.

6.1.2.3 Relationship with PRCP Schedule

No voids are located within flood plains so no further considerations are necessary for the proposed rehabilitation methodology.

6.1.3 Final Landform Flood Susceptibility

Modelling of a post-mining flood scenario has been completed by WRM consultants for IPEE (2019) (Appendix D). The TUFLOW model was adjusted to account for the removal of infrastructure, flood protection levees and the shape of the final landform. The modelling which can be seen in section 8.5 of Appendix D demonstrates that the final voids would not be inundated in a post mining environment under the conditions of a 0.1% AEP flood. Peak flow velocities are not considered excessive however appropriate scour protection should be incorporated in final landform design. Key features of the post-mining model are provided below.

Additionally, a final void flooding assessment was undertaken by HydroBalance (2025) (Appendix Q). The existing Isaac River TUFLOW model was used to determine the Probable Maximum Flood (PMF) water levels to assess the potential interaction between regional and local floodwaters and the proposed final landform.

6.1.3.4 Smoky Creek

a. Impacts

Impacts associated with flooding levels of Smoky Creek are confined and short lived. Small zones around the removed haul roads will be impacted and not have an effect on the flows of Smoky Creek. Flooding will dissipate before reaching the Mine area.

b. Flood Levels

Flood levels from the increase of Smoky Creek extend approximately 475 m outside the ML boundary near the Pit 4 final landform. The maximum flood level outside the ML boundary is approximately 0.06 m.

6.1.3.5 Billy's Gully

a. Impacts

Impacts associated with flooded levels of Billy's Gully at the Mine are confined and short lived. Small zones around the removed haul roads will be impacted and not have an effect on the flows of Billy's Gully. Flooding will dissipate before reaching the Mine area.

b. Flood Levels

Flood levels from the increase in Billy's Gully near the E2 pit final landform extends approximately 20 m outside the ML boundary. The maximum flood level outside the ML boundary is approximately 0.03 m.

6.1.3.6 PMF Flood Modelling

As identified by HydroBalance (Appendix Q) the existing mining pits are not located within the PMF event extent. Elevated depths were observed in a number of locations in Smoky Creek, particularly near N1 pit and E5 pit. As the Mine is a significant distance from the Isaac River floodplain, there is no modelled interaction between the Isaac River PMF floodplain and the Mine final landform (HydroBalance 2025).

The post-closure flood modelling (Appendix Q) showed that the final voids are not located within the PMF event extent, hence it is highly unlikely that the final void would be located within the local creek floodplain for any conceivable flood event (HydroBalance 2025).

The impact of the final landform on the existing PMF water level and on flood velocities are shown in Figures 2.4-2.7 of Appendix Q. These figures show that water level impacts would generally be confined within the MLs, with the exception of some minor impacts in Five Mile Gully extending up to 750 m downstream of the ML (HydroBalance 2025). Flood level impacts generally manifest in lower water levels, aside from several localised increases, particularly near E4 Pit and E1 Pit (HydroBalance 2025). The velocity impacts vary across site, ranging between decreases of 1.0 m/s and increases of 2.0 m/s, the velocity impacts do not extend more than 750 m downstream of the MLs (HydroBalance 2025).

6.1.3.7 Relationship with PRCP Schedule

Flood modelling shows that rehabilitated areas of the Mine are not significantly impacted by flood waters. Furthermore, the final landform flood assessment demonstrates that the Isaac River and local creek flooding would not interact with or flow into the final voids for the PMF event (HydroBalance 2025). Adequate vegetation cover of final landforms will provide protection from scouring during flood events. Final voids are not located within the flood plain. Relevant rehabilitation/improvement areas are **RA1, RA2, RA3, RA4, RA7, RA8** and **RA9**.

Relevant milestones are **RM2, RM3, RM6, RM7** and **RM8.**

6.1.4 Soil and Capping Material Assessment

The Mine manages topsoil as per the IPC Topsoil Management Plan (TMP) (2020). The plan provides strategies to control topsoil management and identifies the key steps in the topsoil management process as:

- land identified as necessary for mining or associated infrastructure
- permit to disturb land is approved
- topsoil stripping
- topsoil stockpiling
- topsoil placement
- topsoil records updated

6.1.4.1 Topsoil Quantity

Topsoil is available at various locations across the Mine in 167 stockpiles. Available topsoil quantities are provided in Table 33.

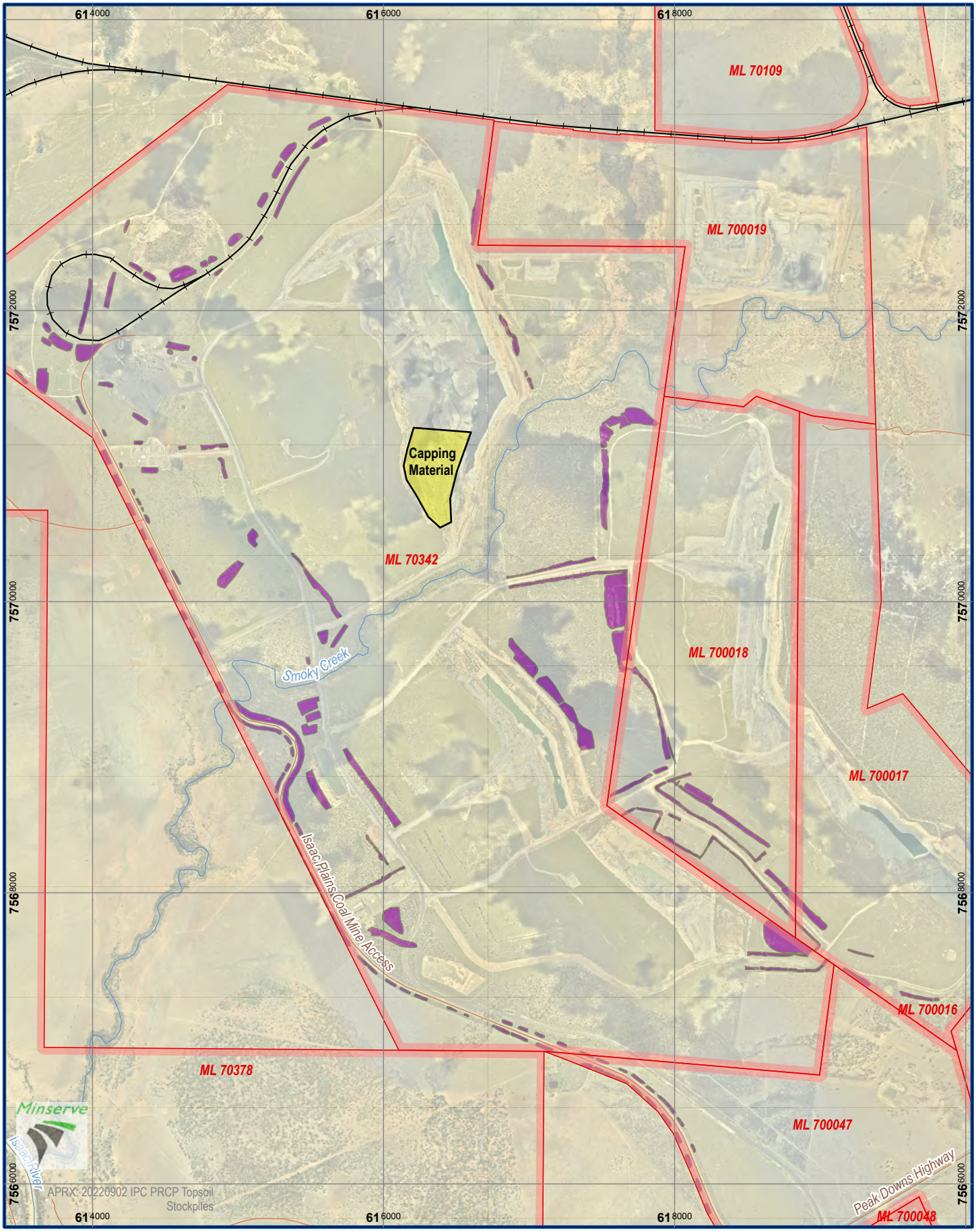
Table 33 Topsoil Quantities

Area	Mining lease	Sum of volume in loose cubic metres (LCM)
S2 high wall	ML70342	111,778
Smoky Creek	ML70342	61,566
S2 sediment dam	ML70342	75,491
Admin	ML70342	56,536
Rail loop	ML70342	135,524
N2	ML70342	45,995
Raw water dam	ML70342	18,348
CHPP	ML70342	21,238
MIA	ML70342	26,247
Fan pad	ML70342	31,710
N1S	ML70342	37,288
Access road	ML70342	616,374
Access road	outside lease	76,795
Quarry	ML70342	2,217
N1N high wall	ML70342	47,784
Pit 2	ML70342, ML700017 and ML700018	321,106
Pit 3	ML700018	184,831
Pit 4	ML70342, ML700018	380,296
IPE access road	ML70342	63,923
Total available LCM		**2,315,047**
Total required LCM (based on disturbance mapping)	**1,481,100**	
Additional topsoil available		**833,947**

The available topsoil quantities at the Mine in Table 33 show that there is adequate topsoil to complete the rehabilitation outlined in this PRC plan if applied at a depth of 15 cm. As there is an excess of topsoil at the Mine, any areas that are impacted by subsidence, or have localised depression / erosion, or limited existing soil cover will have additional soil applied where needed, and as determined by an AQP. Topsoil application on rehabilitated areas will be considered by an AQP to ensure surface requirements are met.

6.1.4.2 Location

Stockpile locations are shown in Figure 16.



ML
Waterway
Railway
Road
Topsoil Stockpiles
Capping material for CDA/TSF

N

0 200 400 600 800 1,000
Meters

stanmore

Topsoil Inventory and CDA Capping Material
Figure 16

6.1.4.3 Quality

The RMP provides the following properties of soil as acceptable for use in rehabilitation works at the Mine:

- pH (1:5) 6.0–9.0
- EC (1:5) < 0.6 dS/m
- exchangeable sodium percentage (ESP) value < 6%
- Cation exchange capacity (CEC) > 9 meq/100g

The latest topsoil assessments on rehabilitated areas from the 2021 Isaac Plains Rehabilitation Inspection (C&R, 2021) provide the following results for topsoil fertility at the Mine:

- EC values for historical rehabilitation are compliant as most results are <0.6 dS/m (three sites exceeded)
- pH is compliant as all results between 6.0-9.0
- ESP values for historical rehabilitation are compliant (<6%). Eleven 2021 sites exceeded the limit
- results for two sites were compliant with a CEC of greater than 9 meq/100g

Low nutrient content in the topsoil was detected across most sites in the form of total nitrogen, total phosphorus and organic matter. Full results can be seen in Appendix I.

6.1.4.4 Amelioration

Topsoil stockpiles may require the addition of fertilizer to ameliorate low macronutrients in the soil. Gypsum may be applied to decrease ESP and increase stability. It recommended this be completed based on topsoil rehabilitation site results.

On soils where gypsum is required a rate of 2.5 t/ha has been included as per ERC calculations for IPC. Fertiliser will be applied at a rate of 100 kg/ha as per previous rehabilitation at the Mine.

6.1.4.5 Soil Application

Topsoil will be spread over the surface of disturbed land at an average depth of 15 cm (RMP, 2019). Shallow or deep ripping will be done to break up the compacted surface layers or to key in the topsoil with the underlying soil.

6.1.4.6 Erosion and Sediment Control

Disturbed areas will be rehabilitated using suitable erosion and sediment controls outlined in the RMP. Management methods have been extracted from the Erosion and Sediment Control Plan (2020) for the Mine. Table 34 describes the measures that may be used to prevent erosion and sediment release.

Table 34 Erosion and Sediment Controls

Area	Control measure
Spoil dumps	• Placement of spoil dumps should not be in locations subject to flooding, adjacent to water bodies or water courses and should be dampened to reduce any dust impacts • Infrastructure that should be used to control sediment movement from dumps include diversion drains, contour banks, capture drains, sediment dams and drop structures

Area	Control measure
ROM and other stockpiles	• Placement should not be in areas subject to flooding, adjacent to water bodies or water courses • Piles should be dampened to reduce dust and covered during storm events • Capture drains may be required which divert into a sediment dam/pit • Diversion drains may be used to divert non-mine affected water • Stockpiling of coal materials should only occur in mine-affected areas where downstream drainage is terminated by a pit or sediment dam • Topsoil stockpiles should be seeded with appropriate vegetation to prevent erosion until use
CHPP	• Drains are to be used around the CHPP infrastructure and stockpiles to divert clean water around contaminated materials • Catch bunds will prevent sediment from escaping the associated stockpiles and coal pads • Catchment from the CHPP area drains into the CHPP process pond • Check dams and pondage areas in drainage lines to reduce sediment in the sediment dams • Regular inspections of control structures
Site wide	• Vegetation clearing is not to be undertaken until earthworks operations are ready to commence • Vehicle movement restricted to roads to reduce disturbance to ground and vegetation • Plans are followed for excavation processes to avoid disturbance to outside trees and pasture areas
Sediment dams	• Sediment dams to be constructed or designed as per the former DME guidelines (*Technical Guidelines for Environmental Management of Exploration and Mining Activities*, DME 1995) and consistent with the IECA design standard
Workshop	• Sediment trap used with overflow into sediment dam 4. Overspill to be captured by release dam 1

Area	Control measure
Haul roads and rail loop	• Berm and catch drain configurations are to be used to stop flow from the haul roads and rail loop. Regular checks required to determine structural integrity

6.1.4.7 Relationship Between Soil and Vegetation Ecosystems

Reference sites (often illustrating pre-mining conditions) provide useful comparisons to determine the composition, structure and function of the desired rehabilitation outcome. Noting that reference sites should be used for guidance and not as firm targets.

Rehabilitated areas are trending towards composition, structure and function of reference sites for pasture based on completed rehabilitation monitoring.

6.1.4.8 Capping Material

Capping material will be required for the rehabilitation of TSF areas adjacent to N1 pit and in-pit tailings. Large volumes of N1 low wall spoil are available for capping. The required depth of capping material will be determined by cover trials (section 8.5.2) however the quantities of spoil available mean that adequate material is readily available.

The *Geotechnical Assessment of Isaac Plains Complex Final Voids for Rehabilitation Purposes* GeoTek Solutions Pty Ltd (GeoTek) (2022) (Appendix J) states that geotechnically, overburden spoil that has been generated at Isaac Plains is suitable for capping material.

6.1.4.9 Relationship with PRCP Schedule

Topsoil volumes are adequate to complete rehabilitation at the Mine. Topsoil will be ameliorated in accordance with this PRC plan. Spoil material is suitable for capping and adequate volume is available. Rehabilitation trials will be used to inform the cover design for tailings and rejects areas.

Relevant rehabilitation/improvement areas are **RA1, RA2, RA3, RA4, RA5, RA6, RA9** and **IA1**. Relevant milestones are **RM2, RM3, RM4, RM5, RM6, RM7, RM8** and **MM2**.

6.1.5 Waste Characterisation

The following section provides a summary of mine waste characterisation from the *IPC Mining Waste Management Plan* (MWMP) (C&R 2018) (Appendix K) and the *IPC N1-TSF Mine Waste Management Plan* (N1MWMP) (2021) (Appendix L) prepared by ATC Williams.

6.1.5.1 Sampling Methodology

The MWMP explains that waste rock should be monitored continually throughout mining operations and tested as per condition E6 of the EA. Characterisation of the excavated waste should be carried out in accordance with the *Assessment and Management of Acid Drainage guideline of the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* series (DME 1995) and any other applicable best practice guidelines.

Ongoing sampling of rejects is to be completed annually to attain the physical properties of rejects during placement and actual rejects from the CHPP and rejects disposal areas for the properties outlined in the N1-TSF monitoring, inspection and review schedule (Table 9) from the N1 MWMP.

6.1.5.2 Mineral Waste Volumes

The total volume of overburden moved during life of mine (LOM) is given in Table 35. This includes projected volumes for future pits.

Table 35 LOM Overburden Volumes

Location	Estimated Overburden Movement (bank cubic meters (BCM))
N1 and N2 pits	56,807,277
S1, S2 and S3 pits	47,194,085
E2, E3 and E4 pits	35,643,774
E1 pit	7,000,000[1]
E5 pit	9,000,000[1]
Total	155,645,136

1. Projected overburden volumes from the Mine plan

The projected volume of tailings until 2030 is given in Table 36. This includes projected tailings from future mining and Isaac Downs coal processing.

Table 36 Project Tailings Volume

Year	Tailings (m^3)
2022	408,000
2023	408,000
2024	408,000
2025	408,000
2026	408,000
2027	485,769
2028	408,000
2029	408,000
2030	408,000
Total	**3,749,769**

6.1.5.3 Overburden Characterisation

a. Geochemistry

A summary of results provided for overburden samples in the MWMP (Appendix K) is provided below:

- Predominantly alkaline ranging from 7.0-9.7 pH units
- Slightly saline (102-1136 µS/cm)
- Slightly dispersive
- Low acid generating potential
- Elevated levels of Ni and Cu

Monitoring of seepage through overburden dumps has not been done at the Mine. Due to the soil in the area being naturally alkaline with pH levels (1:5) of 8.0–9.0, seepage volumes and concentrations are presumed to be not of concern. Saline seepage is not expected to be an issue due to the water being contained by the Mine water management system.

Methodology for disposal of dispersive overburden material at the Mine include disposing of the material in the centre of the out of pit dump. If Permian material is available, it will be placed over the top to cover the more dispersive material and an average depth of 1 m.

Overburden emplacement areas will be rehabilitated as per the below methodology:

- Re-grade external spoil slopes to a slope of no greater than 15%
- Re-grade internally draining slopes to a slope of no greater than 30%
- Topsoil is to be spread over the surface to a minimum of 15 cm depth
- Topsoil to be ripped
- Seed and monitor

6.1.5.4 Tailings and Reject Characterisation

a. Geochemistry

A summary of tailings and rejects characterisation from the N1 MWMP (Appendix L) is provided below:

- Almost 70% of samples classified as non-acid forming (NAF) with total sulfur contents of 0.5%-1%
- Total metal/metalloid concentrations are low (compared to natural element abundance in soil in the earth's crust)
- Saline leachate potential is low
- Some rejects could produce low concentrations of Al and/or As seepage
- Reject liquor samples had a neutral to alkaline pH (7.5-8.6 pH units), were low-moderately saline and had low concentrations of metals/metalloids

Rejects at the Mine including fine, course, current and potential show subtle variation geochemically however not enough to warrant separate handling, processing or disposal.

6.1.5.5 Relationship with PRCP Schedule

Waste material is largely benign and does not require specific treatment during rehabilitation. Rejects and tailings are stored in specific storage facilities which will be rehabilitated to mitigate the potential migration of contaminants.

Relevant rehabilitation/improvement areas are **RA1, RA2, RA3, RA4, RA5, RA6, RA9** and **IA1**. Relevant milestones are **RM2, RM3, RM4, RM5, MM1, MM2, MM3** and **MM4.**

6.1.6 Final Landform Design

6.1.6.1 3D Design Plans for the Final Landform

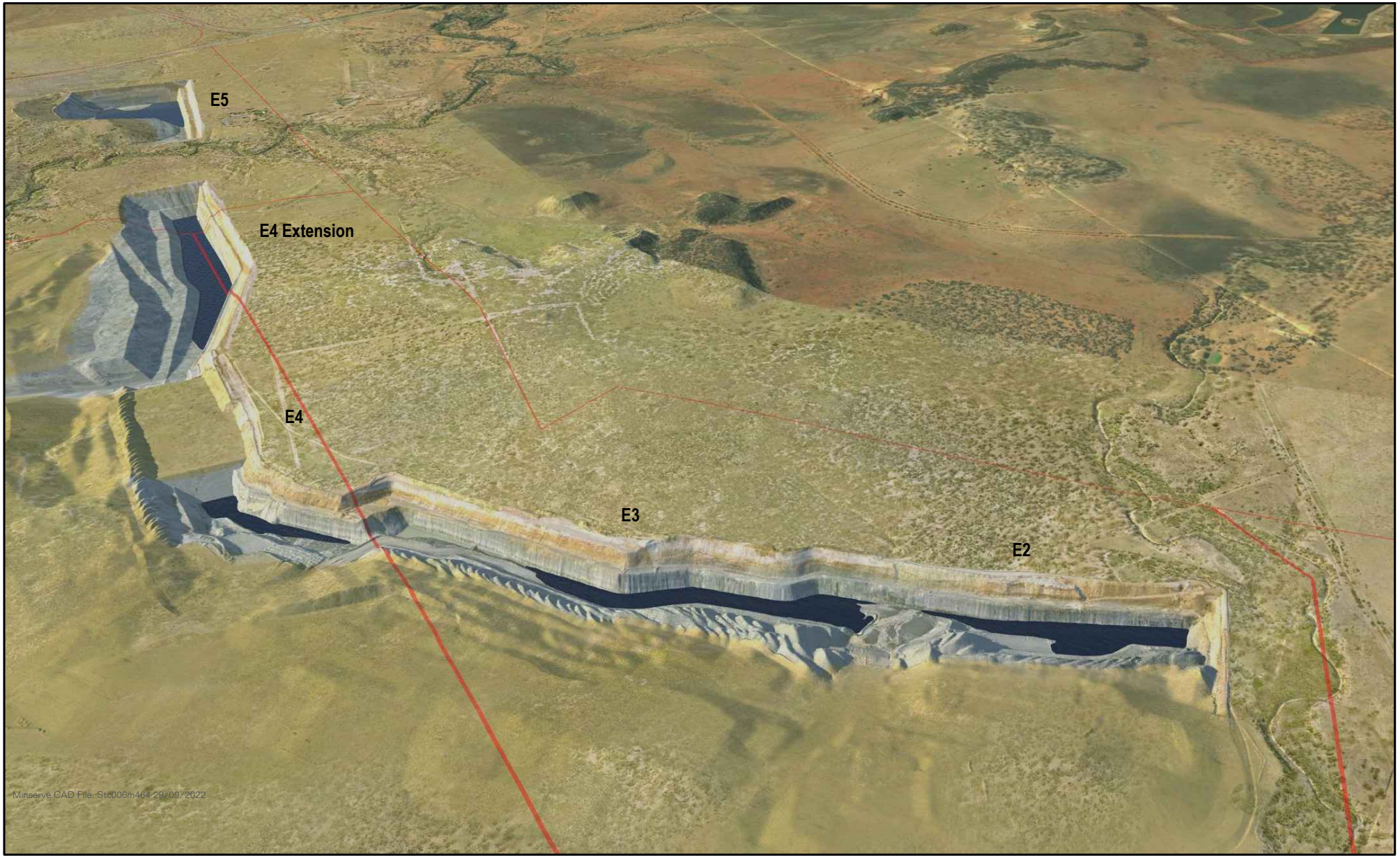
The 3D design plan and cross-sections for the final landforms are given in Figure 17 – Figure 22.

stanmore

Conceptual Final Landform
Site Looking North East
Figure 17

stanmore

Conceptual Final Landform
Isaac Plains Voids S2 and N1
Figure 18



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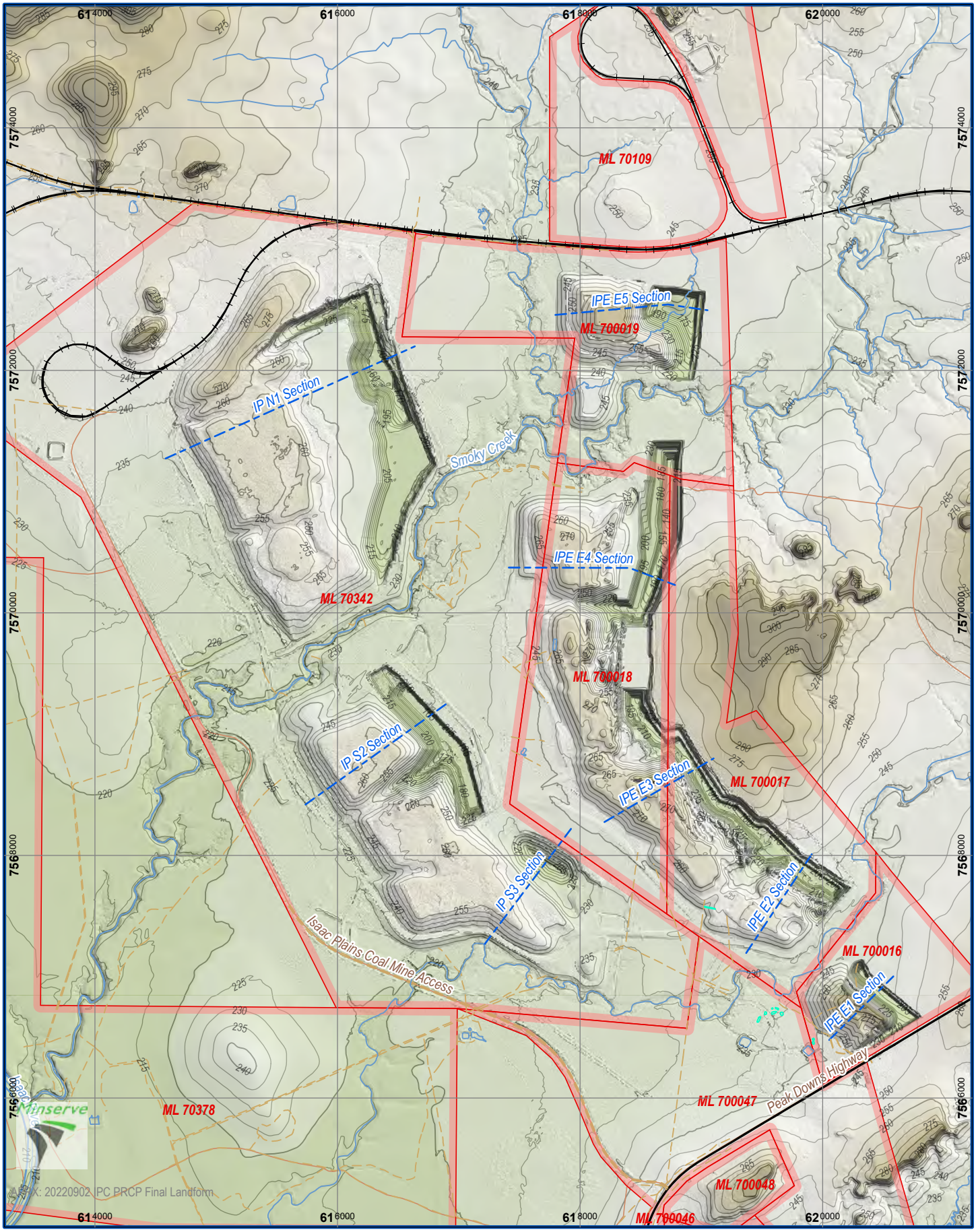
Conceptual Final Landform
Isaac Plains East Voids E2/3/4/5
Figure 19



ML
Waterway
Railway
Road
5m Topography Contours
Contour Line, Intermediate
Contour Line, Major
Section Locations
LAYER
Creek
Culvert
Dam
Edge of bitumen
Ford
Rail
River
Track
Water Hole

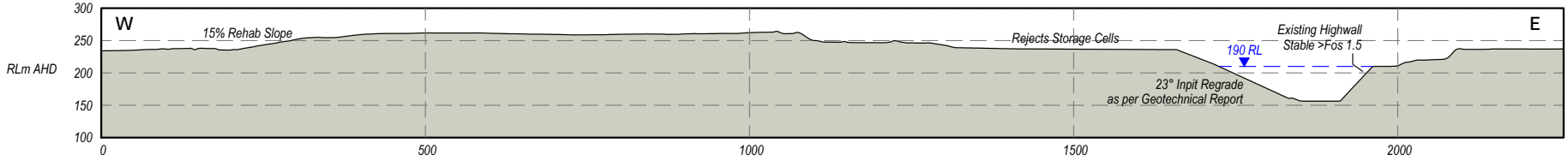
N

0 500 1,000 1,500 2,000 2,500
Meters

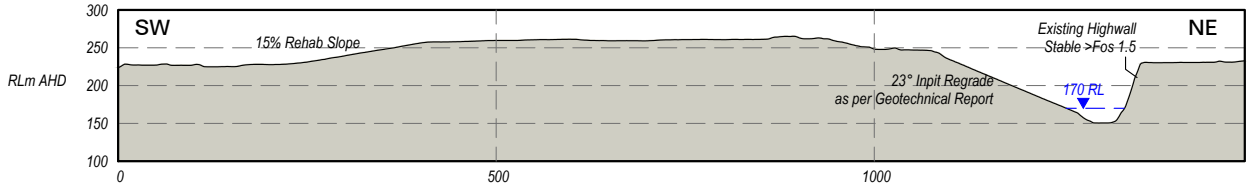
stanmore

Final Landform
Figure 20

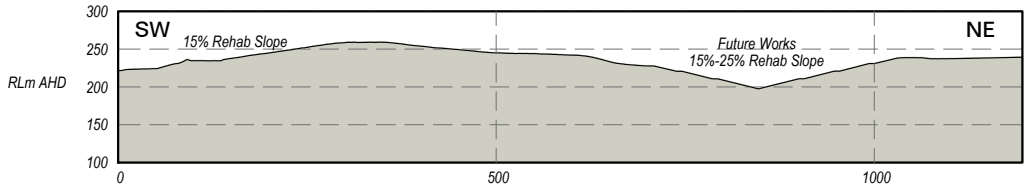
Section IP N1



Section IP S2



Section IP S3



Minserve CAD File: Stc006m465 14/09/2022

SCALE
No vertical exaggeration

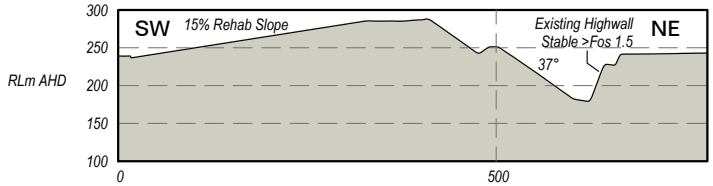
0 250m

NOTE:
Refer to GeoTek Solutions Pty Ltd Report
for details on Final Low wall and Highwall Stability Results

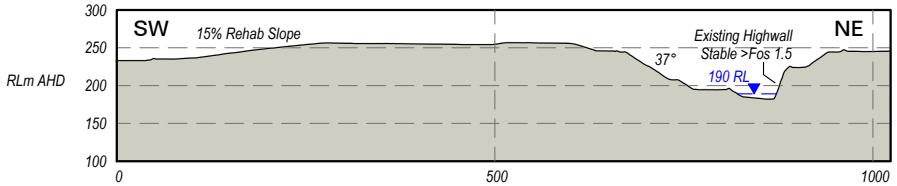
stanmore

Isaac Plains Mine Final
Landform Sections
Figure 21

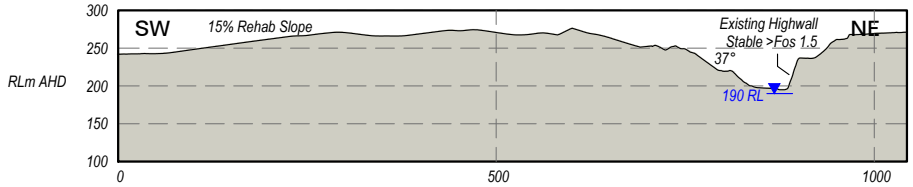
Section IPE E1



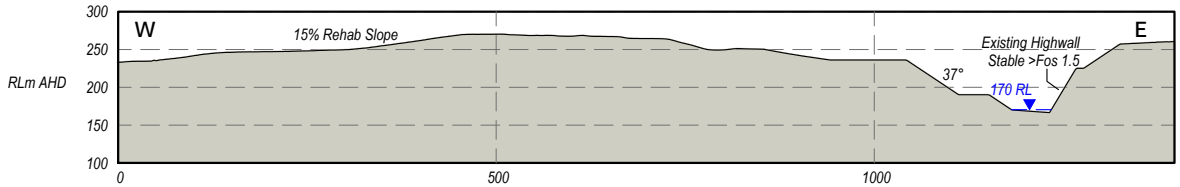
Section IPE S2



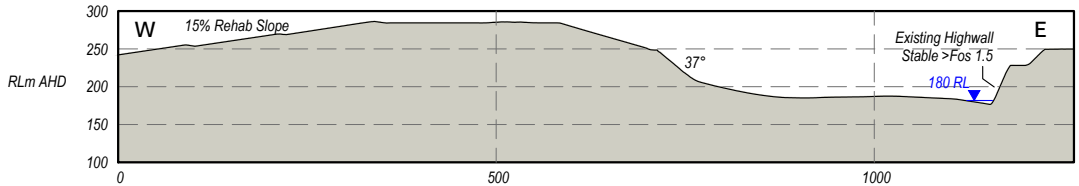
Section IPE S3



Section IPE S4



Section IPE S5



Minserve CAD File: Stc006m465 14/09/2022

SCALE
No vertical exaggeration

0 250m

NOTE:
Refer to GeoTek Solutions Pty Ltd Report
for details on Final Low wall and Highwall Stability Results

stanmore

Isaac Plains East Mine
Final Landform Sections
Figure 22

6.1.6.2 Method of Determining Landform Design

Final landform design, particularly for overburden dumps, has been based on the requirements of the EA. Landforms have been designed with regard to the method of mining (primarily dragline) and to be achievable using dozer push. Designs have been developed to achieve landform stability and ensure suitability for the PMLU of grazing. Overburden emplacement rehabilitation includes 15% (or 8.5˚) overall external dump slopes.

Progressive rehabilitation will include outer slopes being reshaped to a landform of 8.5˚ (15% overall slope) and internally draining overburden dumps to overall slope of 17˚ (30%).

The conceptual design for all pits within the Mine is shown in Figure 23. This design is consistent with current EA requirements and the local topography which includes a landscape modified by historical mining activities, and gently sloping hills and outcrops.

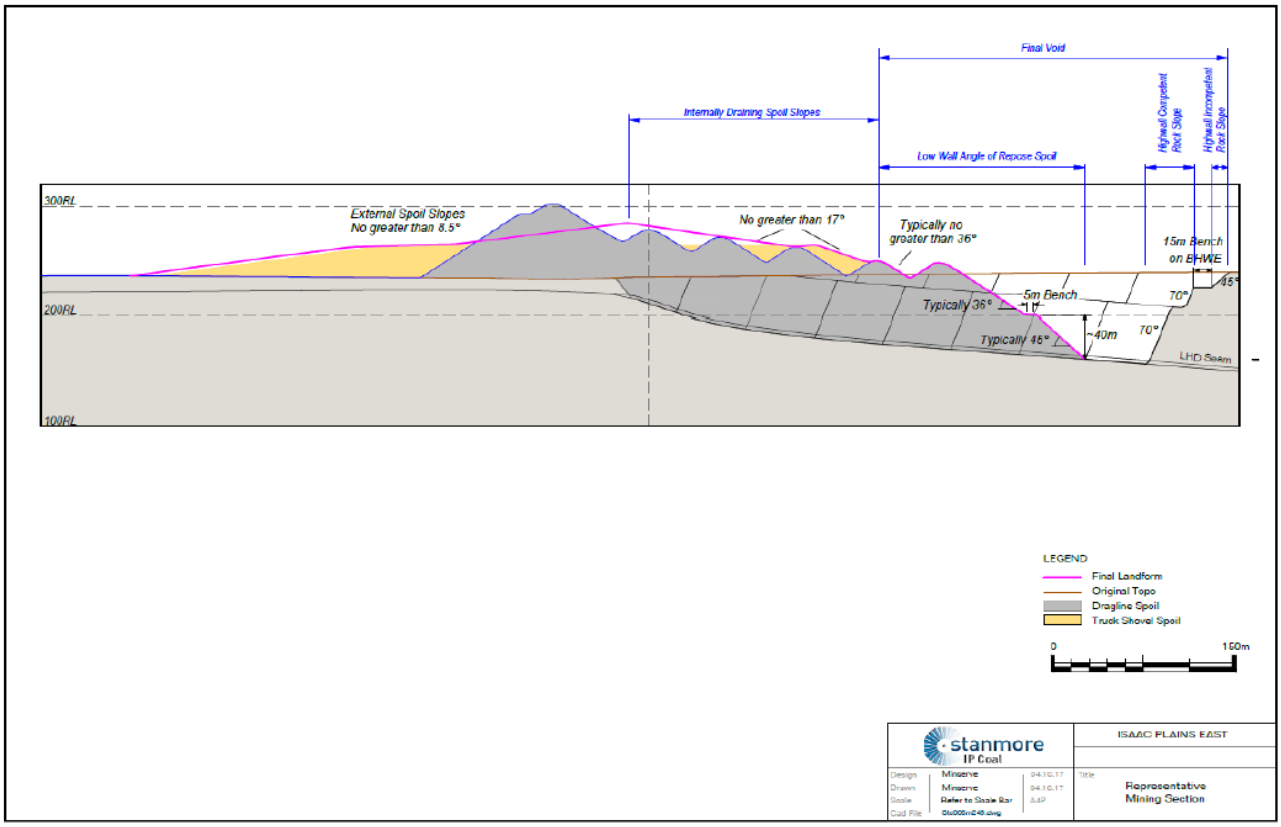


Figure 23 Conceptual Pit Design

6.1.6.3 Long-Term Stability

The objective of final landform design is to achieve long-term stability. This includes geotechnical and erosional stability. Erosional stability of rehabilitated areas is determined by visual inspection during rehabilitation monitoring. The erosion status of rehabilitated areas is considered moderate to minor with rills and washouts present in some areas. These areas have largely been stabilised by revegetation. These areas are expected to further stabilise over time as preferential flow pathways are established and recolonised by stabilising vegetation. Geotechnical stability is given in section 2.1.8.

6.1.6.4 Quality Assurance / Quality Control Requirements

Key risks associated with final landform construction include a failure to follow the design, construction materials not conforming to specifications, poor or inadequate construction quality and the failure of quality assurance and quality control (QA/QC) to identify construction inadequacies. Final landform construction management, technical supervision and QA/QC will be done by an AQP who can make sure that

construction is carried out in accordance with the design plan. GPS machine guidance will assist during landform constriction and reshaping while light detection and ranging (LiDAR), aerial or on-ground surveys will be used to periodically monitor construction against design. Construction quality will be managed through effective mine planning and field supervision during construction.

A QA/QC document will be prepared by an AQP to verify final landform design has been done in accordance with the design plan and is stable.

6.1.6.5 Methodology to Verify the Predicted Success

Measures to ensure stability of placed topsoil during vegetation establishment include:

- Deep ripping of surface material prior to or during topsoiling to reduce compaction, encourage water infiltration and provide surface roughness for better adhesion of topsoil to the contoured surface
- Scarifying placed topsoil along the contour to reduce compaction, encourage water infiltration, create rills to slow water flow downslope and create furrows and depressions for water collection to enhance seed germination
- Appropriate scheduling of topsoil/seeding to ensure sufficient subsoil moisture levels and favourable weather conditions for germination
- Selected cover crop species in seed mixes to provide fast vegetation cover for erosion protection

The success of these measures is measured by visual inspection of erosion in rehabilitated areas during rehabilitation monitoring.

6.1.6.6 Limitation and Assumptions of the Final Landform Design

The final landform design has the following limitations:

- The accuracy of soil availability and quality at closure
- Effects of climate change on future rainfall event intensities, durations and / or frequencies
- Nature of the final waste material

The final landform design has the following assumptions:

- The materials tested are representative of the general lithologies at the Mine
- The nature of the waste material is like the current assessments
- Progressive rehabilitation will continue using similar methodology to completed rehabilitation

6.1.6.7 Relationship with PRCP Schedule

Final landforms have been designed to maximise long term stability. Management and supervision during construction will ensure compliance with design.

Relevant rehabilitation/improvement areas are **RA1, RA2, RA3, RA4, RA5, RA6, RA7, RA8, RA9, RA10, RA11** and **IA1**.

Relevant milestones are **RM1, RM2, RM3, RM4, RM5, RM7, RM8, MM1, MM2, MM3** and **MM4**.

6.1.7 Cover Design

No detailed cover design has been completed for the rejects or tailings emplacement areas. As these areas are still in operation future trials are planned to inform detailed design. An outline of the proposed trials is given in section 7.5.2.

6.1.7.1 Relationship with PRCP Schedule

Cover systems will be designed to mitigate the potential for migration of contaminants from tailings storage areas to the receiving environment.

Relevant rehabilitation/improvement areas are **RA6** and **IA1**.

Relevant milestones are **RM3, RM4, RM8** and **MM2**.

6.1.8 Water Management

6.1.8.1 Contaminants

a. Groundwater

A list of potential groundwater contaminants from the Mine can be seen in Table 32.

b. Surface Water

The IPEE Surface Water Impact Assessment (WRM 2019), reviewed mine affected water results for S3 pit over a two-year period to identify the possible contaminants of concern to the surface water in the area. The review identified:

- High pH levels ranging between 8.45–8.60 pH units
- High EC values of 5,820–6,690 µS/cm
- Al levels above the storage and release contaminant trigger levels

Any release of water will be in accordance with EA condition C2 from the approved release points outlined in Table 1: Mine Affected Water Release Points, Sources and Receiving Waters from the EA.

c. Acid Rock Drainage

There is moderate to low potential for acid rock drainage at IPC. Co-disposal of coal rejects and waste rock suggest that any acid generated will be neutralised as it seeps through the surrounding waste rock. No negative impacts have been identified during rehabilitation inspections.

d. Alkaline and Saline Drainage

As discussed in section 6.1.5.3, seepage volumes and concentrations from overburden material is not expected to be high enough to warrant concern.

6.1.8.2 Infiltration and Seepage Intervention and Collection Controls

The MWMP identifies that mine affected waters at IPC are contained by the following storages:

- RD1
- S2 pit
- S2 sediment dam
- CHPP process pond

Plans for future storage of mine affected waters at IPC include using the S2 pit as the primary storage location until 2029. After this time inactive IPE pits will provide storage capacity for excess mine affected water. N1 pit will be kept dewatered for use as tailings and rejects in-pit disposal. A series of pumps and pipelines are in place to transfer water around the mine for storage.

6.1.8.3 Surface Water Diversions and Long-Term Management Requirements

a. Smoky Creek N1 Levee

The Smoky Creek N1 Levee is classified as a regulated structure of ‘significant’ consequence. The levee protects the decommissioned southern N1 mining pit from Smoky Creek. The structure is up to 10 m from the natural ground surface and is used as a haul road/levee (0.1% AEP). Observations from the 2021 inspection (CCE 2021) show the rehabilitated batter of the N1 levee has well established grass cover with minor rilling on the south side above the rock protection.

The N1 Levee is to remain during operations and will be incorporated into the final landform.

b. Smoky Creek S1 Levee

The Smoky Creek S1 Levee is classified as a regulated structure of 'significant' consequence. The levee protects the S1 and S2 mining pits from flood flows in Smoky Creek. The structure is up to 10m from the Smoky Creek riverbed and is used as a haul road/levee (0.1% AEP + 500 mm). Observations from the 2021 inspection (CCE 2021) show the downstream batters are well vegetation and there is no rilling or erosion.

The S1 Levee is to remain during operations and will be incorporated into the final landform.

6.1.8.4 Dewatering Requirements

The WRM (2021) Water Balance Model Update (Appendix M) predicts that pits at the Mine may fill during extreme

wet weather events due to insufficient dewatering rates. The model shows that E2 and E3 pit may take over 100 days to fully dewater using a pump capacity of 100 litres/second (L/s) during extreme wet conditions.

Residual clean water dams are to be drained of mine-affected or sediment affected water before relinquishment.

6.1.8.5 Ongoing Water Management and Reduction Requirements

Mining pits will continue to be monitored during operations to assess dewatering requirements. All water sources in rehabilitated areas will have available water tested to assess the suitability for stock consumption.

6.1.8.6 Relationship with PRCP Schedule

The potential for groundwater contamination has been discussed in section 6.1.1.7. Non-retained water infrastructure will be decommissioned and rehabilitated to a grazing PMLU. Retained infrastructure will be drained and desilted prior to relinquishment. Regulated levees will be incorporated into the final landform.

The relevant rehabilitation/improvement area is **RA1, RA2, RA3, RA5, RA6, RA9, RA11** and **IA1**.

Relevant milestones are **RM1, RM2, RM3, RM7, RM8** and **MM4**.

6.1.9 Revegetation Plan

A revegetation plan has been developed to describe activities proposed to establish self-sustaining vegetation communities that suit the intended PMLUs.

The following PMLUs are approved across the Mine:

- Grazing
- Water storage

6.1.9.1 Objectives

Revegetation objectives across the site can be summarised as follows:

- To establish self-sustaining vegetation consistent with the PMLU and the completion criteria of 70% groundcover by non-declared weed species for three consecutive years
- To establish self-sustaining vegetation in grazing areas that is productive, comparable to surrounding grazing areas and supports the commercial interest of future land holders
- To establish self-sustaining vegetation that supports endemic species but is also productive for cattle grazing
- To monitor and manage weed and pest species which are detrimental to the establishment and persistence of key flora and fauna species

6.1.9.2 Key Flora Species

Buffel grass (*Cenchrus ciliaris*) has been identified as the key flora species for revegetation at the Mine. Buffel grass is the dominant pasture species in the Moranbah region and tends to naturally return to rehabilitated landscapes where it may become dominant. It is well suited for the PMLU at the Mine due to its palatability for cattle.

6.1.9.3 Species of Conservation Significance

Significant flora that may occur at the Mine is given in section 2.1.9.4.

6.1.9.4 Fauna Habitat and Use

Depressions are created in suitable areas during rehabilitation works to establish brolga baths across the site for fauna use. There are existing brolga baths in undisturbed areas of grazing land adjacent to the Project, therefore, these seasonal watering points are constituent to a grazing PMLU in this region. Water quality within these areas can support stock animals as well as native wildlife including emus, brolga, kangaroos, and various birds amongst other species which have been sited using the baths onsite.

6.1.9.5 Reference Sites

Reference sites will be monitored as per the EA condition F16 at the approved locations in Table 18 of the EA. Full detail of the reference sites is shown in section 8.1.

6.1.9.6 Management of Revegetation

Revegetation is planned in advance of earthworks. If areas are reshaped and particularly if they are topsoiled, seeding should occur immediately to minimise the risk large rain events on exposed soil. Seed is ordered in advance to ensure adequate supply.

6.1.9.7 Seed Mix

The seed mix for the grazing PMLU is given in Table 37.

Table 37 Pasture Grazing Seed Mix

Common Name	Scientific Name	Seeding Rate (kilograms per hectare (kg/ha))
King Bluegrass	*Dichanthium queenslandicum*	Minimum total seed rate of 10-15kg/ha; must include 4 palatable perennial pasture species. Must also include up to 50% native species
Black Speargrass	*Heteropogon contortus*	
Sabi Grass	*Urochloa mosambicensis*	
Rhodes Grass	*Chloris gayana*	
Kangaroo grass	*Themeda triandra*	
Gayndah Buffel grass	*Cenchrus ciliaris*	
Butterfly Pea	*Clitoria ternatea*	
Round-leafed Cassia	*Chamaecrista rotundifolia*	
Red Natal Grass	*Melenis repens*	
Sugar-drip Sorghum	*Sorghum sp.*	
Japanese Millet	*Echnochloa esculenta*	
River She-Oak	*Casuarina cunninghamiana*	
Narrow-leaved Ironbark	*Eucalyptus crebra*	

6.1.9.8 Seed Application

The seeding rate is supplied in Table 37.

6.1.9.9 Infrastructure for Revegetation Protection

Fencing will be used to restrict access to rehabilitated areas by cattle and other fauna if required during vegetation establishment.

6.1.9.10 Growth Media

Stockpiled topsoil on site is suitable and sufficient in quantity to sustain the PMLU as per section 6.1.9.10.

6.1.9.11 Topsoil Depths

Topsoil is to be spread at an average depth of 15 cm. Further information on topsoil methodology is provided above in section 6.1.4.

6.1.9.12 Relationship with PRCP Schedule

The relevant rehabilitation/improvement area is **RA1, RA2, RA3, RA4, RA5, RA6, RA7, RA8, RA9** and **RA10**.

Relevant milestones are **RM5, RM6, RM7** and **RM8**.

6.2 Tailings Storage Facilities

6.2.1 Existing Storage Areas

Tailings disposal is carried out in accordance with the N1 MWMP (Appendix L). The plan includes:

- Tailings and reject material characterisation
- Potential groundwater impacts and management
- Operational objectives and design criteria
- Pumping and water management
- LOM rejects and tailings volumes
- Monitoring and reporting

The five N1-TSF rejects/tailings cells will be rehabilitated to a safe, stable and non-polluting landform with a grazing PMLU.

Detailed cover design for N1—TSF will be determined by cover trials as per section 7.5.2. The installed cover will be effective in mitigating the potential for interaction of contaminants up until when the natural water level rises in the N1 void to create a water cap.

6.2.2 Planned Storage Area

Further tailings storage will be required after the five existing cells at N1- TSF have been filled to capacity. Tailings will be stored in the southern section of the N1 void. Construction will require a built embankment to separate the tailings from the mine affected water in the northern section. The embankment will be at an elevation of 193 m RL and will likely be constructed using coarse rejects. The southern storage area has adequate storage to contain the LOM tailings volume.

As per the IPEE Groundwater Report (Appendix F) N1 void has a maximum modelled water level of 170 m AHD. This is well below the required 217 m AHD groundwater trigger level. Tailings and water levels should stay below the source/sink trigger elevation of 217 m AHD to prevent impacts to groundwater and downstream receptors.

Detailed cover design for N1—TSF will be determined by cover trials as per section 7.5.2.

6.3 Voids

Final voids have been classified as NUMAs as per section 5.2.

6.3.1 Options for Minimising Final Void Area

Final void areas have been minimised to ensure they are within EA limits. The following sections give a summary of operational steps to minimise void size.

6.3.1.1 N1 Pit

N1 pit was largely mined out prior to the Stanmore acquisition of the Mine. N1 pit will be utilised for future tailings storage. Existing areas of in-pit spoil have been used for rejects/tailings disposal.

6.3.1.2 N2 Pit

N2 pit was backfilled to ground level leaving no residual void as per EA requirements.

6.3.1.3 S1 Pit

S1 pit was backfilled to ground level leaving no residual void as per EA requirements.

6.3.1.4 S2 pit

S2 pit will be used as an access point for IPU and is therefore not available for backfill. Existing spoil areas have been reshaped and rehabilitated to the grazing PMLU.

6.3.1.5 S3 Pit

S3 pit has been partially backfilled. Further backfilling is planned which will bring the void base above the long- term groundwater level. This will also enable the walls of void to be rehabilitated to a grazing PMLU as per EA requirements.

6.3.1.6 E1 Pit

The size of E1 pit will be minimised by in-pit dumping where possible. The pit has currently not been mined.

6.3.1.7 E2, E3 and E4 Pit

E2, E3 and E4 pits have been mined together as a single operation. In-pit dumping was employed where possible to minimise out of pit spoil.

6.3.1.8 E5 Pit

The size of E5 pit will be minimised by in-pit dumping where possible. The pit is currently operational.

6.3.2 Void Dimensions

Void dimensions are shown in Figure 12.

6.3.3 Void Stability

Geotechnical stability of the final voids was assessed by Geotek (2022) (Appendix J) and revised in 2024 to reflect the current proposed landform and estimated water levels in the voids (Appendix P).The assessment included stability of the highwall, low wall and end walls of pits N1, S2, S3, E1, E2, E3, E4 and E5. A critical FoS was determined for each area and assessed against typical FoS acceptance criteria *in Guidelines for Open Pit Slope Design* (Read and Stacey 2009). The adapted criteria table is given in Table 38.

Table 38 Typical FoS and PoF Acceptance Criteria (from Wesseloo and Read 2009)

Slope scale	Consequences of failure[3]	Acceptance criteria [4]		
		FoS minimum (min) (static)	**FoS (min) (dynamic)**	**Probability of failure (PoF) maximum (max) P[FoS≤1]**
Overall	Low	1.2-1.3	1.1	10%
	Medium	1.3	1.05	5-10%
	High	1.3-1.5	1.1	≤5%

Table 38 indicates a FoS of 1.5 is appropriate where there is a high consequence of failure and that the FoS would apply to the overall slope. In civil engineering a FoS of 1.5 would be appropriate to permanent works where there is a high level of public exposure such as a road or rail cutting. It is noted the IPE-1 Pit is located in proximity to the Peak Downs Highway which has a high level of public exposure. The nominated target geotechnical FOS for the final voids for the purposes of this report is 1.50. A series of stability analyses was undertaken to determine the FOS for the existing voids and where the calculated FOS was less than 1.50, alternative scenarios were tested to achieve the target FOS. The consequence of failure for the final voids has been assessed as low as shown in section 8.

The results of this assessment are given in Table 39. Results have been colour coded as follows:

- FOS <1.19 red
- FOS 1.20 – 1.49
- FOS ≥ 1.50 green

Table 39 Final Void Stability Assessment Values (GeoTek 2024)

Section line	Water level (m AHD)	Description	Failure Surface	Calculated FoS
IP N1 Pit				
IP-N1-1	197.5	Existing endwall	Circular	1.65
IP-N1-2	197.5	Existing highwall	Circular	2.39
IP-N1-3	197.5	Existing lowwall	Circular	1.01
IP-N1-3	197.5	Existing lowwall – regraded to 18˚	Circular	1.52
IP-N1-4	197.5	Existing highwall	Circular	2.31
IP-N1-5	197.5	Existing endwall	Circular	2.02

Section line	Water level (m AHD)	Description	Failure Surface	Calculated FoS
IP S2 Pit				
IP-S2-1	190.8	Existing endwall – backfill batter 33˚	Circular	1.32
IP-S2-1	190.8	Existing endwall – backfill batter regraded to 27˚	Circular	1.53
IP-S2-2	190.8	Existing highwall – final void lake	Circular	1.58
IP-S2-3	190.8	Existing lowwall	Circular	1.10
IP-S2-3	190.8	Existing lowwall – batter regraded to 20˚	Circular	1.50
IP-S2-4	190.8	Existing highwall – final void lake	Circular	1.68
IP-S2-5	190.8	Existing lowwall batter at 31˚	Circular	1.14
IP-S2-5	190.8	Existing lowwall batter regarded to 20˚		1.55
IP-S2-6	190.8	Existing softwalled endwall	Circular	1.36
IP-S2-6	190.8	Existing softwalled endwall – highly weathered horizon batter regarded to 27˚	Circular	1.66
IP S3 Pit				
IP-S3-1	190.8	Lowwall backfilled – floor level increased to 200 mAHD – slope regarded to 15%	Circular	3.04
IP-S3-1	190.8	Highwall backfilled – floor level increased to 200 mAHD – slope regarded to 25%	Circular	3.88
IPE 1 Pit				
IPE-1-1	203.8	Proposed endwall backfilled to bench level – Tertiary basalt batter 36˚	Circular	2.89
IPE-1-2	203.8	Proposed highwall – final void lake	Circular	2.47
IPE-1-3	203.8	Proposed lowwall – batter at 37˚	Circular	0.99
IPE-1-3	203.8	Proposed lowwall – batter regraded to 23˚	Circular	1.51
IPE 2 Pit				
IPE-2-1	204.9	Existing highwall – final void lake	Circular	3.02

Section line	Water level (m AHD)	Description	Failure Surface	Calculated FoS
IPE-2-2	204.9	Existing low wall	Circular	1.19
IPE-2-2	204.9	Existing lowwall – batter regraded to 20˚	Circular	1.50
IPE-2-3	204.9	Existing endwall – final void lake	Circular	2.47
IPE3 pit				
IPE-3-1	203.7	Existing highwall – final void lake	Circular	2.27
IPE-3-2	203.7	Existing highwall – final void lake	Circular	2.00
IPE-3-3	203.7	Existing lowwall	Circular	1.33
IPE-3-3	203.7	Existing lowwall	Non-Circular	1.57
IPE-3-3	203.7	Existing lowwall spoil – batter regraded to 25˚	Circular	1.51
IPE-3-3	203.7	Existing lowwall spoil – batter regraded to 25˚	Non-circular	1.79
IPE 4 Pit				
IPE-4-1	201.1	Existing lowwall - lower batter	Non-circular	2.11
IPE-4-1	201.1	Existing lowwall - upper level	Non-circular	1.74
IPE-4-2	201.1	Existing endwall – partially backfilled with final void lake	Circular	2.20
IPE-4-3	201.1	Existing highwall – final void lake	Circular	2.59
IPE-4-4	201.1	Existing lowwall easternmost external batter	Non-circular	1.39
IPE-4-4	201.1	Existing lowwall easternmost external batter - batter regraded to 31°	Non-circular	1.55
IPE-4-4	201.1	Existing lowwall eastern internal batter	Circular	1.62
IPE-4-4	201.1	Existing lowwall western internal batter	Non-circular	1.68
IPE-4-5	201.1	Existing highwall - final void lake	Circular	2.28
IPE 5 Pit				
IPE-5-1	202.1	Proposed northern wall - final void lake	Non-circular	3.20

Section line	Water level (m AHD)	Description	Failure Surface	Calculated FoS
IPE-5-2	202.1	Proposed eastern wall - final void lake	Circular	2.49
IPE-5-3	202.1	Proposed southern wall - backfilled	Circular	2.65
IPE-5-4	202.1	Proposed western lowwall - final void lake	Circular	2.14
IPE-5-4	202.1	Proposed western lowwall - backfilled	Circular	1.78

The highwalls in fresh rock achieve a FOS ≥1.50. Highly weathered rock and soil horizons at the top of highwalls typically have a FOS <1.50, however, these are usually less than 20 m thick. They have been excavated to batter angles around 45˚ and can be reshaped or allowed to erode to a stable slope of around 27˚.

Overburden dumps where the base of the spoil is not inundated by a final void lake have critical FOS of ≥1.50. Where the base of the spoil has been inundated, the critical FOS is <1.50. To achieve a FOS ≥1.50, the most practical solution would be to level the existing spoil down to angles that would range between 18˚ to 27˚, dependent on the specific pit geometries. As shown in Table 39, the geotechnical assessment concludes the endwall and highwall for the IPE-1 pit will achieve a factor of safety equal to 2.89 and 2.47 respectively. The proposed lowwall results in a critical factor of safety =0.99. Moving the spoil with a dozer to an angle of 23° results in a critical Factor of Safety (FOS) of 1.51 for the circular failure mode.

6.3.4 Void Hydrology

6.3.4.1 Water Balance and Long-Term Water Quality

Long term water modelling of the final voids available in Appendix M show the final water levels and quality projections for voids at the Mine are:

E2 and E3 Pit

- Water level reaches equilibrium between 175 m AHD and 190 m AHD after 100 years
- Maximum modelled water level is around 37 m below the source/sink threshold level of 227.7 m AHD
- Salt is expected to accumulate at an average rate of 645 tonnes per year (t/yr) and the voids are expected to become hyper-saline (>53,850 µS/cm) after 60 years

E4 Pit

- Water level reaches equilibrium between 155 m AHD and 170 m AHD after 100 years
- Maximum modelled water level is around 48 m below the source/sink threshold level of 225.6 m AHD
- Salt is expected to accumulate at an average rate of 1,445 t/yr and the void is expected to become hyper-saline (>53,850 µS/cm) after 60 years

E5 Pit

- Water level reaches equilibrium between 170 m AHD and 180 m AHD after 100 years
- Maximum modelled water level is around 44 m below the sink/source threshold level of 228.5 m AHD
- Salt is expected to accumulate at an average rate of 230 t/yr the void is expected to become hyper-saline (>53,850 µS/cm) after 40 years

N1 Pit

- Water level reaches equilibrium between 170 m AHD and 185 m AHD after 100 years

- Maximum modelled water level is around 13 m below the source/sink threshold level of 215.0 m AHD
- Salt is expected to accumulate at an average rate of 220 t/yr the void is expected to become hyper-saline (>53,850 µS/cm) after 40 years

S2 Pit

- Water level reaches equilibrium between 155 m AHD and 170 m AHD after 100 years
- Maximum modelled water level is around 45 m below the source/sink threshold level of 214.1 m AHD
- Salt is expected to accumulate at an average rate of 375 t/yr the void is expected to become hyper-saline (>53,850 µS/cm) after 40 years

Modelling of the final void water balance at the Mine shows that all final voids will remain as groundwater sinks in the long term.

6.3.5 Rehabilitation Strategies

6.3.5.1 N1 Pit

The final highwall and end wall for N1 pit are geotechnically stable and do not require further treatment. The low wall is not currently stable and will be regraded to 18° as per section 6.3.3. Rehabilitation of the out of spoil was completed in 2020 with in pit spoil rehabilitation progressing as mining advanced. The remaining areas of in pit spoil are being utilised for disposal of rejects and tailing. The rejects cells will be capped with inert spoil as they become available. The cover thickness will be determined by rehabilitation trials as per section 7.5. They will then be reshaped and rehabilitated to a PMLU of grazing.

The in-pit tailings storage facility will be capped with inert spoil from the adjacent dragline spoil. The cover thickness will be determined by rehabilitation trials as per section 6.5.2. This storage facility will be below the long term recovered ground water level and will remain part of the N1 pit NUMA.

6.3.5.2 S2 Pit

The central S2 ramp will be used as access for IPU with new facilities proposed to support the Mine on the backfill spoil to the south. Once the underground mine is completed it will be possible to reshape the batters of the access ramp and reshape the northern low wall spoil to 20° as per section 6.3.3.

The final highwall and end wall for S2 pit are geotechnically stable and do not require further treatment.

6.3.5.3 S3 Pit

S3 pit requires further backfill to bring the base of the void above the long-term water level. The pit may also be used for the disposal of rejects however further studies will be required prior to this action.

Once backfilling is completed the internal batters around the void will be reshaped to 15%, topsoiled and seeded to support the PMLU of grazing. The final highwall has been assessed as geotechnically stable as per section 6.3.3.

6.3.5.4 E1 Pit

Mining has not started in E1 pit. When mining is completed there will be a residual void. Out of pit spoil will be reshaped to 15%, topsoiled and seeded to support the grazing PMLU. In pit spoil will be reshaped to achieve a minimum FoS of 1.5 as per section 6.3.3.

6.3.5.5 E2 Pit

Out of pit batters on the low wall side will be reshaped to 15%, topsoiled and seeded to support the grazing PMLU. The final highwall and end wall has been assessed as geotechnically stable. The existing low wall batter will be regarded to 20° as per section 6.3.3 and do not require further treatment.

6.3.5.6 E3 Pit

Out of pit batters on the low wall side will be reshaped to 15%, topsoiled and seeded to support the grazing PMLU. The final highwall and low wall has been assessed as geotechnically stable as per section 6.3.3 and do not require further treatment.

6.3.5.7 E4 Pit

Out of pit batters on the low wall side will be reshaped to 15%, topsoiled and seeded to support the grazing PMLU. The final highwall has been assessed as geotechnically stable as per section 6.3.3 and do not require further treatment. The exiting low wall easternmost external batter will be regraded to 31°. The northern end wall will be mined as part of the E4 pit extension.

6.3.5.8 E5 Pit

E5 pit is currently operational. When mining is completed there will be a residual void. Out of pit spoil will be reshaped to 15%, topsoiled and seeded to support the grazing PMLU. In pit spoil will be reshaped to achieve a minimum FoS of 1.2 as per section 6.3.3.

6.4 Underground Mining

Mine approvals include the development of IPU located to the east of the existing IPM open cut pits and west of the IPE open cut pits. IPU has been designed as a bord and pillar operation which will extract coal from the 3-4.5 m thick Leichardt Seam within the Rangal Coal Measures. The planned working depth extends from around 90 m at the highwall entries off the existing open cut operation (S2 pit) to over 350m in the eastern extent. Secondary reserve extraction will be via bottom coal recovery.

6.4.1 Geotechnical Study

A geotechnical assessment for IPU was undertaken by Blackrock in 2018 (Appendix H). The desktop assessment identified preferred parameters to provide adequate stability for bord and pillar mining operations. The stability assessment was done using the empirical Coal Mine Roof Rating (CMRR) method, which is an accepted methodology for quantifying geotechnical properties of coal mine strata.

The analysis, supported by empirical data indicates that to a depth of 250 m, extended cut, two pass bord and pillar workings can be undertaken using what is considered a low support density with a suitable TARP system to accommodate deteriorating or structured conditions. At depths of greater than 250 m the support density is required to increase.

Analysis of the pillar geometries was undertaken using the University of New South Wales (UNSW) pillar geometry criteria for a range of extraction heights from 3 m through to 4.5 m (full seam extraction). The analysis undertaken was based on the assumption that the FoS was maintained at a minimum of 1.6 under the flood plain areas and 2.11 under the designated Smoky Creek Channel as per environmental approval requirements.

6.4.2 Groundwater

The bord and pillar mining methodology proposed will involve dewatering at the site causing depressurisation of the overlying and surrounding strata. Mining operations is estimated to be at a depth of 290 m to access the target coal seam at a lower elevation than the IPC open cut pits. The following activities have been identified as having the potential to impact the groundwater at the Mine (KCB, 2019):

- The extraction of coal through bord and pillar mining, with associated depressurisation of the surrounding strata
- The use of hydrocarbons and chemicals which may result in groundwater contamination

Modelling completed by KCB (2019) (Appendix G) provides predictions detailing the impacts that may occur during mining operations at IPU.

Post-closure groundwater levels are not predicted to recover above surface levels, except within the pit voids, therefore, impacts associated with discharge to the surface are not predicted.

6.4.2.1 Drawdown and Depressurisation

The model shows that depressurisation will occur locally in the Mine area by approximately 260 m. This is expected to be most prominent in the north-eastern part of the IPU area where mining with be at a depth of 290 m. Depressurisation is mainly constrained to the coal seam but is predicted to extend to the upper weathered profile of the Permian and Triassic sediments to the north and the east of the Mine. Minor localised depressurisation is expected to the east of the Mine area.

6.4.2.2 Groundwater Take

The modelled groundwater take peaks at 1,200 megalitres per year (ML/yr) during mining operations. Actual loss of groundwater to the regime will be less than the modelled value as groundwater will be lost to wetting surfaces, ventilation and retained moisture within the coal.

6.4.2.3 Post Closure Recovery

The model predicts that depressurisation in the Mine area will recover in approximately 50 years post mining.

6.4.2.4 Conceptual Cross-Section

Figure 23 Conceptual Cross Section (KCB 2019) shows a conceptual cross-section of IPU.

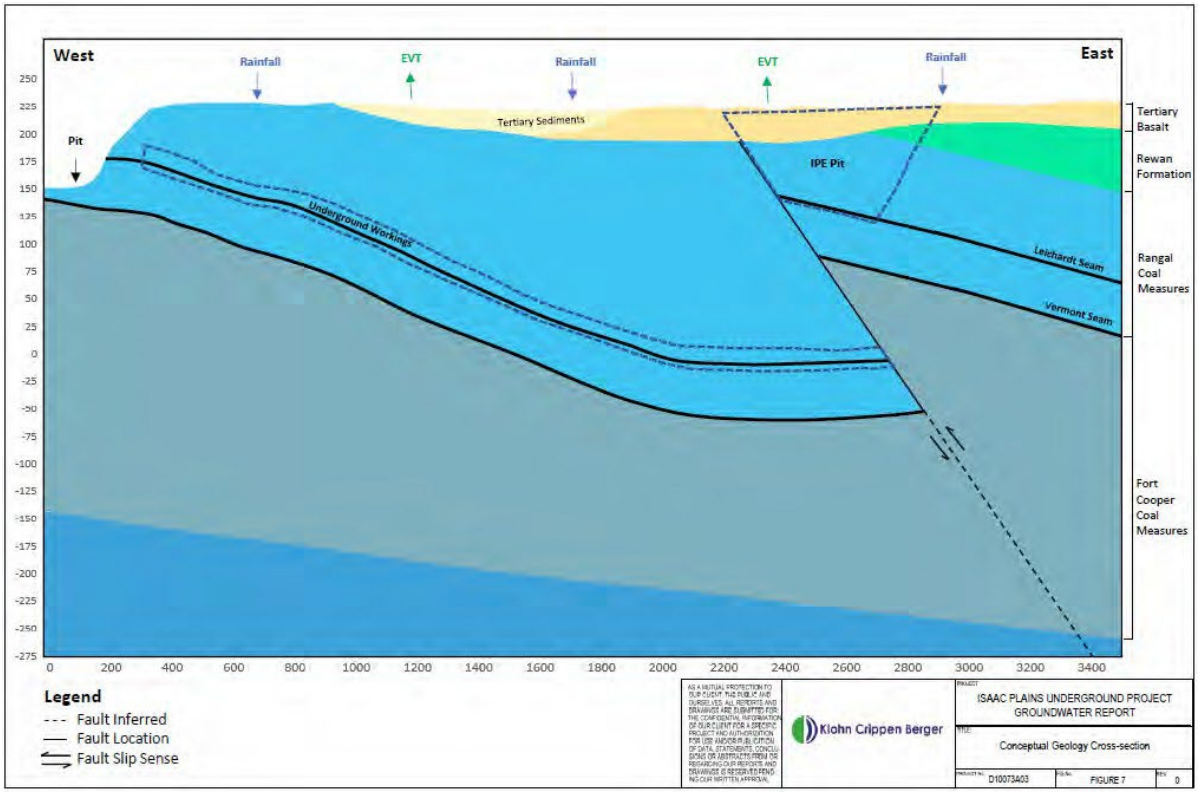


Figure 23 Conceptual Cross Section (KCB 2019)

6.4.3 Subsidence

In contrast to high extraction mining such as longwall mining, partial pillar extraction areas are not expected to cave or induce caving related subsidence. Any surface subsidence above stable bord and pillar areas such as those with FoS of 1.6 and width to height ratios greater than 5 is almost entirely as a result of elastic compression of the coal pillars and the resulting sag of the overlying strata. The subsidence at the surface above the pillars can be estimated to equal the expected elastic compression of the pillars and the immediate roof and floor strata.

The expected surface deflection above the first workings panels, based on the pillar dimensions provided at all depths of the IPU reserve will be in the order of 20-60 mm. The limit of resolution is typically 20 mm on

subsidence surveys and the swell and shrink of the soils in the Bowen Basin will likely mask this level of movement.

Above the secondary working Modified Duncan panels where the narrow pillars and bell outs are extracted the remaining larger pillars have a FoS of 1.6 and width: height ratios in excess of seven. As such these are considered as long-term stable pillars with minimal risk of floor punching. The unsupported spans in these extraction panels may result in some degree of roof spall and sag, but no true caving of the strata is expected. In the Modified Duncan panels the level of surface deflection is expected to be in the region of 100 mm to 150 mm.

6.4.4 Sealing of Workings

Rehabilitation and sealing of underground workings will be conducted in accordance with section 325 of the *Coal Mining Safety and Health Regulation 2017.* Consideration will be given to the following when construction seals:

- Design criteria
- Strength of materials
- Placement of seals
- Placement and number of sampling tubes
- Tying in hatches
- Service pipes

The Underground Mine Manager will review the quality control of the installed product, validate the engineering integrity of the seal via an engineering review and regularly review the relevant Safety and Health Management System documentation as per the guidance issued by the Chief Inspector of Coal Mines.

6.5 Built Infrastructure

6.5.1 MIA and Rail Facilities

Rehabilitation of the MIA will include the decommissioning and removal of a number of structures. Removeable infrastructure to be removed includes:

- CHPP buildings and structures
- Rail loop
- Powerlines
- Workshops
- Demountable buildings
- Sheds
- Chemical and fuel storage areas
- Laydown areas

A contaminated land assessment will be completed to determine the presence of contamination in infrastructure areas. If contamination is detected the contaminated material must be removed off-site or disposed of in the in- pit tailings storage facility. Evidence must be provided that contaminated areas have been remediated for rehabilitation activities. The area will be topsoiled and seeded to the PMLU of grazing.

6.5.2 ROM and Product Stockpiles

ROM and product stockpiles will have remnant coal and rejects material removed and disposed of in the N1 tailings storage facility. The area will be reshaped, topsoiled and seeded to a grazing PMLU.

6.5.3 Roads and Tracks

6.5.3.1 Roads

All roads will require decommissioning unless an agreement with the underlying landholder exists. All hard materials on roads such as bitumen or spoil will be removed and disposed of on site in a hydraulically secure location. Roads must be reshaped to suit the surrounding landscape and drainage features. Once reshaping has been completed the area will be ripped, topsoiled and seeded with the appropriate seed mix.

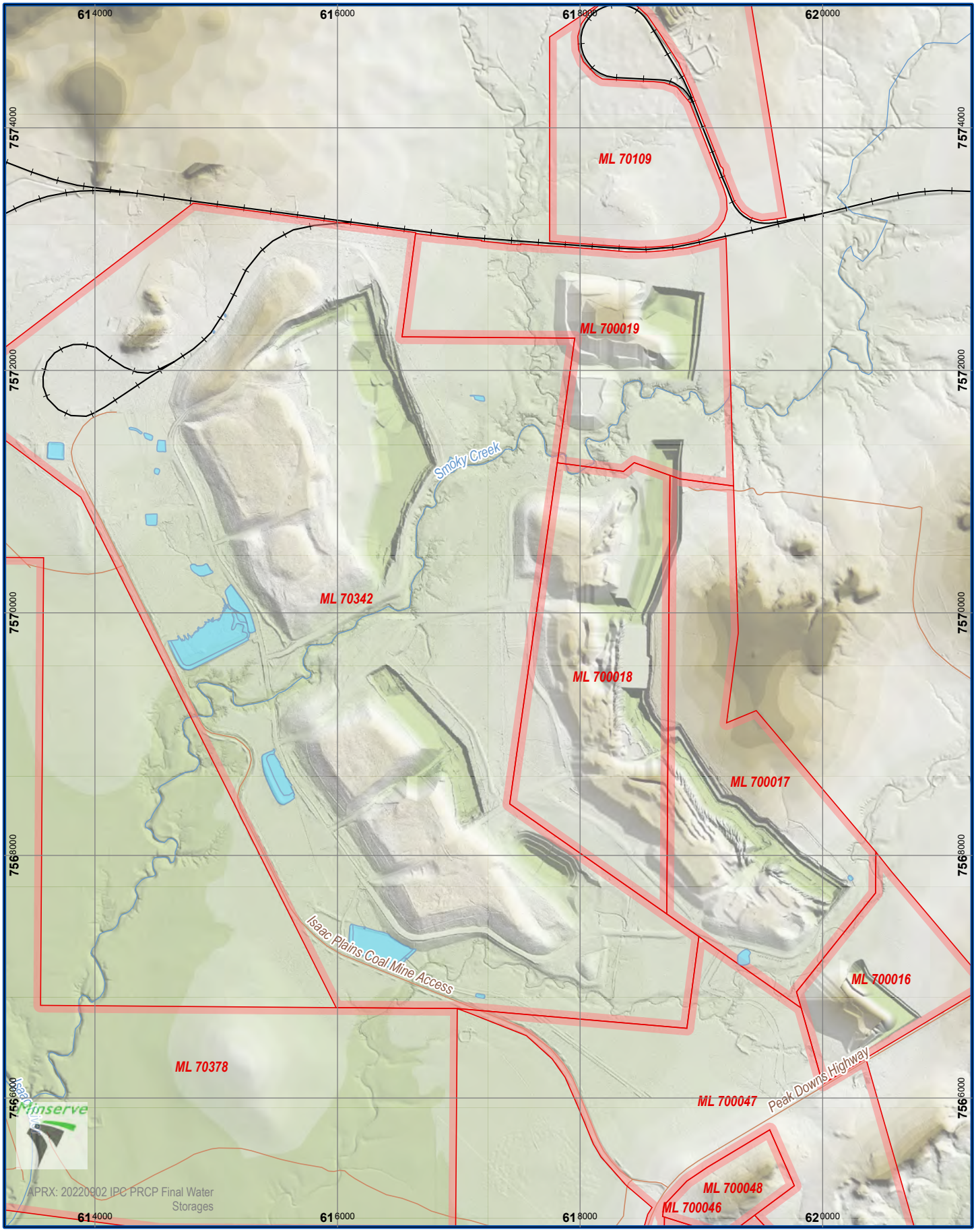
6.5.3.2 Tracks

Tracks will be assessed for compaction and ripping will take place if the track does not look suitable for local vegetation to re-establish autonomously. The area may be lightly seeded with the appropriate seed mix to promote revegetation.

6.5.4 Dams and Water Infrastructure

6.5.4.1 Dams

All water storage dams at the Mine are to be retained for landowner use as per a written agreement in accordance with condition F5 of the EA. Retained infrastructure has a PMLU of water storage. The written agreement can be seen in Appendix N. The location of all current and proposed dams that will be retained for landowner use is shown in Figure 24.



ML
Waterway
Railway
Road
Dams Retained for Landowner

N

0 500 1,000 1,500 2,000 2,500
Meters

stanmore

Location of All Dams Retained for Landowner Use
Figure 25

6.5.4.2 Water Infrastructure

Other water infrastructure includes clean, process and sediment water drains. These areas will require reshaping by a dozer, topsoiling and seeding to a PMLU of grazing.

6.5.5 Topsoil Stockpiles

Topsoil will be removed from stockpiles and used in rehabilitation. When stockpiles are exhausted, they will be ripped and seeded to a grazing PMLU. If excess topsoil remains in stockpiles, it will be reshaped, ripped and seeded to a grazing PMLU.

6.5.6 Exploration Areas

The methodology used to rehabilitate drill pads at the Mine is consistent with the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME) 1995. Drill holes will be sealed with a plug made from a durable material. Sumps will be backfilled and the space above the plug will be filled with rock, soil or drill cuttings to above ground level to allow for subsidence and settlement. Topsoil (if required) will be spread across the drill pad, followed by ripping and seeding.

6.5.7 Subsidence Areas

The proposed underground development will be undertaken using 'bord and pillar' methods, which is not predicted to result in any significant subsidence above the underground workings. Where areas impacted by subsidence have been identified, they will be remediated to allow for surface water runoff to drain, and to limit ponding of water and capture of overland flow, in accordance with condition F20 of the EA. These areas will be ripped and reshaped as required. Seed will be applied in areas where natural regrowth is not sufficient.

6.5.8 Gas Infrastructure

Gas infrastructure is owned by other third parties but is situated on the Mine. Infrastructure removal will be the responsibility of other parties. These areas are expected to self-recruit given the minimal disturbance.

6.5.9 Heritage

Stanmore's CHA with the Barada Barna Aboriginal Corporation states that Stanmore and the Barada Barna Aboriginal Party will manage operational activities undertaken in the Mine area so as to avoid or otherwise reasonably minimise harm to Aboriginal Cultural Heritage. This will be achieved by taking the cultural heritage compliance measures listed in the CHA. Operational activities include:

- No impact activities (class A)
- Activities consistent with the previous land use impacts (class B)
- Activities inconsistent with previous land use impacts (class C)
- New projects (class D)

6.6 Rehabilitation Maintenance

Maintenance of rehabilitated areas must take place to demonstrate:

- Stability of landforms
- Erosion control measures remain effective
- Stormwater runoff and seepage from rehabilitated areas does not negatively affect the environmental values of any waters
- Vegetation establishment and continued growth is occurring and rehabilitated areas are managed regarding declared pest plants

Maintenance activities on rehabilitation areas will be guided by general site inspections and rehabilitation monitoring results. Maintenance activities may include:

- Maintenance of new vegetation, e.g. addition of fertiliser, re-planting of significant areas of failed vegetation, etc
- Repair of failed drainage or significantly eroded areas
- Modifications to landforms or structures to improve management of surface water runoff
- Upkeep of water management structures
- Removal of temporary drainage structures not required for long-term stability
- Replacement and repairs to fencing and signage

7. RISK ASSESSMENT

Identifying environmental, community, social and economic impacts and risks associated with closure and rehabilitation is critical for effective closure and rehabilitation planning. The overall objective of the closure and rehabilitation risk assessment (the risk assessment) is to identify risks of a stable condition for land not being achieved and how Stanmore intends to manage or mitigate the identified risks in accordance with Section 126C(1)(f) of the EP Act. The meaning of a 'stable condition' is given in Section 111A of the EP Act:

111A Meaning of a stable condition

Land is in a stable condition if —

a. The land is safe and structurally stable

b. There is no environmental harm being caused by anything on or in the land

c. The land can sustain a post-mining land use

The risk assessment was developed considering the standard AS ISO 31000:2018 Risk Management — Guidelines. Risks and opportunities were identified for all decommissioning, demolition and closure and rehabilitation related activities that are yet to have occurred, or already have occurred at the Mine. The post closure and rehabilitation monitoring periods were also included. The risk management process is shown in Figure 25.

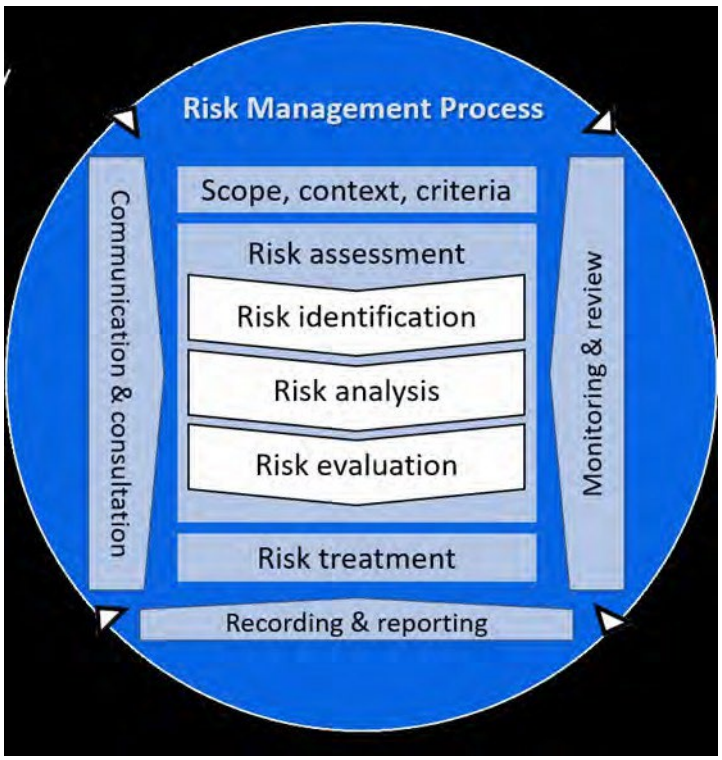


Figure 25 Risk Management Process Overview

7.1 Risk Identification

The risk identification step was used to:

- Identify and define risks to land being safe and structurally stable
- Identify and define risks which have the potential to adversely affect environmental values (EVs)
- Identify and define risks to land sustaining the PMLU

7.2 Risk Analysis

The risk analysis process considered the maximum probable outcome for each identified risk with the current control measures in place. Each identified risk was then analysed using the consequence categories and associated criteria given in Figure 26 and the likelihood categories in Figure 27. This determined the risk rankings also given in Figure 28.

The 'Environmental Impact' consequence category from the Stanmore standard consequence table was the only category considered during the risk assessment process. This is to ensure that only environmental risks associated with land not achieving a stable condition are considered, as per the requirements of the PRC guideline. This consequence category was further broken down into three broad categories based on the EP Act definition of a 'stable condition'. These categories are:

- Safe and stable
- Impact to EV's
- Impact to the potential PMLU

CONSEQUENCE	DEFINITIONS				
LOSS TYPE	**1 - Insignificant**	**2 - Minor**	**3 - Medium**	**4 - Major**	**5 - Catastrophic**
Environmental Impact	Environmental nuisance; small short-term impact to area of low significance with minimal or no physical remediation required; no regulatory breach.	Minor environmental harm; recurring remediation; reportable breach; minor non-compliance; potential warning notice.	Serious environmental harm; locally significant, short-term reversible impact; infringement notice but prosecution unlikely	Major environmental harm; locally significant, medium-term impact to natural environment; adverse community health statistics potentially linked to operation.	Extreme environmental harm; regionally significant, irreversible impact; adverse community health impacts.

Figure 26 Modified Consequence Table

LIKELIHOOD	Benchmark Guide	Indicative Probability
5 - Almost Certain	Is currently occurring or will almost definitely occur within 12 months in the construction or heavy industries	> 90%
4 - Likely	Has occurred or could be expected to occur within 12 months within the construction or heavy industries	70 – 90%
3 - Possible	Has occurred or may occur with 1-5 years within the construction or heavy industries	30 – 70%
2 - Unlikely	Has occurred or may occur with 5-10 years within the construction or heavy industries	10 – 30%
1 - Rare	Has occurred or may occur once per 10+ years, although only in exceptional circumstances, within the construction or heavy industries	< 10%

Figure 27 Likelihood Table

LEVEL OF RISK	CONSEQUENCE				
LIKELIHOOD	**Insignificant**	**Minor**	**Medium**	**Major**	**Catastrophic**
Almost Certain	11 (H)	16 (H)	20 (H)	23 (E)	25 (E)
Likely	7 (M)	12 (H)	17 (H)	21 (E)	24 (E)
Possible	4 (L)	8 (M)	13 (H)	18 (E)	22 (E)
Unlikely	2 (L)	5 (L)	9 (M)	14 (H)	19 (E)
Rare	1 (L)	3 (L)	6 (M)	10 (H)	15 (H)

Figure 28 Risk Matrix

7.3 Risk Evaluation

Risk evaluation involves comparing the results of the risk analysis with the establishment of risk criteria to determine where additional action is required. Additional actions may include:

- Do nothing further
- Consider risk treatment options
- Undertake further analysis
- Maintain existing controls
- Reconsider objectives

The results of the PMLU and NUMA risks assessment are given in Table 40 and Table 41 respectively.

7.4 Risk Treatment

Risk treatment involves evaluating options for the management or mitigation of identified risks. The most appropriate risk treatment options (proposed actions) have been selected based on multiple criteria including cost benefit, regulatory obligations, community responsibility and protection of EVs. Actions to apply these options have been allocated to the appropriate work parties, scheduled and performance measures and constraints identified.

7.4.1 Residual Risk

The nominated treatment options have been assessed as adequate in reducing the original risk ranking to an acceptable level. The risk treatments and the remaining risk should be monitored and reviewed regularly with any significant changes or emerging issues communicated with relevant parties. Treatments may be modified, replaced, or complemented with additional treatments as needed to make sure an acceptable level of risk is maintained.

Table 40 Risk Identification, Analysis and Evaluation – PMLU

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Responsibility	Resource requirements	Performance measures	Reporting and monitoring	Timing and scheduling	Residual risk		
				Consequence	Likelihood	Risk score								Consequence	Likelihood	Risk score
RM1 - Infrastructure Decommissioning and Removal	Inadequate removal of infrastructure	Safe and stable	Infrastructure may create erosion points causing instability Remnant infrastructure is a hazard to fauna or grazing animals	2	3	8	Mine plans show locations of infrastructure PRC plan includes infrastructure removal Infrastructure may only be retained with written landholder approval Infrastructure included in ERC	Including in PRC and ERC ensures a documented and auditable record of infrastructure removal requirements and provides direction for planning and provisioning.	Site management team	Survey support GIS support	Decommissioning checklist (to be developed)	Visual inspection	Following removal	2	2	5
RM2 – Remediation of Contaminated Land	Residual contamination of land	Impact to EV's	Contaminated soil and / or impacts to downstream water quality	3	2	9	PRC includes identification, assessment and proper disposal of contaminated soil Contaminated soil disposal included in ERC Monitor incidents involving hydrocarbon or chemical spills Utilise site Spill Response Plan AS1940 audits and inspections Validation testing following contaminated land clean up	The inclusion in PRC/ERC allows for proper budgeting and planning of contaminated soil disposal/treatment. Effective spill controls and auditing allows for high- risk areas to be identified and prioritised for treatment. Validation testing will verify if contamination has been appropriately remediated.	Site management team	SafeX (incident recording) Spill response procedure Auditing and inspection tools Contaminated land assessment (by AQP)	Contaminated land assessment	Contaminated land assessment to be completed post operations (as necessary) and included in the final relinquishment report	Prior to further earthworks	1	2	2
		PMLU	Contamination impacts PMLU	3	2	9								1	2	2

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Responsibility	Resource requirements	Performance measures	Reporting and monitoring	Timing and scheduling	Residual risk		
				Consequence	Likelihood	Risk score								Consequence	Likelihood	Risk score
RM3 - Landform Development and Reshaping/Reprofiling	Excessive slope on landform	Safe and stable	Increased erosion risk if slope exceeds material limits	3	2	9	GPS guidance and survey control during landform construction GPS guidance and survey control during landform reshaping	Current slopes have been designed with regard to material limitations. GPS and survey controls will ensure the landform is constructed as per design.	Site manage ment team	Survey support GPS machine guidance	Review of survey data vs design	As per section 8.7	During construction / annually	2	2	5
		PMLU	Steep slopes not suitable for cattle and / or landholder access	3	2	9	Current design slope within accepted limits for grazing / landholder access GPS guidance and survey control during landform reshaping Grazing trials	Landform slopes of equal to or less than 15% for grazing is well within limits for cattle and landholder access. GPS and survey controls will ensure the landform is constructed as per design. Rehabilitation monitoring to demonstrate suitability	Site manage ment team	Survey support GPS machine guidance Rehabilitation monitoring data	Review of survey data vs design	As per section 8.7	Annually	2	2	5
	Structural stability of landforms not achieved	Safe and stable	Constructed landforms not geotechnically stable	4	2	14	Current design assessed as geotechnically stable Geotechnical monitoring during operations Ensure deviations from design are reassessed by a geotechnical engineer (AQP)	Landform slopes are designed to be geotechnically stable for the construction (dumped) material. Monitoring during operations can be used to validate the proposed design and update if required.	Site manage ment team	Geotechnical monitoring data	Review of monitoring data vs predicted behaviour	As per section 8.7	During construction / annually	3	2	9

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Responsibility	Resource requirements	Performance measures	Reporting and monitoring	Timing and scheduling	Residual risk		
				Consequence	Likelihood	Risk score								Consequence	Likelihood	Risk score
RM4 — Installation of cover system	Ineffective drainage on final landform	Safe and stable	Damage to previously completed rehabilitation Increased likelihood of erosion Ponding causes instability	2	3	8	Drainage considerations included in final landform design Rehabilitation monitoring Erosion and sediment control plan (ESCP) monitoring Receiving environment monitoring program (REMP)	Rehabilitation planning and methodology includes effective drainage. Rehabilitation and ESCP monitoring will monitor effectiveness of landform drainage.	Site manage ment team	Rehabilitation monitoring program, ESCP monitoring program REMP monitoring	Monitoring data	As per section 8.5 and section 8.9	As per section 8.8 and section 8.9	2	2	5
		Impact to EV's	Increased risk of downstream sedimentation	2	3	8								2	2	5
	Adequate quantity/quality of materials not available for the cover system	Safe and stable	Cover system not installed to design	3	2	9	Materials balance Shows adequate material availability Material characterisation shows material suitable for use as a cover Rehabilitation trials on proposed cover system	Material balance and testing demonstrates suitability of available material. Field trials of cover systems to determine final design.	Site manage ment team	Survey support Material characterisation data ERC calculator	ERC volumes Survey support	Survey checks Results of rehabilitatio n trials	Prior to construction	2	2	5
	Cover system not effective due to design fault	Impact to EV's, safe and stable	Cover system ineffective leading to instability and potential impact to surface and groundwater	4	2	14	Cover trials as per section 8.5.2	Cover trials will field verify cover designs as performing effectively	Site manage ment team	Cover trial data	Cover trial outcomes	Cover trials as per section 7.5.2	Cover trials as per section 7.5.2	2	2	5
	Excessive erosion or instability of the rehabilitate d tailings	Safe and Stable / PMLU	Area not geotechnically or erosionally stable impacting the PMLU	3	2	9	Geotechnical monitoring Rehabilitation monitoring	Monitoring to confirm stability of cover system or to provide an early indication of potential issues	Site manage ment team	Geotechnical monitoring program	As per section 8.7	As per section 8.7	As per section 8.8	2	2	5

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Responsibility	Resource requirements	Performance measures	Reporting and monitoring	Timing and scheduling	Residual risk		
				Consequence	Likelihood	Risk score								Consequence	Likelihood	Risk score
	storage area impacts the PMLU															
	Insufficient topsoil reserves	PMLU	Inadequate topsoil to establish vegetation and support PMLU	2	3	8	Projected inventory of stripped topsoil adequate for rehabilitation Topsoil inventory and mapping to be maintained during operations Review of topsoil inventory against rehabilitation requirements Topsoil volumes and requirements included in ERC	Available volume of topsoil is adequate for rehabilitation of disturbed areas. Maintaining a topsoil inventory and mapping allows for regular checks against requirements including ERC.	Site manage ment team	Survey support Topsoil inventory tool ERC calculator	Topsoil inventory tool and ERC volumes Survey support	Survey checks	After use of stockpile in rehabilitation	2	2	5
RM5 – Surface preparation	Inadequate topsoil cover	PMLU	Failed vegetation establishment not supporting the PMLU	2	3	8	Projected inventory of stripped topsoil adequate for rehabilitation GPS and survey control during topsoiling Supervision during topsoiling Test-pitting of topsoil depths prior to seeding	Survey and test - pitting checks to ensure minimum topsoil depth is applied	Site manage ment team	Survey support Topsoil inventory tool	Topsoil depths (field verified) Survey data (eg. LiDAR)	Survey checks	Immediately following topsoiling	2	2	5

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Responsibility	Resource requirements	Performance measures	Reporting and monitoring	Timing and scheduling	Residual risk		
				Consequence	Likelihood	Risk score								Consequence	Likelihood	Risk score
RM6 - Revegetation	Topsoil not suitable for target vegetation	PMLU	Topsoil unable to support target rehabilitation species	3	2	9	Topsoil management plan outlines topsoil stripping, handling and storage requirement Long history of established rehabilitation with target species present Rehabilitation monitoring includes soil analysis Rehabilitation trials	Rehabilitation species selected have been successful in previous rehabilitation and are suitable for the soil type. Appropriate management will maintain the integrity of the topsoil resource. Rehabilitation monitoring and trials will inform success	Site manage ment team	Topsoil management plan Survey support Topsoil inventory tool Rehabilitation monitoring program Rehabilitation trials	Rehabilitation monitoring data	Rehabilitatio n monitoring report	Annual rehabilitation monitoring	2	2	4
	Heavy rainfall prior to vegetation establishm ent	PMLU, safe and stable	Loss of topsoil resource preventing adequate vegetation establishment, excessive erosion and instability of slope	3	3	13	Seeding to be scheduled immediately following surface preparation Seeding not scheduled prior to large rain events Cover crop included in seed mix	Appropriate timing of topsoiling/seeding reduces the risk of weather impacting vegetation establishment	Site manage ment team	PRC schedule	PRC schedule audits	As required	As required	2	3	8
	Inadequate ripping (not completed, downslope or insufficient depth)	Safe and stable	Topsoil not keyed into subsoil allows excessive erosion or downslope rip lines create erosion channels	2	3	8	Rehabilitation methodology includes cross slope ripping Supervision during ripping operations Visual inspection of ripped surface ESCP monitoring	Supervision during ripping to ensure correct direction and depth is achieved. Inspections following ripping provide visual confirmation.	Site manage ment team	Rehabilitation monitoring program ESCP monitoring	Rehabilitation monitoring data ESCP monitoring data	Visual inspection	Immediately after ripping	2	2	5

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Responsibility	Resource requirements	Performance measures	Reporting and monitoring	Timing and scheduling	Residual risk		
				Consequence	Likelihood	Risk score								Consequence	Likelihood	Risk score
RM7 – Achievement of surface requirements	Seed quality or application not Sufficient for vegetation establishment	PMLU	Vegetation does not adequately establish to support PMLU	2	3	8	Seed mix and rate based on local conditions Seed quality and viability testing included in procurement Rehabilitation monitoring	Seed mix and rate based on local conditions Seed quality and viability testing included in procurement Rehabilitation monitoring	Site management team	Seed quality and validation tests Rehabilitation monitoring program	Test results Rehabilitation monitoring results	As per section 8.6	Prior to and immediately after seeding	2	2	5
	Inadequate vegetation cover for grazing	PMLU	Vegetation cover insufficient to support the PMLU	3	2	9	Seed mix and rate based on local conditions and PMLU Rehabilitation monitoring to inform potential changes to mix or application rate Rehabilitation trials to demonstrate it can support the PMLU	Seed mix is consistent with previous rehabilitation and other mine rehabilitation in the Bowen Basin.	Site management team	Rehabilitation monitoring program	Rehabilitation monitoring data	As per section 8.6	As per section 8.8	2	2	5
	Groundcover not sufficient for surface stabilisation	Safe and stable	Inadequate groundcover establishment causes excessive erosion rates	3	2	9	Seed mix and rate based on local conditions Cover crop included in seed mix Rehabilitation monitoring	Species selection includes appropriate groundcover species. Rehabilitation monitoring will inform success.	Site management team	Rehabilitation monitoring program	Rehabilitation monitoring data	As per section 8.6	As per section 8.8	2	2	5
RM8 - Achievement of post-mining land use to a stable condition	Revegetated areas dominated by weeds	PMLU	Weeds	3	2	9	Seed testing included in procurement Weed inspections of rehabilitation machinery Rehabilitation monitoring Weed management plan	Seed testing to verify the quality of seed and the absence of weed species. Inspection and cleaning of equipment to help stop spread of weed species. Weed management plan outlines management options.	Site management team	Rehabilitation monitoring program Equipment inspection checklist Weed management plan	Rehabilitation monitoring data	As per section 8.6	As per section 8.8	2	2	5

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Responsibility	Resource requirements	Performance measures	Reporting and monitoring	Timing and scheduling	Residual risk		
				Consequence	Likelihood	Risk score								Consequence	Likelihood	Risk score
	Erosion rates exceed accepted levels	Safe and stable	Excessive erosion causes instability of landform	3	2	9	Established rehabilitation shows minimal erosion		Site manage ment team	LiDAR survey	As per section 8.5.2	As per section 8.5.2	As per section 8.5.2	2	2	5
	Contamina nts from the tailings storage areas migrate to the environme nt due to an ineffective cover system	Impact to EV's	Contamination of groundwater / downstream surface water	4	3	18	Groundwater monitoring Surface water/seepage monitoring	Monitoring to confirm cover effectiveness or to provide an early indication of potential issues	Site manage ment team	GW monitoring program Surface water monitoring program	As per section 8.3 and section 8.4	As per section 8.3 and section 8.4	As per section 8.3 and section 8.4	3	2	9
	Lack of rehabilitatio n maintenanc e i.e. Repair of significant erosion	Safe and stable	Excessive erosion progressively impacts stability of final landform	3	2	9	Rehabilitation monitoring determines maintenance requirements Rehabilitation maintenance program	Regular monitoring and maintenance of rehabilitation allows issues to be addressed promptly.	Site manage ment team	Rehabilitation monitoring and maintenance program	As per section 8.5 and section 8.6	As per section 8.5 and section 8.6	As per section 8.5 and section 8.6	2	2	5
	Inappropria te final land use	PMLU	Loss of land resource and conflict with stakeholder engagement outcomes	3	2	9	Soils and rehabilitation design assessed as suitable for the PMLU's PMLU's compatible with surrounding land uses Rehabilitation monitoring	The selected PMLU's are consistent with surrounding land uses and would be expected to be suitable	Site manage ment team	Rehabilitation monitoring program	Rehabilitation monitoring data	As per section 8.6	As per section 8.6	2	2	5
	Rehabilitati on vegetation lost or damaged due to bushfire	Impact to EV's	Loss of biodiversity Damage to previously completed rehabilitation	3	2	9	Rehabilitation monitoring Bushfire management Selective grazing	Rehabilitation monitoring will identify areas requiring grazing or fire management to reduce fuel load	Site manage ment team	Rehabilitation monitoring program Bushfire management plan	Visual inspection and as per section 8.6	Visual inspection and as per section 8.6	Visual inspection and as per section 8.6	2	2	5

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Responsibility	Resource requirements	Performance measures	Reporting and monitoring	Timing and scheduling	Residual risk		
				Consequence	Likelihood	Risk score								Consequence	Likelihood	Risk score
	Surface water Runoff causes environmental harm	Impacts to EV's	Environmental harm from contaminated runoff	3	2	9	Surface water monitoring	Monitoring to provide early indication of potential contamination	Site management team	Surface water monitoring program	As per section 8.3	As per section 8.3	As per section 8.3	2	2	5
	GW contamination from rehabilitated area	Impacts to EV's	Contamination of groundwater	3	2	9	GW monitoring	Monitoring to confirm modelling predictions of low risk to groundwater or to provide an early indication of potential issues	Site management team	GW monitoring program	As per section 8.4	As per section 8.4	As per section 8.4	2	2	5
	Area does not meet same condition as reference sites	PMLU	Delay in achievement of stable condition	2	2	5	BioCondition monitoring	BioCondition monitoring provides a quantitative measure of rehabilitation performance against reference sites	Site management team	BioCondition monitoring program	As per section 8.4	As per section 8.4	As per section 8.4	2	2	5
	Water in retained infrastructure does not meet stock water guidelines	PMLU	Infrastructure does not support the PMLU	1	3	4	Surface water monitoring Progressive rehabilitation	Progressive rehabilitation will limit exposed ground and as such the accumulation of potential contaminants in dams from runoff water. Surface water monitoring will give early indications of future dam water quality.	Site management team	Surface water monitoring program	As per section 8.3	As per section 8.3	As per section 8.3	1	2	2

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Responsibility	Resource requirements	Performance measures	Reporting and monitoring	Timing and scheduling	Residual risk		
				Consequence	Likelihood	Risk score								Consequence	Likelihood	Risk score
MM1 — Achievement of structural stability	Highwall (HW) and / or low wall (LW) and / or end wall (EW) does not achieve geotechnical stability	Safe and stable	HW, LW or EW not geotechnically stable and not considered safe	3	3	13	Most current pit structures assessed as geotechnically stable by an AQP PRC plan schedule includes rectification works for areas not geotechnically stable Ongoing monitoring and assessment	Most current pit structures assessed as geotechnically stable by an AQP. Pit structures have been in place for a long time and have been monitored in that time. No major failures have been recorded in recent monitoring	Site management team	Geotechnical monitoring program	Geotechnical monitoring program	Review of monitoring data vs predicted behaviour	Annually	2	2	5
MM2 — Installation of cover system (in-pit tailings)	Adequate quantity/quality of materials not available for the cover system	Safe and stable	Cover system not installed to design	3	2	9	Materials balance shows adequate material availability Material characterisation shows material suitable for use as a cover Rehabilitation trials on proposed cover system	Material balance and testing demonstrates suitability of available material. Field trials of cover systems to determine final design.	Site management team	Survey support Material characterisation data ERC calculator	ERC volumes Survey support	Survey checks Results of rehabilitation trials	Prior to construction	2	2	5
	Cover system not effective due to design fault	Impact to EV's, safe and stable	Cover system ineffective leading to instability and potential impact to surface and groundwater	4	2	14	Cover trials as per section 7.5.2	Cover trials will field verify cover designs as performing effectively	Site management team	Cover trial data	Cover trial outcomes	Cover trials as per section 7.5.2	Cover trials as per section 7.5.2	2	2	5
	Cover system not effective due to installation fault	Impact to EV's, safe and stable	Cover system ineffective leading to instability and potential impact to surface and groundwater	4	2	14	Detailed design will include QA/QC controls Supervision during construction	Effective supervision during construction will ensure cover system is installed to design	Site management team	Detailed cover design	QA/QC testing results	QA/QC testing	During construction	2	2	5

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Responsibility	Resource requirements	Performance measures	Reporting and monitoring	Timing and scheduling	Residual risk		
				Consequence	Likelihood	Risk score								Consequence	Likelihood	Risk score
	Excessive erosion or instability of the rehabilitated tailings storage area	Safe and stable	Area not geotechnically or erosionally stable	3	2	9	Geotechnical monitoring Rehabilitation monitoring	Monitoring to confirm stability of cover system or to provide an early indication of potential issues	Site management team	Geotechnical monitoring program	As per section 8.7	As per section 8.7	As per section 8.7	2	2	5

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Responsibility	Resource requirements	Performance measures	Reporting and monitoring	Timing and scheduling	Residual risk		
				Consequence	Likelihood	Risk score								Consequence	Likelihood	Risk score
MM3 — Achievement of surface requirements / access controls	Fencing / bunding not installed or ineffective	Safe and stable	Un-bunded/unfenced areas pose a risk to humans or livestock	3	3	13	Abandonment bund setback distance is in accordance with calculated geotechnical factor of safety Abandonment bund constructed of competent material and to geometry specified to prevent traversing by vehicles Fencing erected on the outside of the abandonment bund to specification (nominally four strand barbed stock fencing) Safety signage (design in accordance with Australian Standard) erected at specified intervals along the fence line (nominally one sign every 100m) Bunding, fencing and signage provisioned in ERC	Sufficient abandonment bund, fencing and signage is an effective method of reducing potential interaction with the residual void	Site management team	Final bunding and fencing plan	Visual inspection	Visual inspection	Regularly during construction then annually following construction	2	2	5

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Responsibility	Resource requirements	Performance measures	Reporting and monitoring	Timing and scheduling	Residual risk		
				Consequence	Likelihood	Risk score								Consequence	Likelihood	Risk score
MM4 — Achievement of sufficient improvement	Flood impacts on final void	Impact to EV's	Capture of overland flow and potential release of contaminants	3	3	13	Flood modelling shows voids at risk from flood waters Voids protected from flood waters by overburden dumps	Overburden dumps are positioned in the same location as regulated levees but are much larger and robust.	Site manage ment team	Flood modelling	AQP inspections	As per section 8.7	Annually	2	2	5
	Residual void Water quality causes environme ntal harm	Impact to EV's	Residual void water causes harm to environmental values	4	2	14	Final void water modelling indicates minimal risk to receiving environment No identified users of groundwater in the area GW monitoring	Modelling indicates minimal risk which will be validated by ongoing monitoring	Site manage ment team	GW monitoring program	GW monitoring data	As per section 8.4	As per section 8.4	2	2	5
	Residual void not safe and stable due to geotechnic al or erosional instability	Safe and stable	Void not safe and stable and impacts surrounding land	3	2	9	Geotechnical monitoring	Geotechnical monitoring by an AQP will allow comparison of monitoring data vs model predictions	Site manage ment team	Geotech monitoring program	Geotech monitoring data	As per section 8.7	Annually	2	2	5

7.5 Rehabilitation Trials

7.5.1 Grazing Trials

7.5.1.1 Objectives

Trials will be used to evaluate the suitability of rehabilitated areas for the PMLU of grazing and to monitor the response of rehabilitated areas to grazing pressure.

7.5.1.2 Design

Cattle supplied by the adjacent landholder will be grazed on rehabilitated areas. The area chosen for initial trials is the western dump of N1 pit. This area is considered suitable because it has:

- Both slopes and flatter areas
- Access for fencing, water supply and maintenance
- Is established rehabilitation representative of other areas
- It is outside of active mining areas

Selected areas will be fenced and cattle introduced. Data will be collected.

7.5.1.3 Timing and Duration

Trials are scheduled to start following the 2022/2023 wet season with the duration determined by weather conditions and consultation with the neighbouring landholder.

7.5.1.4 Monitoring and Evaluation

a. Rehabilitation Monitoring

Areas selected for grazing trials will be monitored prior to and immediately following grazing using the methodology outlined in section 8.5, section 8.6 and section 8.7. Results from grazed areas will be compared to:

- Monitoring results prior to grazing
- Other rehabilitated areas which have not been grazed
- Reference sites representative of the PMLU of grazing

b. Cattle Monitoring

Cattle will be assessed prior to and immediately following grazing on rehabilitated areas for weight gain and general health. Data on weight gain will be compared to local averages and landholder supplied data on comparable land.

7.5.2 Cover Trials

7.5.2.1 Objectives

Cover trials will be used to inform the detailed cover design for tailings and rejects storage areas.

The intent of the cover design for tailings and rejects storage areas is to ensure contaminants are not released to the receiving environment. The outcomes required to be included for the cover design will be based on a risk based assessment. Prior to closure, Stanmore will review available information from the cover trials and AQP recommendations and conduct any required modelling and sampling to inform cover design.

The cover design will provide a stable landform, provide a growth medium for establishing vegetation, and to achieve net percolation rates of better than 10% consistent with the accepted performance of an enhanced store and release cover (5-10% net percolation) (INAP 2017).

7.5.2.2 Design

Proposed cover materials will be analysed for chemical and physical properties and results will be used to model cover design options. Preferred cover options will then be evaluated using column trials with site specific material. This ensures that cover materials are field tested and their performance as a cover system is properly evaluated.

7.5.2.3 Timing and Duration

Trials will be carried out using the same column equipment and as such will be carried out one after the other. Trials of rejects materials will start in late 2023 with tailings cover trials to follow in late 2024. The duration of cover trials will be determined during detailed scoping of the cover trials. It is expected that a minimum of six months of monitoring data will be required.

7.5.2.4 Monitoring and Evaluation

Data collected from the cover trials will be used to develop cover systems for the tailings and reject storage areas.

8. MONITORING AND MAINTENANCE

8.1 Reference Sites

A minimum of three reference sites will be monitored for each rehabilitation domain and results will be provided in the annual monitoring report. The three sites that must be monitored as per condition F16 of the EA are shown in Table 41.

Table 41 Reference Sites (Table 18 from the EA)

Reference site	Domain reference	Easting (GDA94 – Zone 55)	Northing (GDA94 – Zone 55)	Description
REF1	All domains, other than final voids	616438	7567159	Buffel grass pasture with very sparse shrubs
REF2	All domains other than final voids	617415	757058	Buffel grass pasture with very sparse shrubs
REF3	All domains other than final voids	618966	757314	Buffel grass pasture with very sparse shrubs

8.2 Milestone Monitoring

The following sections of the PRC plan describe monitoring and maintenance activities that will be done post-rehabilitation. Information collected during monitoring will demonstrate that the rehabilitation and improvement criteria have been met and contribute to satisfying the administering authority's decision to progress surrender of the EA.

The post-rehabilitation phase will start when all rehabilitation activities specified in section 6 of this PRC plan are finished. Rehabilitation monitoring will be conducted to assess whether the closure objectives and rehabilitation criteria are being met, while maintenance will be done to address where the objectives and rehabilitation criteria remain incomplete or unsatisfactory. Data collected during this time will enhance monitoring data requirements for the post-closure monitoring period.

8.3 Surface Water

Surface water in water storages and receiving waters will be monitored twice annually during rehabilitation and maintenance. Seepage water monitoring will occur during rehabilitation inspections and when seepage is observed by site personnel.

8.3.1 Water Storages

Water storages at the Mine will be monitored to meet the requirement of livestock drinking water and to satisfy the requirements of **RM8**. Contaminant limits have been taken from the ANZECC and ARMCANZ (2000) stock water quality guidelines. Parameters to be tested are:

- pH 4.0-9.0 pH units
- EC ≤5970 µS/cm
- Sulfate ≤1000 mg/L
- Fluoride (total) ≤2 mg/L
- Al (total) ≤5 mg/L
- As (total) ≤0.5 mg/L
- Cd (total) ≤0.01 mg/L
- Co (total) ≤1 mg/L
- Cu (total) ≤1 mg/L
- Pb (total) ≤0.1 mg/L
- Ni (total) ≤1 mg/L
- Zn (total) ≤20 mg/L

8.3.2 Monitoring for Seepage

Samples will be taken from soils and pooled water at seepage zones during rehabilitated area monitoring and when observed at the top of spoil dumps and benches. Seepage zone water samples are to be tested for the below parameters:

- Physical parameters — suspended solids, turbidity, pH, EC
- Major cations and anions — alkalinity, chloride. Sulphate, calcium, magnesium, sodium and potassium
- Metals (total and dissolved) — Al, As, barium (Ba), beryllium (Be), Cd, Co, chromium (Cr), Cu, manganese (Mn), Ni, Pb, vanadium (V), Zn), molybdenum (Mo), selenium (Se), silver (Ag), uranium (U), boron (B), iron (Fe), fluoride and mercury (Hg)
- Nutrients — ammonia as N, nitrate as N, nitrite as N and total phosphorus

Soil samples collected from seepage zones are to be tested for:

- Physical parameters — total soluble salts, pH, EC
- Major cations and anions — alkalinity, chloride. Sulphate, calcium, magnesium, sodium and potassium
- Metals (total and dissolved) — Al, As, Ba, Be, Cd, Co, Cr, Cu, Mn, Ni, Pb, V, Zn, Mo, Se, Ag, U, B, Fe, fluoride and Hg
- Nutrients — ammonia as N, nitrate as N, nitrite as N and total phosphorus
- Organics — total organic carbon and total organic matter

8.3.3 Receiving Waters

Receiving waters will be monitored as per the current EA conditions and in the locations shown in Table 42. Receiving waters will be assessed for completion of **RM7**, **RM8** and **MM4**. Contaminant trigger levels for the receiving waters are provided Table 43.

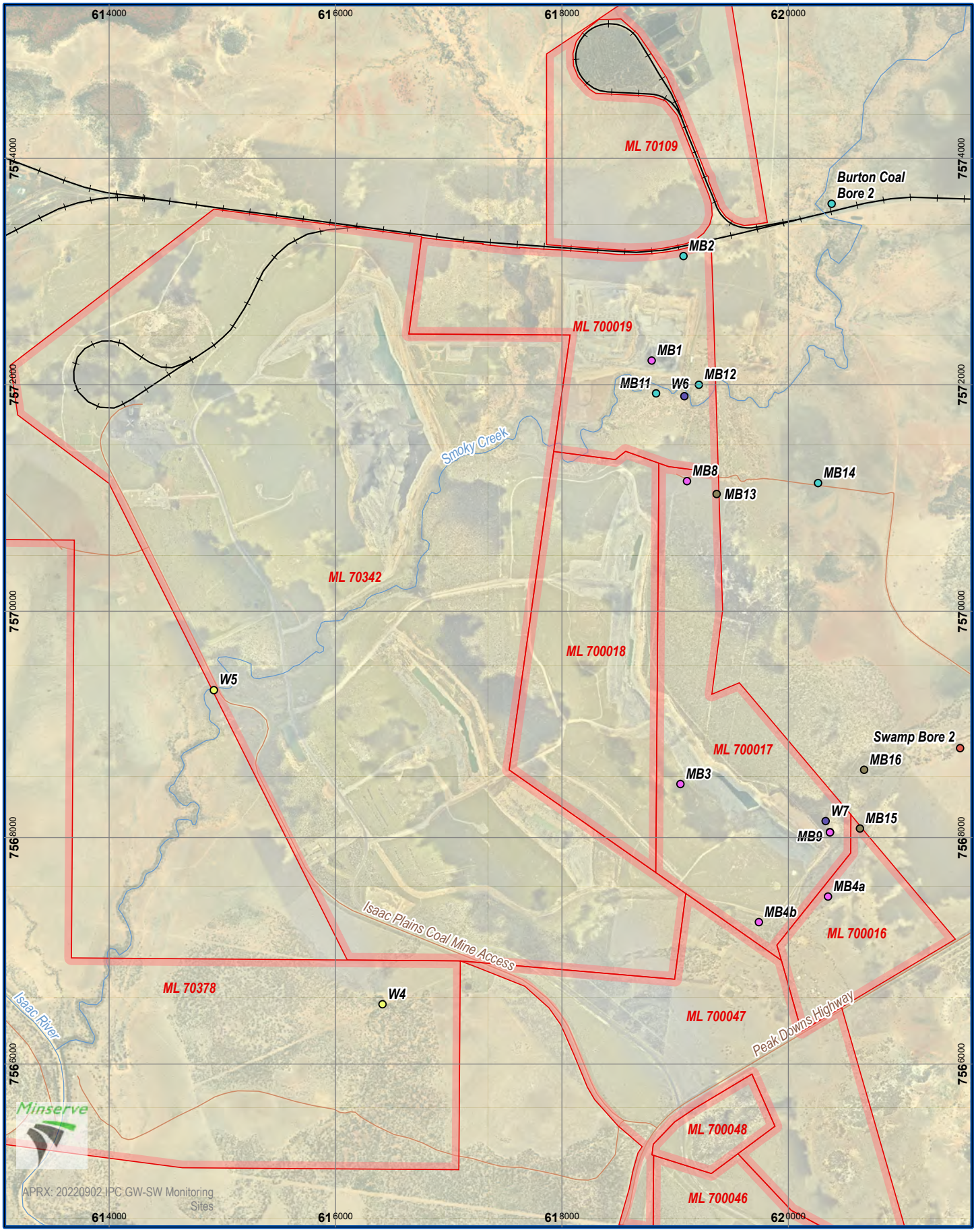
Table 42 Receiving and Downstream Water Monitoring Points

Monitoring points (MP)	Receiving waters location	Easting (GDA94– zone 55)	Northing (GDA94– zone 55)
Upstream background monitoring points			
MP 1	W6 — Smoky Creek upstream (u/s)	619082	7571899
MP 2	W7 — Billy's Gully u/s	620330	7568146
Downstream monitoring points			
MP 4	W4 — Billy's Gully 1,340 m downstream of RP2	616415.04	7566527.5
MP 5	W5 — Smoky Creek 750 m downstream of RP1	614925.04	7569302.5

Table 43 Surface Water Quality Limits

Quality Characteristic	**Unit**	**Limit**	**Source**
pH	pH units	6.5-8.5	Upper Isaac River WQO
Electrical conductivity	µS/cm	720	Upper Isaac River WQO - baseflow
Sulfate	mg/L	25	Upper Isaac River WQO
Turbidity	NTU	50	Upper Isaac River WQO
Aluminum (Dissolved)	µg/L	55	ANZG 2018
Antimony (Dissolved)	µg/L	9	ANZG 2018
Arsenic (Dissolved)	µg/L	13	ANZG 2018
Iron (Dissolved)	µg/L	290	Site-specific
Mercury (Dissolved)	µg/L	0.06	ANZG 2018
Molybdenum (Dissolved)	µg/L	34	ANZG 2018
Selenium (Dissolved)	µg/L	5	ANZG 2018
Total recoverable hydrocarbons (C6-C9)	µg/L	20	-
Total recoverable hydrocarbons (C10-C36)	µg/L	100	-
Major ions Calcium, chloride, potassium, magnesium, sodium, bicarbonate, carbonate	Mg/L	For interpretation purposes only	-

Receiving water monitoring points are shown in Figure 29.



Waterway
Railway
Road
ML

Status
Upstream Monitoring
Downstream Monitoring
Existing
Abandoned
To Be Commissioned
To Be Decommissioned

N

0 500 1,000 1,500 2,000 2,500
Meters

stanmore

Surface and Groundwater Monitoring Location (EA)
Figure 30

8.4 Groundwater

Groundwater monitoring is to be completed in accordance with condition C43-C49 of the EA (Table 44). Monitoring will be undertaken on a quarterly basis whilst the updated groundwater monitoring network required for rehabilitation is developed. Once the network is finalised, monitoring will then be required every six months. Groundwater contaminant trigger limits are set at within 5% of baseline monitoring data (Table 45) as required for rehabilitation milestone **RM8** and improvement milestone **MM4**. Groundwater levels are to be monitored and compared with the quality limits in Table 45 (as per Appendix 6 of the PRCP Schedule).

Table 44 Groundwater Monitoring Locations and Frequency

Monitoring Point	Location		Surface RL	Total Depth	Screen Interval (mbgl)	Hydro-stratigraphic Unit	Monitoring Frequency	Monitoring Parameter
	Easting (GDA94 – Zone 55)	Northing (GDA94 – Zone 55)						
MB2	619074	7573137	242.7	51.9	48.7 – 51.6	Rangal Coal Measures	Quarterly	Level
MB11	618832	7571924	231.8	5.0	3.0 – 4.0	Tertiary sediments	Quarterly	Level
MB12	619210	7572000	239.5	129	126 – 128	Rangal Coal Measures	Quarterly	Level
MB4b	619740	7567253	233.9	12.4	9.4 – 12.4	Rangal Coal Measures	Quarterly	Level
MB9	620368	7568049	239.5	80.5	77.5 – 80.5	Rangal Coal Measures	Quarterly	Level
MB14	620263	7571132	257.3	24	20 – 23	Tertiary basalt	Quarterly	Level
Swamp bore 1	621518	7568790	245.9	55.0	24.0 – 55.1	Rewan Group	Quarterly	Quality and level
Burton Coal bore 2	620383	7573599	240.8	37.0	30.3 – 34.6	Rewan Group	Quarterly	Quality and level

Table 45 Groundwater Quality Limits

Parameter	Unit	Limits	Source
pH	pH Units	7.0-8.5	Site-specific
Electrical Conductivity	µS/cm	12,300	Site-specific
Sulfate	mg/L	130	Site-specific
Aluminium (Dissolved)	µg/L	55	ANZG 2018
Antimony (Dissolved)	µg/L	1	Site-specific
Arsenic (Dissolved)	µg/L	13	ANZG 2018
Iron (Dissolved)	µg/L	300	ANCG
Mercury (Dissolved)	µg/L	0.06	ANZG 2018
Molybdenum (Dissolved)	µg/L	1	Site-specific
Total Petroleum Hydrocarbons C6-C9	µg/L	20	Maximum
Total Petroleum Hydrocarbons C10-C36	µg/L	50	Maximum
Selenium (Dissolved)	µg/L	5	ANZG 2018
Silver (Dissolved)	µg/L	0.05	ANZG 2018
Major ions Calcium, chloride, potassium, magnesium, sodium, bicarbonate, carbonate	mg/L	For interpretation purposes only	-

Notes:

- All metals and metalloids must be measured as 'dissolved' (from analysis of a field filtered sample) and total (unfiltered)
- Limits for metals and metalloids apply to dissolved results
- ANZG (2018) aquatic ecosystem protection for moderately disturbed system (95% protection)

Groundwater monitoring locations are shown in Figure 29.

8.5 Soil and Erosion

8.5.1 Soil

Soils in rehabilitated areas will be monitored to assist with confirming the completion criteria associated with rehabilitation milestone **RM5** and **RM6**. One sample site per 25 hectares (ha) of rehabilitation (or per <25 ha if the area is smaller) is to be monitored annually. Samples are to be collected at 0 cm, 10 cm, 20 cm and 50 cm depths and tested for the following parameters at a NATA accredited facility:

- pH and EC
- Total soluble salts

- Ammonia, total nitrogen and total phosphorus
- Metals including Al, As, Ba, B, Cd, Cr, Cu, Fe, Pb, Mn, Ni, U and Zn
- Exchangeable sodium percentage
- Emerson aggregate test
- Total organic matter, total organic carbon
- Carbon:nitrogen ratio

This testing will assist in determining the ability of the soil to support growth. Soil samples will also be taken from reference sites to compare conditions as a requirement of the completion criteria.

8.5.2 Erosion

Rehabilitation areas will be monitored for signs of erosion using a simple walk over or fly over method with a drone and a more detailed method collecting observations using transects on an annual basis for rehabilitation milestones **RM3, RM4, RM5, RM6, RM7**. Full details of the transect inspection are detailed in the RMP. Rehabilitated areas will be given an erosion rating during inspections using the erosion rating system from the RMP seen in Table 46. It is suggested that erosion modelling should be completed and a measurement of soil loss is to be recorded. Any active areas of slumping, slips, or gully erosion greater than 60m in depth, and as defined in the Australian Soil and Land Survey Field Handbook will be stabilised.

Table 46 Erosion Rating System

Erosion Rating	Rills per transect	Average depth of rills	Topsoil depth	General observations
0	0-3	<10 cm	>90% of original depth	Generally little erosion. The majority of rills are <10cm depth.
1	2-6	<20 cm	>75% of original depth	Minimal instances of sheet-wash and gully erosion.
2	3-8	<50 cm	>50% of original depth	Minimal-moderate erosion occurring but limited to localised areas.
3	4+	>50 cm	>40% of original depth	Moderate erosion occurring.
4	4+	any >80 cm depth	>30% of original depth	Heavy erosion occurring.

8.6 Vegetation

To satisfy completion criteria for rehabilitation milestones RM6 and RM7 the vegetation present in rehabilitated areas will be monitored annually. Ten random quadrats will be assessed for the following:

- Overall vegetation cover
- % dry matter cover
- % vegetation cover
- % soil cover
- Tree/bush species present
- Groundcover species composition

Some of the criteria may be determined during high resolution aerial photographs. Any visible deterioration in vegetation is to be recorded. Fauna observed at the time of the survey is to be recorded and discussed in the annual reporting. Vegetation surveys are to be completed in accordance with the Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland (Neldner et al. 2012).

8.6.1 Weed Management

The existing areas at the Mine have low levels of weed infestation with only minor occurrences of Parthenium (Parthenium hysterophorus), Harissa Cactus (Harrisia tortuosa) and Prickly Pear (Opuntia stricta) observed.

Rehabilitated areas will be inspected annually and any invasive species will be documented in site records and mapped accordingly. Weed monitoring will help assess the completion of rehabilitation criteria for milestone RM7. Any siting of invasive species during rehabilitation, maintenance and care operations will be documented as per the inspection protocol. The full explanation of site weed management and operational control can be read in section 19.2 of the RMP.

8.7 Geotechnical Stability

Routine condition monitoring of the residual voids and overburden dumps should be completed to observe slope stability. Monitoring may be visual, survey, aerial survey or other methodology nominated by an AQP. Rehabilitation reports should include the conditions observed. Once a void is permanently out of operation a geotechnical investigation will be completed to determine if the final landform is stable and meets completion criteria. Geotechnical stability monitoring will help assess the completion of rehabilitation and improvement criteria for milestone **RM4, RM7, RM8, MM1, MM2** and **MM4**.

8.8 Schedule

The monitoring schedule is given in Table 47.

Table 47 Proposed Monitoring Schedule

Name	Frequency	Duration (post-closure)
Reference sites	Annually	10 years
Surface water/receiving environment	Twice yearly	10 years (then every 5 years until the achievement of RM8)
Groundwater	Annually	10 years (then every 5 years until the achievement of RM8)
Soil	Every two years	10 years (then every 5 years until the achievement of RM8)
Erosion/final landform stability	Every two years	10 years (then every 5 years until the achievement of RM8)
Vegetation	Annually	10 years (then every 5 years until the achievement of RM8)

8.9 Schedule of Monitoring, Reporting and Review of Each Milestone

The milestone monitoring schedule is given in Table 48.

Table 48 Milestone Monitoring

To Milestone reference	Rehabilitation/improvement milestone	Milestone criteria	Monitoring analysis and reporting	Contingency strategy	Rehabilitation review
	Infrastructure Decommissioning and Removal	RM1a. All services, excluding retained infrastructure, are disconnected and decommissioned.	Once after criteria completion	N/A	Visual inspection and review of termination documentation by AQP
		RM1b. All buildings, excluding retained infrastructure, are demolished/or and removed offsite.			
		RM1c. All road materials (bitumen and gravel), excluding retained infrastructure, are removed.			
		RM1d. All pipelines, excluding retained infrastructure, are drained and removed.			
		RM1e. All waste removed from site unless authorised by the EA for disposal onsite.			
		RM1f. All exploration drill holes rehabilitated in accordance with the eligibility criteria and standard conditions for exploration and mineral development projects – V2 (DEHP 2016).			
		RM1g. Infrastructure required for the ongoing health and safety of operators such as road safety bunds are, to be retained until deemed safe to remove in accordance with the *Coal Mining Safety and Health Act 1999*.			
		RM1h. All dams dewatered and desilted as per AQP recommendation.			
		RM1i. Watercourse crossings and culverts, excluding retained infrastructure, removed.			
		RM1j. All machinery and equipment, not required for rehabilitation works removed from rehabilitation area.			
		RM1k. Infrastructure to be retained for use by underlying landholder, deemed fit for purpose and accepted by signed agreement from the underlying landholder.			
RM1		RM1l. An AQP has certified the achievement of RM1a) to k).			
RM2	Remediation of Contaminated Land	RM2a. Preliminary and intrusive contaminated land investigations carried out by an AQP to assess potentially contaminated mine domain areas.	Annually	Prepare remediation plan for remaining areas of contamination, update as required. • Investigate as per NEPM legislation and sampling and analysis • verification (SAP) standards • Update register/records/maps	Document review and site inspection

To Milestone reference	Rehabilitation/improvement milestone	Milestone criteria	Monitoring analysis and reporting	Contingency strategy	Rehabilitation review
				• Start remediation of failed areas	
		RM2b. Depending on the result of RM2. a) Suitably Qualified Person (SQP) determines applicability of relevant requirements of Chapter 7, part 8 of the *Environmental Protection Act 1994* (Qld) (EP Act) to the identified contaminated land areas.			
		RM2c. Contaminated and hazardous material either remediated in-situ or removed/transported to an approved landfill for disposal and waste tracking information recorded and submitted.			
		RM2d. Validation testing confirms that contaminated and hazardous materials have been removed or remediated successfully.			
		RM2e. SQP certifies the achievement of criteria RM2. b) to RM2. d) retained until achievement of RM7.			
	Landform Development and Reshaping / Reprofiling	RM3a. Final landform drainage installed as designed by AQP to allow effective removal of surface water from vegetated slopes.	Monthly during re-shaping Annually post re-shaping (as per rehabilitation monitoring section 8 of the PRC Plan)	Remediate areas if required Update designs if required	Ground survey, LiDAR and document review
		RM3b. All major earthworks completed, slopes and general reshaping and pushing/ trimming are completed in accordance with the design specification provided by an AQP.			
		RM3c. The Smoky Creek N1 and S1 levees are incorporated into the final rehabilitated landform with established vegetation and selective placement of non-erosive materials and/or rock mulch protection as per AQP advice to ensure landform stability to sustain flood stress of up to PMF event.			
		RM3d. All flood protection landforms (e.g. levees or landforms) provide immunity to at least the 0.1% AEP flood event plus 0.5m freeboard.			
		RM3e. S3 void to be partially backfilled above the long-term groundwater level.			
		RM3f. The rehabilitated landform reshaped to: i. For RA1 and RA6, ≤15% for the external slope and ≤30% for internally draining slopes. ii. For RA2, RA3, RA4, RA5, RA7, RA8, RA9, RA10 ≤15%			
		RM3g. All landforms are shaped to be water shedding.			
		RM3h. Erosion and sediment control systems are designed by an AQP, installed, and fit for purpose			
RM3		RM3i. Final landform drainage installed as designed by AQP to reduce ponding of surface water from the vegetated slopes.			

To Milestone reference	Rehabilitation/improvement milestone	Milestone criteria	Monitoring analysis and reporting	Contingency strategy	Rehabilitation review
		RM3j. Seepage and surface runoff from rehabilitation areas is directed to the sediment dams through appropriate permanent, low maintenance and stable drainage systems, as agreed by the underlying landholder.			
		RM3k. Final rehabilitated landforms (RA1, RA5, RA6, RA9, RA11) including back-filled pits, N2, S1 and S3 voids other than residual voids assessed as geotechnically stable by an AQP with a factor of safety (FOS) of 1.5.			
		RM3l. Final rehabilitated overburden dumps in which the base of the spoil is not inundated have critical FOS values ≥ 1.5, and the base of spoil with risk of inundation have FOS between 1.3 - 1.5.			
		RM3m. Disturbed natural watercourse bed and banks returned to a natural condition with profile similar to the pre-disturbance condition.			
		RM3n. Any areas of subsidence with measurable ponding of overland flow, resulting from the Isaac Plains Underground Project, are ripped and reshaped as required to ensure free drainage.			
		RM3o. Water storages are safe for stock access and have vegetated banks.			
		RM3p. An AQP has certified the achievement of RM3 a) to o).			
	Installation of cover system	RM4a. Tailings have consolidated and are considered safe by an AQP for installing the cover system.	• Monthly during construction • Annually post install	Certified designs updated by an AQP or rectification works undertaken	Visual inspections, ground surveys and document review by AQP
		RM4b. An AQP to determine appropriate detailed cover design for installation.			
		RM4c. An AQP certify installation of cover system as designed per RM4.b).			
RM4		RM4d. Following installation of a cover system in accordance with RM4.a), the cover system achieves the following criteria: i. Surface is water-shedding and achieves net drainage flux less than 10% of average annual rainfall and demonstrated by modelling that the cover design is capable to minimising average net percolation to below 10% annual rainfall. ii. Growth media has been approved by an AQP and ameliorated and/or fertilised if necessary to support the target vegetation species. iii. Sampling of the ameliorated and/or fertilised growth media confirms the soil properties are suitable for the vegetation species as per **Appendix 1 – Pasture**			

To Milestone reference	Rehabilitation/improvement milestone	Milestone criteria	Monitoring analysis and reporting	Contingency strategy	Rehabilitation review
		grazing seeding mix unless alternative species recommended by an AQP.			
		RM4e. The installed cover is erosional and geotechnically stable and supports the marginal grazing PMLU.			
		RM4f. An independent AQP has certified the achievement of RM4. a) – RM4. e).			
	Surface preparation	RM5a. An assessment of growth media has been completed by an AQP to confirm growth media and suitability for PMLU and target vegetation establishment.	• Ongoing during works • Annually (rehabilitation monitoring rehabilitation monitoring as per section 8 of the PRC Plan)	Remediate areas as required Review appropriateness of controls if required	Visual inspection pre and post wet season
		RM5b. Application rate of ameliorants such as fertiliser, gypsum/or organic matter and physical treatment plan determined by an AQP based on the assessment required by **RM5a** and implemented.			
		RM5c. Records demonstrate topsoil placement has achieved a minimum target depth of 150 mm.			
		RM5d. Deep ripping of compacted areas as per the requirements of the soil material assessment, including along the contour slopes.			
		RM5e. Filling and ripping of surface cracks greater than 20cm wide to a depth as required in areas impacted by subsidence, prior to topsoil application.			
		RM5f. Following amelioration, representative soil testing confirms: i. pH (1:5) 5.6–8.4 ii. Saturation Extract EC (Ece) ≤ 10 dS/m from 0-0.6 m depth iii. Exchangeable sodium percentage (ESP) ≤6% (0-0.1 m depth) or ≤23% (at 0.5 m depth) (Placement of growth media to a minimum depth of 150 millimetres (mm), with additional growth media added as needed to high-risk areas where informed by an AQP).			
		RM5g. Remediate any erosion or subsidence by, but not limited to, addition of rock and/or log cover to assist erosion resistance of eventual vegetative groundcover.			
		RM5h. Construction of seal from surface into the underground workings complies with regulation 325 of the Queensland Coal Mining Safety and Health Regulations 2020 (CMSHR) and Registered Professional Engineer of Queensland (RPEQ) design.			
RM5		RM5i. The surface and groundwater monitoring is underway (at least one year of sampling undertaken).			

To Milestone reference	Rehabilitation/improvement milestone	Milestone criteria	Monitoring analysis and reporting	Contingency strategy	Rehabilitation review
		RM5j. An AQP to certify achievement of RM5.a) to i). For areas affected by subsidence, AQP confirms following: i. Surface deflection within range of 20-60mm above UG area, except in modified Duncan panels. ii. Modified Duncan panels surface deflection within range of 100 -150mm. iii. The cessation of subsidence. iv. Depression/ponding areas are free draining and require no further drainage works.			
	Revegetation	RM6a. Complete seeding in accordance with target species at rate of 3P (perennial, palatable and productive) with a selection of species and at a rate consistent with **Appendix 1 - Pasture grazing seed mix**.	• Ongoing during works • Annually (rehabilitation monitoring rehabilitation monitoring as per section 8 of the PRC Plan)	• Reseed as required • Review revegetation methodology, planting, rate, species etc.	Review rehabilitation monitoring reports
		RM6b. The seed application required by RM6a must include minimum of 4 palatable perennial pasture species and include up to 50% native species			
		RM6c. Complete seeding of topsoil surfaces for areas impacted by subsidence using a seed mix and a rate consistent with **Appendix 1 - Pasture grazing seed mix**.			
RM6		RM6d. An AQP has certified the achievement of RM6.a) to RM6.c).			
RM7	Achievement of surface requirements	RM7a. Rehabilitated areas demonstrate achievement of the following criteria: i. Minimum 70% established and persistent vegetative ground cover, comprising 50% palatable perennial pasture species. ii. Presence of rocks, logs or other effective erosion control cover is limited to 30% of total groundcover. iii. Achievement of following as per Guidelines for Agricultural Land Evaluation in Queensland: • Land class 4 – RA1, RA6 • Land class 3 – RA2, RA3, RA4, RA5, RA7, RA8, RA9, RA10 iv. Weed presence is less than 10% of total vegetative groundcover confirmed by an AQP in annual monitoring. v. Subsided areas do not have residual ponding, and overland flows and surface runoff drain freely from these areas.	Annual (rehabilitation monitoring as per section 8 of the PRC Plan)	• Remediate areas of instability • Review and update plans if required • Investigate non-compliant results as required	• Review rehabilitation monitoring reports • Review grazing trial results
		Soil quality and erosion			

To Milestone reference	Rehabilitation/improvement milestone	Milestone criteria	Monitoring analysis and reporting	Contingency strategy	Rehabilitation review
		RM7b. Representative soil testing of the growth media confirms: i. pH (1:5) 5.6–8.4 ii. Saturation Extract EC (Ece) ≤ 10 dS/m from 0-0.6 m depth iii. Exchangeable sodium percentage (ESP) ≤6% (0-0.1 m depth) or ≤23% (at 0.5 m depth) iv. Evidence of nutrient and organic matter cycling is occurring (through presence of organic carbon and nitrogen in the soil profile for a period of 3 years).			
		RM7c. Erosional stability must meet the following: i. No evidence of erosion classified as 'moderate' or 'severe' as defined by **Appendix 2: Erosion classification framework**. ii. Any erosion present will not compromise the achievement of a PMLU to a stable condition. iii. The final landform design demonstrates that rates of erosion are <5 t/ha/yr. iv. Evidence of scouring, overtopping, sedimentation or destabilisation in or associated with erosion and sediment control and engineered drainage structures, limited to minor classification as per **Appendix 2: Erosion classification framework**.			
		Surface water quality			
		RM7d. Surface water runoff from rehabilitation areas collected at appropriate location/s determined by an AQP for monitoring surface water runoff quality when surface flows occur and when it is safe to do so.			
		RM7e. Surface water runoff monitoring in accordance with RM7.e) shows surface water runoff is non-polluting to receiving waters and complies with the following: i. pH 6.5-8.5 pH units ii. EC ≤720 µS/cm iii. Turbidity ≤50 NTU iv. Sulfate ≤25 mg/L			
		RM7f. Water sampling of water storages (RA11) for quality monitoring purposes undertaken quarterly and achieve **Appendix 4: Surface water quality limits** for native wildlife and/or livestock ingestion for a minimum of 5 years.			

To Milestone reference	Rehabilitation/improvement milestone	Milestone criteria	Monitoring analysis and reporting	Contingency strategy	Rehabilitation review
		RM7g. AQP certifies achievement of RM7.a) to RM7.f).			
	Achievement of post-mining land use to a stable condition	**Contaminated Land**			
		RM8a. If deemed necessary by the SQP under RM2, Contaminated Land Investigation Document (CLID) completed in accordance with the EP Act, including: i. Site Suitability Statement confirming the suitability of the property (all lot/plans within the mining lease area) for the PMLUs. ii. Site Investigation Report and, where required, a Validation Report and/or a draft Site Management Plan provided. iii. Removal of land from Environmental Management Land Register (EMR)/ Contaminated Land Register (CLR).	Annual (monitoring as per section 8 of the PRC plan)	Investigate non-compliant results as required and remediate accordingly.	• Review final rehabilitation report • Review grazing trial results
		RM8b. The final rehabilitated landforms are structurally stable by achievement of following: **i.** For RA1 and RA6, ≤15% for the external slope and ≤30% for internally draining slopes. **ii.** For RA2, RA3, RA4, RA5, RA7, RA8, RA9, RA10 ≤15%.			
		RM8c. Final rehabilitated landforms, including back-filled pits (N2 and S1 voids) but excluding residual voids, are assessed as geotechnically stable by an AQP with a FOS of 1.5			
		RM8d. Overburden dumps in which the base of the spoil is not inundated have critical FOS values ≥ 1.5, and the base of spoil with risk of inundation have FOS between 1.3 - 1.5.			
		RM8e. No tunnel erosion or fissures present in areas subject to subsidence.			
		RM8f. Bed and banks of subsidence drainage structures are stable.			
		RM8g. No bed and bank erosion within watercourses as a result of or associated with subsidence or subsidence management.			
		RM8h. No cracking or destabilisation present in bed or banks of watercourses as a result of subsidence or subsidence management.			
		RM8i. Subsidence areas that may be subject to flooding are designed to withstand flood stresses compromising structural or erosional stability.			
RM8		RM8j. Vegetation shows preferred pasture species (3P grasses) diversity ≥ 4.			

To Milestone reference	Rehabilitation/improvement milestone	Milestone criteria	Monitoring analysis and reporting	Contingency strategy	Rehabilitation review
		RM8k. Minimum 70% established and persistent vegetative ground cover, comprising 50% palatable perennial pasture species.			
		RM8l. Presence of rocks, logs or other effective erosion control cover is limited to 30% of total vegetative groundcover.			
		RM8m. Achievement of following as per Guidelines for Agricultural Land Evaluation in Queensland: Land class 4 – RA1, RA6 (Marginal grazing) Land class 3 – RA2, RA3, RA4, RA5, RA7, RA8, RA9, RA10 (grazing)			
		RM8n. Weed presence is less than 10% of total vegetative groundcover.			
		RM8o. Restricted invasive plants (as defined in the *Biosecurity Act 2014* Qld) comprise ≤5% of vegetation groundcover.			
		RM8p. Infrastructure to be transitioned to a landholder will be deemed fit for purpose and accepted, by signed agreement, with the landholder.			
		RM8q. Rehabilitation is resilient to fire and grazing pressures.			
		Soil Quality, Erosion and Retained Infrastructure			
		RM8r. Growth media quality meets the parameters outlined in **RM7.b).**			
		RM8s. No evidence of erosion classified as 'moderate' or 'severe' as defined by **Appendix 2: Erosion classification framework.**			
		RM8t. The final landform design demonstrates that rates of erosion are <5 t/ha/yr.			
		RM8u. Evidence of scouring, overtopping, sedimentation or destabilisation in or associated with erosion and sediment control and engineered drainage structures, limited to minor classification			

To Milestone reference	Rehabilitation/improvement milestone	Milestone criteria	Monitoring analysis and reporting	Contingency strategy	Rehabilitation review
		as per **Appendix 2: Erosion classification framework.**			
		RM8v. Any erosion present will not compromise the achievement of a PMLU to a stable condition.			
		RM8w. Water storages (RA11) contain suitable water quality for native wildlife and/or livestock ingestion and achieve the water quality criteria outlined in **Appendix 4 – Surface water quality limits**.			
		RM8x. Water storages are safe for native animals and stock access and have vegetated banks.			
		RM8y. An independent AQP certifies achievement of RM8. a) to RM8. x).			
Improvement milestones					
MM1	Achievement of structural stability	MM1a. Highwall and end wall landforms (where not backfilled) must: i. Prevent the ingress of floodwater into the void; ii. Be geotechnically stable. iv.	• Monthly during re-shaping • Annually post re-shaping	• Remediate areas if required • Update designs if required	Ground survey, LiDAR and document review
		MM1b. The following slope geometry achieved for highwall and end wall (where not backfilled): i. Competent (unweathered) rock slopes are overall 275% (70°) with 35 m high batters; and 10m wide bench at the base of each batter; ii. Non-competent (weathered) rock slopes are overall 100% (45°) and 10 m wide bench at the base of weathering; iii. The uppermost layer of soil and extremely weathered rock are battered back to overall 27° (50%) and protected from surface runoff to minimise gullying; iv. Low-wall void slopes battered to a maximum overall angle of 100% (45°) in incompetent rock.			
		MM1c. Following slope geometry achieved for low wall spoil: i. Slopes battered to an overall angle of 73% (36°) or angle of repose in incompetent rock.			

To Milestone reference	Rehabilitation/improvement milestone	Milestone criteria	Monitoring analysis and reporting	Contingency strategy	Rehabilitation review
		MM1d. Walls / slopes assessed as stable by an AQP (geotechnical engineer) (FoS ≥1.2 or ≥1.5 for E1 pit).			
		MM1e. Residual voids are not subject to inundation from floodwaters up to and including the 0.1% AEP.			
		MM1f. The risk associated with a probable maximum flood (PMF) event with respect to residual voids must also be considered in final landform design.			
		MM1g. AQP assesses that the existing smoky creek N1 and S1 levees incorporated into the final landform provide flood protection to N1 pit and S2 pit at the minimum 0.1% AEP level + 0.5m freeboard.			
		MM1h. Levees and abandonment bunds have appropriate scour protection to sustain flood velocities of minimum 0.1% AEP and consider PMF flood stress as advised by AQP based on a risk assessment completed in accordance with **PRCP Condition 4**.			
		MM1i. The location of the voids and associated safety bunds does not cause instability or degradation to the land outside the NUMA.			
		MM1j. Residual voids must not overtop.			
		MM1k. An AQP demonstrates with monitoring of water quality, water level within void and modelling data, that the residual void/s act as groundwater sinks post-closure.			
		MM1l. An AQP certifies achievement of MM1.a) to MM1.i) and MM1.k).			
MM2	Installation of cover system (in-pit tailings)	MM2a. Tailings have consolidated and are considered safe by an AQP for installing the cover system.	• Monthly during construction • Annually post install	• Remediate areas if required • Update designs if required	Ground survey, LiDAR and document review
		MM2b. An AQP to determine appropriate detailed cover design for installation, including non-acid forming (NAF) spoil placed in a minimum 1m thick layer over consolidated tailings.			

To Milestone reference	Rehabilitation/improvement milestone	Milestone criteria	Monitoring analysis and reporting	Contingency strategy	Rehabilitation review
		MM2c. An AQP certify installation of cover system as designed per MM2.b).			
		MM2d. Installed cover displays erosional and geotechnical stability.			
		MM2e. Installed cover is effective in mitigating the potential for interaction of contaminants from tailings storage areas with the surrounding environment, up until when the natural water level rises in the N1 void to create a water cap.			
		MM2f. An independent AQP certifies achievement of MM2.b) to MM2.e).			
MM3	Achievement of surface requirements / access controls	MM3a. Safety bund setback distance is in accordance with calculated geotechnical FoS of ≥1.5 and achieves a minimum distance of 15 m.	Annual visual inspection for bunding Quarterly inspections of fences and signage	• Remediate areas as required • Carry out repairs as required	Visual inspections and ground survey
		MM3b. The safety bund is constructed around the perimeter of the final void to prevent access to the residual void, in accordance with engineering requirements including: i. Constructed from non-weathered dumped rockfill where possible; ii. A minimum 2m in height iii. A minimum of 5 m base width; iv. Not greater than 1 in 1.5 batters.			
		MM3c. Fencing installed at nominated offset from safety bund (nominally a four-strand barbed stock fence)			
		MM3d. Safety signage (design in accordance with Australian Standard) is erected at 100m intervals along the fence			
		MM3e. No public access to highwall or end wall areas			
		MM3f. An AQP certifies achievement of MM3.a) to MM3.e).			
	Achievement of sufficient improvement	MM4a. The highwall landform has been constructed in accordance with the final design by an AQP.	Annual visual inspection	Investigate non-compliant results and remediate accordingly	Review final rehabilitation report
		MM4b. Appropriate safety infrastructure at the geotechnical set-back distance has been installed to prevent access to the NUMA.			
		MM4c. Annual monitoring shows exclusion fences and bunds present remain effective.			
		MM4d. The residual void is safe to humans and livestock.			
MM4		MM4e. The final void is geotechnically stable including:			

To Milestone reference	Rehabilitation/improvement milestone	Milestone criteria	Monitoring analysis and reporting	Contingency strategy	Rehabilitation review
		v. Walls / Slopes assessed as stable by an AQP (geotechnical engineer) (FoS ≥1.2 or ≥1.5 for E1 pit) vi. Drainage measures and structures have been appropriately established and are directing overland flow away from the highwall edge vii. Erosion and sediment control measures have been installed and are operating as per design			
		MM4f. The residual void meets the criteria set out in **Appendix 7: Final Void Dimensions**.			
		MM4g. Risk from the void is as low as reasonably practical (ALARP) in accordance with the latest version of AS/NZS ISO 31000:2009 Risk Management and certified by an AQP.			
		MM4h. Residual voids are monitored for water level six monthly, for 10 years in conjunction with **PRCP Condition 15** to demonstrate residual void sink behaviour.			
		MM4i. The water level and quality in the void continually show that it does not and will not cause environmental harm to the receiving environment, and continue to act as a sink, as demonstrated by groundwater modelling and monitoring of groundwater level and quality. **Note:** here **PRCP Condition 12** groundwater quality results applicable to demonstrate 'no harm' criteria and **PRCP Condition 15** and **MM4.h)** applicable for residual void sink behaviour).			
		MM4j. Voids retain minimum 0.1% AEP flood immunity, supported by flood modelling re-run at end of life and calibrated against the final landform.			
		MM4k. Erosion of the landform within the NUMA area will not negatively impact on the stability of any adjacent rehabilitation areas, or their ability to sustain their PMLU.			
		MM4l. An independent AQP certifies achievement of MM4.a) to MM4.k).			

8.10 QA/QC

Monitoring, data assessment and reporting will be done by an AQP. This could be staff (e.g. environment officer) or an external consultant. All monitoring data files will be stored onsite. Mine staff will be responsible for reviewing monitoring data, analysis, reports and managing consultants.

Aspects to consider when reviewing the data, analysis and reports include QA/QC of data, methodologies used, fluctuating trends in data from previous years, accuracy of figures and graphs and general conclusions made about rehabilitation progress.

8.11 Review

This monitoring plan will be reviewed if circumstances change. The review will consider:

- Evaluation of rehabilitation objectives and indictors
- Opportunities for improvement identified in inspection checklist records
- Reports of environmental incidents
- Any amendments to relevant legislation, policy and guidelines
- Any changes to Mine plans, mining activities or construction / mining / rehabilitation works contractors at the Mine
- Rehabilitation completion criteria based on the above items

8.12 EA Surrender

The administering authority must be satisfied with the rehabilitation before it can certify progressive rehabilitation for part of the Mine or accept the surrender of the EA for the whole or part of the Mine tenure. The administering authority's decision is based on an assessment of either a progressive rehabilitation report for part of the Mine (refer to section 318Z of the EP Act) or a final rehabilitation report (refer to section 264 of the EP Act) for the whole Mine tenure or a singular part being surrendered.

The Proponent is required to prepare a progressive / final rehabilitation report, including a compliance statement and submit it to the administering authority for assessment. The administering authority will consider the relevant rehabilitation requirements (refer to section 318ZI or section 268 of the EP Act) when deciding whether to certify progressive rehabilitation or whether to approve a surrender application. The Proponent is also required to develop a post-relinquishment management plan to assist ongoing land management beyond surrender of the Mine tenure.

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APPENDIX A PRCP SCHEDULE

DRAFT PRCP schedule

Environmental Protection Act 1994

DRAFT PRCP schedule PRCP_EPML00932713_V1

This is the approved form for a Draft PRCP schedule issued by the administering authority under Chapter 5 of the *Environmental Protection Act 1994.*

PRCP schedule: PRCP_EPML00932713_V1

PRCP schedule holder(s)

Name(s)	Registered address
Stanmore IP Coal Pty Ltd ACN: 080 772 283	Level 32, 12 Creek Street Brisbane, Qld 4001

Location details

Location(s)
ML70342, ML700016, ML700017, ML700018, ML700019

Take effect

In accordance with section 202B of the *Environmental Protection Act 1994* (EP Act), the PRCP schedule has effect on the day the environmental authority for carrying out relevant activities on land to which the schedule relates takes effect. Pursuant to section 202C of the EP Act, a PRCP schedule continues in force until the environmental authority for the relevant activities to which the PRCP schedule relates is cancelled or surrendered, even if the resource tenure expires or is cancelled and even if the relevant environmental authority is suspended under Chapter 5, part 11 or 11A of the EP Act.

Jessica Johnson

Date

Department of the Environment, Tourism, Science and Innovation
Delegate of the administering authority
Environmental Protection Act 1994

Enquiries:
Business Centre Coal
PO Box 3028, Emerald QLD 4720
Phone: (07) 4987 9320
Email: CRMining@des.qld.gov.au

Queensland Government

Obligations under the *Environmental Protection Act 1994*

Pursuant to section 202E of the EP Act, if there is an inconsistency between an environmental authority and a PRCP schedule, the environmental authority prevails to the extent of the inconsistency.

Pursuant to section 285 of the EP Act:

1) the holder of a PRCP schedule must commission an audit of the schedule by a rehabilitation auditor for the following periods (each an audit period) —

   (a) the 3-year period starting on the day the schedule takes effect

   (b) each 3-year period starting on the day after the previous audit period ended.

2) the holder must, within 4 months after the end of each audit period, give the administering authority -

   (a) the rehabilitation auditor's report (an audit report) about the audit that complies with section 286 of the EP Act, and

   (b) A declaration by the authorised representative of the EA holder, for the audit report stating the EA holder –

   - Has not knowingly given false or misleading information to the rehabilitation auditor; and
   - has given all relevant information to the rehabilitation auditor.

An audit report for a PRCP schedule must be in the approved form, and include the following:

a) A statement about whether the holder has complied with the schedule during the audit period, including –

   - Details of actions the holder has taken, or failed to take, in relation to the rehabilitation milestones and management milestones under the schedule; and
   - whether the holder has complied, or failed to comply, with conditions imposed on the schedule; and
   - whether information given to the administering authority under this Act about rehabilitation carried out under the schedule is accurate;

b) an assessment of whether the post-mining land use for land the subject of the schedule is likely to be achieved, having regard to the rehabilitation that has been and is to be carried out under the schedule;

c) recommendations about actions the holder should take to ensure rehabilitation milestones and management milestones are achieved or conditions of the schedule are complied with;

d) the other information the administering authority considers necessary to decide whether to take action to amend the schedule under part 6 of the *Environmental Protection Act* 1994 (Qld) (EP Act).

In addition to the requirements found in the conditions of this PRCP schedule, the holder must also meet their obligations under the environmental authority, the EP Act, and the regulations made under the EP Act. For example, the holder must comply with the following provisions of the EP Act:

- general environmental duty (section 319)
- duty to notify environmental harm (section 320-320G)
- offence of causing serious or material environmental harm (sections 437-439)
- offence of causing environmental nuisance (section 440)
- offence of depositing prescribed water contaminants in waters and related matters (section 440ZG)
- offence to place contaminant where environmental harm or nuisance may be caused (section 443).

PRCP schedule

The PRCP schedule incorporates the following sections:

- Section A - Conditions of PRCP schedule
- Section B – Definitions
- Section C – Final site design and reference maps
- Section D - Post mining land uses
- Section E - Non-use management areas.

Section A - Conditions of PRCP schedule

Pursuant to section 206A of the EP Act:

- it is a condition of this PRCP schedule that, in carrying out a relevant activity under the schedule, the holder must comply with a requirement stated in the environmental authority relevant to carrying out the activity.
- it is a condition of this PRCP schedule that the holder must comply with the following matters stated in the schedule -

  (a) each rehabilitation milestone and management milestone

  (b) when each rehabilitation milestone and management milestone is to be achieved

General conditions

PRCP1 All mining disturbance authorised under environmental authority EPML00932713 must have an associated rehabilitation outcome provided in this PRCP schedule.

PRCP2 The holder must, for each rehabilitation and improvement area, achieve the corresponding rehabilitation or management milestone criterion (milestone reference):

a) for the cumulative area available specified in this schedule; and

b) by the milestone completion date specified in this schedule.

PRCP3 Where land becomes 'available for rehabilitation/improvement' more than one year earlier than the nominated 'Date area is available' in this schedule, the holder must:

a) notify the administering authority in writing within 30 days of the land becoming 'available for rehabilitation/improvement',

b) unless otherwise agreed to by the administrating authority in writing, within 4 months of the land becoming 'available for rehabilitation', apply to the administering authority to amend this schedule in a way that maximises the progressive rehabilitation of the land to a stable condition, including bring forward achievement of relevant milestones and criteria.

Note: progressive rehabilitation commenced early under this condition must be carried out in accordance with the milestone and criteria in this schedule, except each of the dates by which milestone are to be completed is brough forward by the same amount of time as the commencement was brought forward.

PRCP4 The holder must maintain a risk register that identifies the risks to not achieving -

a) a stable condition for post-mining land uses, and

b) sufficient improvement for non-use management areas, and

c) how the risks are being managed or minimised.

The risk register must be reviewed every 3 years and include consideration of the outcomes of PRCP monitoring data.

PRCP5 Where an area achieves a rehabilitation/improvement or management milestone, the holder must continue to achieve the milestone criteria until a surrender is approved.

PRCP6 The holder must carry out monitoring of the rehabilitation activities in the rehabilitation areas in accordance with:

a) the monitoring and maintenance program described in the rehabilitation planning part for the activity version Isaac Plains PRCP_V2-0, 30 January 2025, or more recent version of the PRC plan relating to this PRCP schedule;

b) any requirement under this PRCP schedule; and

c) as necessary to demonstrate achievement of each rehabilitation milestone or management milestone criteria.

Note: Where there is any inconsistency between this schedule and the rehabilitation planning part the schedule criteria prevail to the extent of the inconsistency.

PRCP7 The holder must keep up to date records on:

a) achievement and maintenance of each rehabilitation milestone criteria of this schedule;

b) rehabilitation activities and the results of these activities (including but not limited to, actions taken, date, location, methods, data collected and additional records where relevant e.g. QA/QC, photos, waste tracking and disposal records, appropriately qualified person details and assumptions);

c) maintenance of rehabilitation and the results of maintenance activities;

d) monitoring of rehabilitation and the results of monitoring;

e) details and results of rehabilitation trials;

f) designs, drawings, specifications and any similar documents developed in accordance with good professional practice in relation to rehabilitation milestones or milestone criteria;

g) all documents in relation to the requirements of this schedule, including reports (e.g. site investigation report), statements (e.g. site suitability statement), certifications, assessments, investigations, inspections, audits or any similar documents developed in relation to rehabilitation milestones or milestone criteria;

h) landholder agreements; and

i) details of community consultation in the community consultation register relating to rehabilitation and closure activities

PRCP8 Records made under **PRCP7** must be kept until the relevant environmental authority has been surrendered.

PRCP9 Records made under **PRCP7** must be provided to the administering authority in the specified format within 10 business days of a written request.

PRCP10 All Appropriately Qualified Person (AQP) designs, specifications, certifications, assessments and any similar documents, must:

a) include documented considerations of any relevant guideline or publication material, including material published by the administering authority;

b) detail the boundary conditions (of any model);

c) detail any assumptions made, limitations and areas of uncertainty; and

d) must contain sufficient detail to allow for independent peer review and substantiation.

PRCP11 The additional monitoring bores listed in **Appendix 5: Groundwater monitoring locations and frequency** must be installed before 31 December 2026.

PRCP12 With respect to groundwater:

a) Following RM5, the groundwater levels and quality must be monitored quarterly at, but not limited to, bores specified in PRCP schedule **Appendix 5: Groundwater monitoring locations and frequency** and **Appendix 5.1: Groundwater monitoring locations**, for all quality characteristics listed in PRCP schedule **Appendix 6: Groundwater quality limits**; and

b) groundwater quality results must not exceed the limits in PRCP schedule **Appendix 6: Groundwater quality limits**, for 3 consecutive results within the five-year period immediately prior to surrender.

PRCP13 With respect to improvement area (IA1), the EA holder must develop a 'Groundwater Level Monitoring Network' (GLMN) inclusive of following steps:

a) identify relevant regional aquifers (hydrogeological units) likely to be affected individually or collectively by each residual void listed in PRCP schedule **Appendix 7: Final Void Dimensions**;

b) identify location of existing groundwater bores (From PRCP schedule Appendix 5) and as required additional new groundwater monitoring bores to ensure sufficient monitoring coverage for each relevant regional aquifer mapped in accordance with PRCP13(a) by 2029 or 7-years prior mine closure whichever is earlier;

c) include a table in the PRCP schedule of existing and additional new groundwater monitoring bores with coordinates, hydrogeological unit and water level (mAHD); and

d) AQP certify the proposed GLMN is fit for purpose that is, to monitor and support predictions of residual voids behaviour as a sink.

PRCP14 The GLMN developed in accordance with **PRCP13**, must be implemented by the EA holder by 2032 or 4 years prior to mine closure whichever is earlier, inclusive of bore installation, and groundwater level monitoring.

PRCP15 Groundwater level must be monitored six monthly, for 10 years at the bores identified under the GLMN, starting from 2033 or mine closure whichever is earlier, in accordance with **PRCP14**.

PRCP16 With respect to surface water:

a) Following RM5, surface water quality must be monitored monthly during flow (determined by an AQP depending on the creek characteristics) at, *but not limited to,* downstream locations specified in PRCP schedule **Appendix 3: Surface water monitoring locations** and **Appendix 3.1: Surface water monitoring locations**, must not exceed the limits in PRCP schedule **Appendix 4: Surface water quality limits**, for a minimum of 5 consecutive years prior to surrender.

b) if the surface water quality exceeds **Appendix 4: Surface water quality limits**, the applicable upstream site must be compared to the downstream site result; and the quality result measured at a downstream site must be equal to or less than the quality result measured at the applicable upstream site.

PRCP17 Where the surface water quality at the downstream site exceeds the upstream site result as per **PRCP16(b)**, an AQP must complete an assessment of the cause of the exceedance and risk of rehabilitation not achieving a stable condition (**PRCP16(a)**) within the schedule timeframe and:

a) where there is no risk to achieving a stable condition from the mining tenure (ML70342, ML700016, ML700017, ML700018, ML700019), then no further action is to be taken; or

b) where there is a risk to achieve a stable condition, then an assessment of potential environment harm and any changes or rectification actions to rehabilitation activities must be determined and implemented.

c) the EA holder will be non-compliant with **PRCP16(a)**, if **PRCP17(b)** is triggered more than 3 times over 5 consecutive years and **PRCP16(a)** is reset.

d) the assessment/s under **PRCP17** must be completed and provided to the administering authority within 3 months of receiving the relevant sampling results.

END OF CONDITIONS

Section B – Definitions

Appropriately qualified person (AQP)	means a person who has professional qualifications, training, skills and experience relevant to the nominated subject matter and can give authoritative assessment, advice and analysis on performance relative to the subject matter using the relevant protocols, standards, methods or literature.
Activity (EP Regulation)	includes that part, if any, of an activity relating to the following— (a) preparing a place for the activity before carrying out the activity; (b) rehabilitating a place after it has been used for carrying out the activity.
Contaminants	can be a gas, liquid or solid; or an odour; or an organism (whether alive or dead), including a virus; or energy, including noise, heat, radioactivity and electromagnetic radiation; or a combination of contaminants.
Flood stress	is the pressure on structures from rapid water rise, erosion, and saturation during extreme floods, risking instability.
Growth media	is defined as all soil and soil-like material that will support the final vegetation cover. This includes the topsoil and subsoil where these materials are applied independently. Where the topsoil is incorporated into the underlying subsoil/spoil, topsoil refers to the depth of incorporation and the remaining depth is regarded as subsoil. The total depth of growth media is nominally considered to be the effective plant root zone.
Gully	a gully is a channel excavated by water, more than 0.3 m deep.
Independent AQP	is an AQP who is a third party, being independent of the PRCP schedule holder, and has not previously provided advice on the matter the subject of the review. Except for RM4 (Installation of cover system) and MM2 of this schedule, where same independent AQP can certify achievement of RM4 and MM2.
Independently peer reviewed	means a peer reviewer who is a third-party to the PRCP schedule holder and the AQP whose report is being reviewed and substantiated. The peer reviewer shall also be an AQP and documentation provided must contain sufficient detail to allow for independent technical review and substantiation and provide and justify site-specific landform performance (SMART) criteria.
Major earthworks	large scale movement of materials like soil, rock with use of machines to reshape, regrade the landscape, stabilise slopes to create safe, stable landform to sustain a designated post-mine land use or a non-use management area.
Marginal grazing	means grazing on land suitability assessment (LSA) Class 4 which is not suitable for a sustained grazing PMLU but may be grazed for short periods (e.g., land stewardship purposes). This requires careful management of stocking rates and pasture condition to prevent land and water degradation.
Rehabilitation activity	means any activity that the holder is required to carry out in relation to this PRCP schedule.
Relevant material	includes: i. Final landform design report, ii. Durability assessment/ report,

	iii. "As Constructed" report; iv. All monitoring data v. Assessment of monitoring data, vi. All maintenance records; and vii. Modelling and technical assessments.
Rill	A rill is a channel excavated by water, less than 0.3 m deep.
Residual/ Permanent ponding	the accumulation of surface water in a surface depression caused as a direct result of mining subsidence for greater than 3 consecutive months in a 12 month period.
Stable	in relation to land, means landform dimensions are or will be stable within tolerable limits now and in the foreseeable future. Stability includes consideration of environmental context, geotechnical stability, settlement and consolidation allowances, bearing capacity (trafficability), erosion resistance and geochemical stability with respect to seepage, leachate and related contaminant generation.
Stabilised	means one or both of the following conditions apply: no evidence of sediment movement; sides and/or floors of erosion form are revegetated (Australian Soil and Land Survey Field Handbook Fourth Edition).
Stable condition	see section 111A of the *Environmental Protection Act 1994*.
Suitably qualified and experienced person (SQP)	for performing a regulatory function under chapter 7, part 8 (Contaminated Land) of the EP Act or another function prescribed under a regulation, means a person who— (a) has qualifications and experience relevant to performing the function; and (b) if a regulation prescribes an organisation for this paragraph—is a member of the organisation.
Subsidence	means the gradual or sudden sinking, lowering, or collapse of the ground surface due to underground mining activities.
Vegetative groundcover	means plants, plant litter, tree leaf litter, twigs, mulch and woody debris capable of protecting the soil surface from erosion
Water cap	the residual void fills to its long term equilibrium level, permanently submerging the underlying tailings material.

Section C - Final site design and reference maps

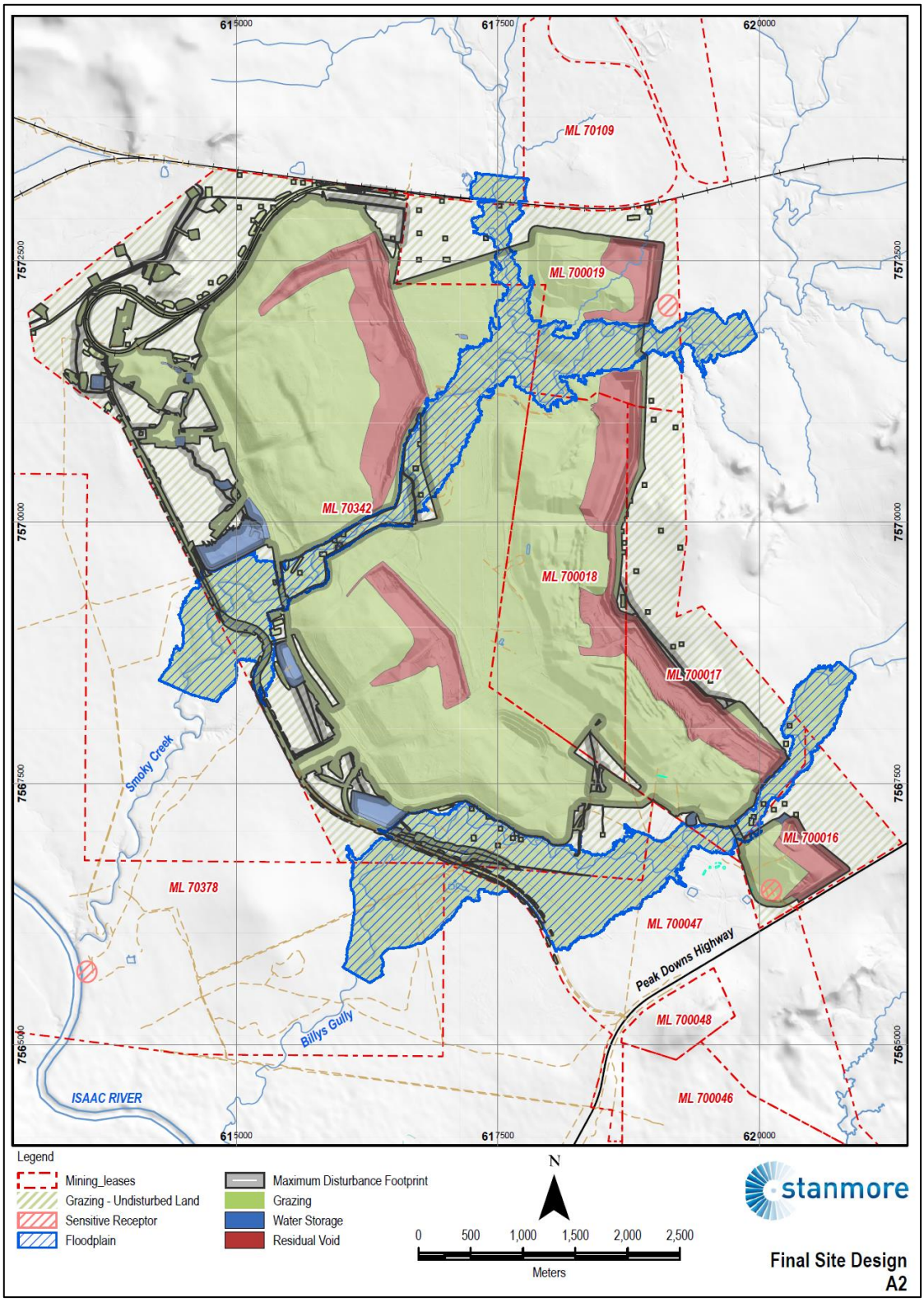


Figure 1: Final Site Design

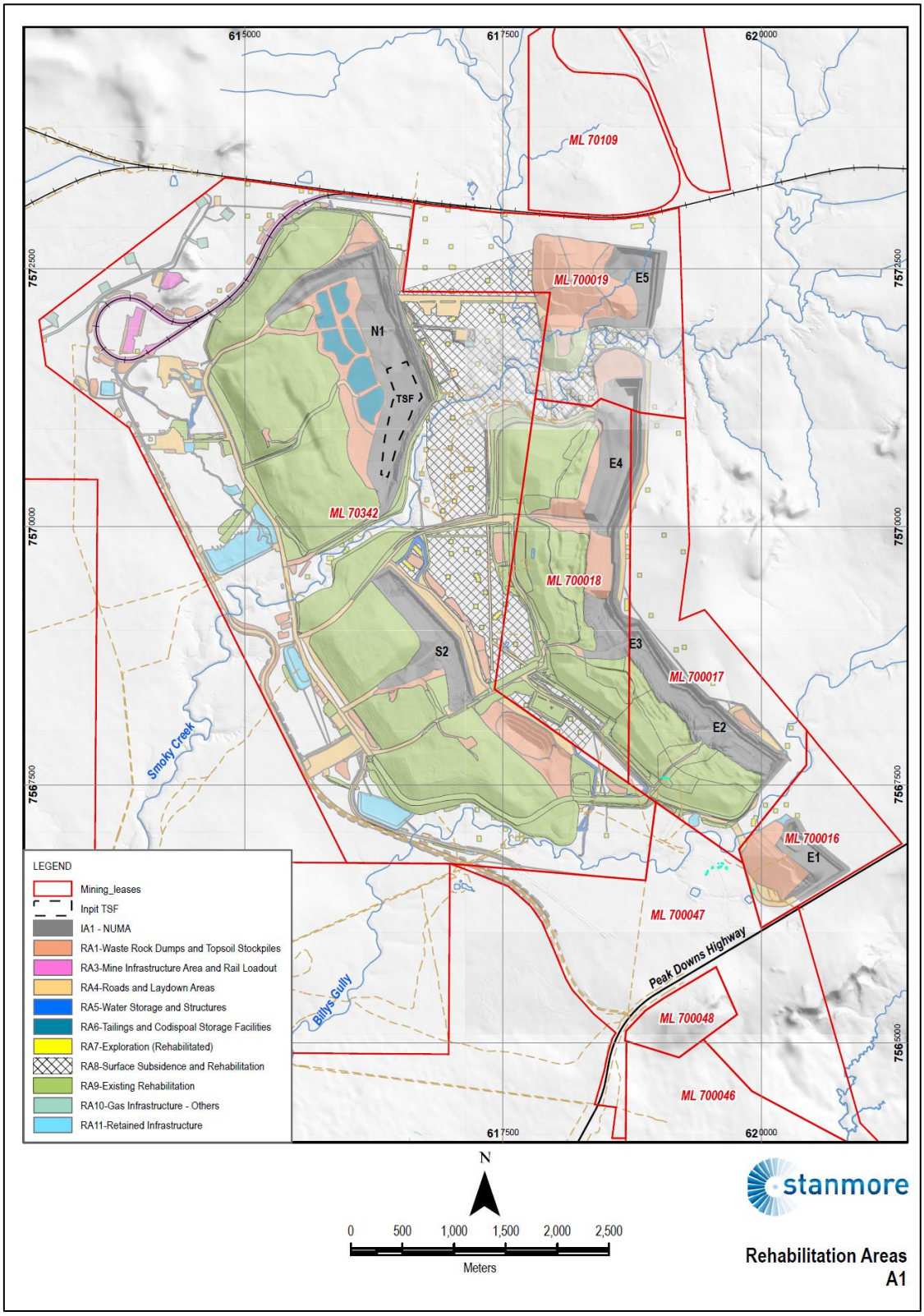


Figure 2: Rehabilitation Areas

Section D – Post mining land uses

(RA) Rehabilitation area 1

Post-mining land uses (PMLU)						
Rehabilitation area	RA1					
Relevant activities	Waste rock dumps and topsoil stockpiles					
Total rehabilitation area size (ha)	310.6					
Commencement of first milestone: RM3	11/12/2025					
PMLU	Grazing					
Date area is available	11/12/2025	11/12/2028	11/12/2031	11/12/2034	11/12/2038	11/12/2043
Cumulative area available (ha)	30.0	135.0	310.6	310.6	310.6	310.6
Milestone completed by	10/12/2028	10/12/2031	10/12/2034	10/12/2038	10/12/2043	10/12/2048
Milestone Reference	**Cumulative area achieved (ha)**					
RM3	30.0	135.0	310.6			
RM5	10.0	100.0	240.0	310.6		
RM6	10.0	100.0	240.0	310.6		
RM7		30.0	135.0	180.0	310.6	
RM8			30.0	100.0	180.0	310.6

(RA) Rehabilitation area 2

Rehabilitation area	RA2			
Relevant activities	ROM and product stockpiles			
Total rehabilitation area size (ha)	15.6			
Commencement of first milestone: RM1	11/12/2037			
PMLU	Grazing			
Date area is available	11/12/2037	11/12/2038	11/12/2043	11/12/2048
Cumulative area available (ha)	15.6	15.6	15.6	15.6
Milestone completed by	10/12/2038	10/12/2043	10/12/2048	10/12/2053
Milestone Reference	**Cumulative area achieved (ha)**			
RM1	15.6			
RM2	15.6			
RM3	15.6			
RM5		15.6		
RM6		15.6		
RM7			15.6	
RM8				15.6

(RA) Rehabilitation area 3

Rehabilitation area	RA3		
Relevant activities	Mine infrastructure area and rail loop		
Total rehabilitation area size (ha)	28.3		
Commencement of first milestone: RM1	01/01/2036		
PMLU	Grazing		
Date area is available	11/12/2036	11/12/2038	11/12/2043
Cumulative area available (ha)	28.3	28.3	28.3
Milestone completed by	10/12/2038	10/12/2043	10/12/2048
Milestone Reference	**Cumulative area achieved (ha)**		
RM1	28.3		
RM2	28.3		
RM3	28.3		
RM5		28.3	
RM6		28.3	
RM7		28.3	
RM8			28.3

(RA) Rehabilitation area 4

Rehabilitation area	RA4						
Relevant activities	Roads, laydowns and cleared areas						
Total rehabilitation area size (ha)	224.2						
Commencement of first milestone: RM1	11/12/2026						
PMLU	Grazing						
Date area is available	11/12/2026	11/12/2028	11/12/2031	11/12/2034	11/12/2038	11/12/2043	11/12/2048
Cumulative area available (ha)	64.0	121.4	179.8	220.0	224.2	224.2	224.2
Milestone completed by	10/12/2028	10/12/2031	10/12/2034	10/12/2038	10/12/2043	10/12/2048	10/12/2053
Milestone Reference	**Cumulative area achieved (ha)**						
RM1	64.0	121.4	179.8	220.0	224.2		
RM2	59.9	104.0	154.6	220.0	224.2		
RM3	30.5	104.0	154.6	179.8	220.0	224.2	
RM5	0.5	64.0	104.0	179.8	220.0	224.2	
RM6	0.5	64.0	104.0	179.8	220.0	224.2	
RM7		0.5	30.5	179.8	220.0	224.2	
RM8				154.6	179.8	220.0	224.2

(RA) Rehabilitation area 5

Rehabilitation area	RA5					
Relevant activities	Water storage and management structures					
Total rehabilitation area size (ha)	21.6					
Commencement of first milestone: RM3	11/12/2027					
PMLU	Grazing					
Date area is available	11/12/2027	11/12/2028	11/12/2031	11/12/2034	11/12/2038	11/12/2043
Cumulative area available (ha)	4.5	8.8	21.6	21.6	21.6	21.6
Milestone completed by	10/12/2028	10/12/2031	10/12/2034	10/12/2038	10/12/2043	10/12/2048
Milestone Reference	**Cumulative area achieved (ha)**					
RM3	4.5	8.8	21.6			
RM5	3.2	6.2	12.2	21.6		
RM6	3.2	6.2	12.2	21.6		
RM7					21.6	
RM8						21.6

(RA) Rehabilitation area 6

Rehabilitation area	RA6				
Relevant activities	Tailings and co-disposal				
Total rehabilitation area size (ha)	31.4				
Commencement of first milestone: RM2	11/12/2033				
PMLU	Grazing				
Date area is available	11/12/2033	11/12/2034	11/12/2038	11/12/2043	11/12/2048
Cumulative area available (ha)	18.3	31.4	31.4	31.4	31.4
Milestone completed by	10/12/2034	10/12/2038	10/12/2043	10/12/2048	10/12/2053
Milestone Reference	**Cumulative area achieved (ha)**				
RM3	18.3	31.4			
RM4		18.3	31.4		
RM5		18.3	18.3	31.4	
RM6		18.3	18.3	31.4	
RM7			18.3	31.4	
RM8			18.3	18.3	31.4

(RA) Rehabilitation area 7

Rehabilitation area	RA7	
Relevant activities	Historic Exploration	
Total rehabilitation area size (ha)	22.3	
Commencement of first milestone: RM7	11/12/2025	
PMLU	Grazing	
Date area is available	11/12/2025	11/12/2028
Cumulative area available (ha)	22.3	22.3
Milestone completed by	10/12/2028	10/12/2031
Milestone Reference	**Cumulative area achieved (ha)**	
RM7	22.3	
RM8		22.3

(RA) Rehabilitation area 8

Rehabilitation area	RA8		
Relevant activities	Subsidence areas		
Total rehabilitation area size (ha)	308.4		
Commencement of first milestone: RM5	11/12/2036		
PMLU	Grazing		
Date area is available	11/12/2036	11/12/2038	11/12/2043
Cumulative area available (ha)	308.4	308.4	308.4
Milestone completed by	10/12/2038	10/12/2043	10/12/2048
Milestone Reference	**Cumulative area achieved (ha)**		
RM5	308.4		
RM6	308.4		
RM7		308.4	
RM8			308.4

(RA) Rehabilitation area 9

Rehabilitation area	RA9				
Relevant activities	Existing rehabilitation				
Total rehabilitation area size (ha)	977.2				
Commencement of first milestone: RM7	11/12/2025				
PMLU	Grazing				
Date area is available	11/12/2025	11/12/2028	11/12/2031	11/12/2034	11/12/2038
Cumulative area available (ha)	977.2	977.2	977.2	977.2	977.2
Milestone completed by	10/12/2028	10/12/2031	10/12/2034	10/12/2038	10/12/2039
Milestone Reference	**Cumulative area achieved (ha)**				
RM7	200.0	560.0	977.2		
RM8		200.0	560.0	850.0	977.2

(RA) Rehabilitation area 10

Rehabilitation area	RA10	
Relevant activities	Gas infrastructure	
Total rehabilitation area size (ha)	10.3	
Commencement of first milestone: RM7	11/12/2041	
PMLU	Grazing	
Date area is available	11/12/2041	11/12/2048
Cumulative area available (ha)	10.3	10.3
Milestone completed by	10/12/2048	10/12/2053
Milestone Reference	**Cumulative area achieved (ha)**	
RM7	10.3	10.3
RM8	0.0	10.3

(RA11) Rehabilitation area 11

Rehabilitation area	RA11					
Relevant activities	Retained infrastructure					
Total rehabilitation area size (ha)	46.3					
Commencement of first milestone: RM5	11/12/2028					
PMLU	Water Storage					
Date area is available	11/12/2028	11/12/2031	11/12/2034	11/12/2038	11/12/2043	11/12/2048
Cumulative area available (ha)	1.2	1.7	13.9	46.3	46.3	46.3
Milestone completed by	10/12/2031	10/12/2034	10/12/2038	10/12/2043	10/12/2048	10/12/2053
Milestone Reference	**Cumulative area achieved (ha)**					
RM5	1.2	1.7	13.9	46.3		
RM6	1.2	1.7	13.9	46.3		
RM7	1.1	1.2	2.6	15.3	46.3	
RM8			1.2	2.6	15.3	46.3

Rehabilitation area milestones

Milestone reference	Rehabilitation milestone	Milestone criteria
RM1	Infrastructure Decommissioning and Removal	a) All services, excluding retained infrastructure, are disconnected and decommissioned. b) All buildings, excluding retained infrastructure, are demolished and/or removed offsite. c) All road materials (bitumen and gravel), excluding retained infrastructure, are removed. d) All pipelines, excluding retained infrastructure, are drained and removed. e) All waste removed from site unless authorised by the EA for disposal onsite. f) All exploration drill holes rehabilitated in accordance with the eligibility criteria and standard conditions for exploration and mineral development projects – V2 (DEHP 2016)[1]. g) Infrastructure required for the ongoing health and safety of operators such as road safety bunds are to be retained until deemed safe to remove in accordance with the *Coal Mining Safety and Health Act 1999*. h) All dams dewatered and desilted as per AQP recommendation. i) Watercourse crossings and culverts, excluding retained infrastructure, removed. j) All machinery and equipment, not required for rehabilitation works removed from Rehabilitation Areas (RA). k) Infrastructure to be retained for use by underlying landholder, deemed fit for purpose and accepted by signed agreement from the underlying landholder. l) An AQP has certified the achievement of RM1a) to k).
RM2	Remediation of Contaminated Land	a) Preliminary and intrusive contaminated land investigations carried out by an AQP to assess potentially contaminated mine domain areas. b) Depending on the result of RM2.a) Suitably Qualified Person (SQP) determines applicability of relevant requirements of Chapter 7, part 8 of the *Environmental Protection Act 1994* (Qld) (EP Act) to the identified contaminated land areas.

[1] *Department of Environment and Heritage Protection (2016) Guideline – Requirement for site specific and amendment applications – underground water rights under the Environmental Protection Act 1994.*

		c) Contaminated and hazardous material either remediated in-situ or removed/transported to an approved landfill for disposal and waste tracking information recorded and submitted. d) Validation testing confirms that contaminated and hazardous materials have been removed or remediated successfully. e) SQP certifies the achievement of criteria RM2.b) to RM2.d) retained until achievement of RM7.
RM3	Landform Development and Reshaping/Reprofiling	a) Final landform drainage installed as designed by AQP to reduce ponding and allow effective removal of surface water from vegetated slopes. b) All major earthworks completed, slopes and general reshaping and pushing/ trimming are completed in accordance with the design specification provided by an AQP. c) The Smoky Creek N1 and S1 levees are incorporated into the final rehabilitated landform with established vegetation and selective placement of non-erosive materials and/or rock mulch protection as per AQP advice to ensure landform stability to sustain flood stress of up to PMF event. d) All flood protection landforms (e.g. levees or landforms) provide immunity to at least the 0.1%AEP flood event plus 0.5m freeboard. e) S3 void to be partially backfilled above the long-term groundwater level. f) The rehabilitated landform reshaped to: i. For RA1 and RA6, ≤15% for the external slope and ≤30% for internally draining slopes. ii. For RA2, RA3, RA4, RA5, RA7, RA8, RA9, RA10 ≤15% g) All landforms are shaped to be water shedding. h) Erosion and sediment control systems are designed by an AQP, installed, and fit for purpose. i) Seepage and surface runoff from rehabilitation areas is directed to the sediment dams through appropriate permanent, low maintenance and stable drainage systems, as agreed by the underlying landholder. j) Final rehabilitated landforms (RA1, RA5, RA6, RA9, RA11) including back-filled pits N2, S1 and S3 voids other than residual voids assessed as geotechnically stable by an AQP with a factor of safety (FOS) of 1.5.

		k) Final rehabilitated overburden dumps in which the base of the spoil is not inundated have critical FOS values ≥ 1.5, and the base of spoil with risk of inundation have FOS between 1.3 - 1.5. l) Disturbed natural watercourse bed and banks returned to a natural condition with profile similar to the pre-disturbance condition. m) Any areas of subsidence with measurable ponding of overland flow, resulting from the Isaac Plains Underground Project, are ripped and reshaped as required to ensure free drainage. n) Water storages are safe for stock access and have vegetated banks. o) An AQP has certified the achievement of RM3 a) to n).
RM4	Installation of cover system	a) Tailings have consolidated and are considered safe by an AQP for installing the cover system. b) An AQP to determine appropriate detailed cover design for installation. c) An AQP certify installation of cover system as designed per RM4.b). d) Following installation of a cover system in accordance with RM4.a), the cover system achieves the following criteria: i. Surface is water-shedding and achieves net drainage flux less than 10% of average annual rainfall and demonstrated by modelling that the cover design is capable to minimising average net percolation to below 10% annual rainfall. ii. Growth media has been approved by an AQP and ameliorated and/or fertilised if necessary to support the target vegetation species. iii. Sampling of the ameliorated and/or fertilised growth media confirms the soil properties are suitable for the vegetation species as per **Appendix 1: Pasture grazing seeding mix** unless alternative species recommended by an AQP. e) The installed cover is erosional and geotechnically stable and supports the marginal grazing PMLU. f) An independent AQP has certified the achievement of RM4.a) – RM4.e).
RM5	Surface preparation	a) An assessment of growth media has been completed by an AQP to confirm growth media and suitability for PMLU and target vegetation establishment.

		b) Application rate of ameliorants such as fertiliser, gypsum/or organic matter and physical treatment plan determined by an AQP based on the assessment required by **RM5.a)** and implemented. c) Records demonstrate topsoil placement has achieved a minimum target depth of 150 mm. d) Deep ripping of compacted areas as per the requirements of the soil material assessment, including along the contour slopes. e) Filling and ripping of surface cracks greater than 20cm wide to a depth as required in areas impacted by subsidence, prior to topsoil application. f) Following amelioration, representative soil testing confirms: i. pH (1:5) 5.6–8.4 ii. Saturation Extract EC (Ece) ≤ 10 dS/m from 0-0.6 m depth iii. Exchangeable sodium percentage (ESP) ≤6% (0-0.1 m depth) or ≤23% (at 0.5 m depth) (Placement of growth media to a minimum depth of 150 millimetres (mm), with additional growth media added as needed to high-risk areas where informed by an AQP). g) Remediate any erosion or subsidence by, but not limited to, addition of rock and/or log cover to assist erosion resistance of eventual vegetative groundcover. h) Construction of seal from surface into the underground workings complies with regulation 325 of the Queensland Coal Mining Safety and Health Regulations 2020 (CMSHR) and Registered Professional Engineer of Queensland (RPEQ) design. i) The surface and groundwater monitoring is underway (at least one year of sampling undertaken). j) An AQP to certify achievement of RM5.a) to i). k) For areas affected by subsidence, AQP confirms following: i. Surface deflection within range of 20-60mm above UG area, except in modified Duncan panels. ii. Modified Duncan panels surface deflection within range of 100 -150mm. iii. The cessation of subsidence. iv. Depression/ponding areas are free draining and require no further drainage works.
RM6	Revegetation	a) Complete seeding in accordance with target species of 3P (perennial, palatable and productive) with a selection of species and at a rate consistent with **Appendix 1: Pasture grazing seed mix**.

		b) The seed application required by RM6a must include minimum of 4 palatable perennial pasture species and include up to 50% native species. c) Complete seeding of topsoil surfaces for areas impacted by subsidence using a seed mix and a rate consistent with **Appendix 1: Pasture grazing seed mix**. d) An AQP has certified the achievement of RM6.a) to RM6.c).
RM7	Achievement of surface requirements	a) Rehabilitated areas demonstrate achievement of the following criteria: i. Minimum 70% established and persistent vegetative ground cover, comprising 50% palatable perennial pasture species. ii. Presence of rocks, logs or other effective erosion control cover is limited to 30% of total groundcover. iii. Achievement of following as per Guidelines for Agricultural Land Evaluation in Queensland: • Land class 4 – RA1, RA6 • Land class 3 – RA2, RA3, RA4, RA5, RA7, RA8, RA9, RA10 iv. Weed presence is less than 10% of total vegetative groundcover confirmed by an AQP in annual monitoring. v. Subsided areas do not have residual ponding, and overland flows and surface runoff drain freely from these areas. **Soil quality and erosion** b) Representative soil testing of the growth media confirms: i. pH (1:5) 5.6–8.4 ii. Saturation Extract EC (Ece) ≤ 10 dS/m from 0-0.6 m depth iii. Exchangeable sodium percentage (ESP) ≤6% (0-0.1 m depth) or ≤23% (at 0.5 m depth) iv. Evidence of nutrient and organic matter cycling is occurring (through presence of organic carbon and nitrogen in the soil profile for a period of 3 years). c) Erosional stability must meet the following:

		i. No evidence of erosion classified as 'moderate' or 'severe' as defined by **Appendix 2: Erosion classification framework**. ii. Any erosion present will not compromise the achievement of a PMLU to a stable condition. iii. The final landform design demonstrates that rates of erosion are <5 t/ha/yr. iv. Evidence of scouring, overtopping, sedimentation or destabilisation in or associated with erosion and sediment control and engineered drainage structures, limited to minor classification as per **Appendix 2: Erosion classification framework**. **Surface water quality** d) Surface water runoff from rehabilitation areas collected at appropriate location/s determined by an AQP for monitoring surface water runoff quality when surface flows occur and when it is safe to do so. e) Surface water runoff monitoring in accordance with RM7.e) shows surface water runoff is non-polluting to receiving waters and complies with the following: i. pH 6.5-8.5 pH units ii. EC ≤720 µS/cm iii. Turbidity ≤50 NTU iv. Sulfate ≤25 mg/L f) Water sampling of water storages (RA11) for quality monitoring purposes undertaken quarterly and achieve **Appendix 4: Surface water quality limits** for native wildlife and/or livestock ingestion for a minimum of 5 years. g) AQP certifies achievement of RM7.a) to RM7.f).
RM8	Achievement of post-mining land use to a stable condition	**Contaminated Land** a) If deemed necessary by the SQP under RM2, Contaminated Land Investigation Document (CLID) completed in accordance with the EP Act, including: i. Site Suitability Statement confirming the suitability of the property (all lot/plans within the mining lease area) for the PMLUs.

		ii. Site Investigation Report and, where required, a Validation Report and/or a draft Site Management Plan provided. iii. Removal of land from Environmental Management Land Register (EMR)/ Contaminated Land Register (CLR). b) The final rehabilitated landforms are structurally stable by achievement of following: i. For RA1 and RA6, ≤15% for the external slope and ≤30% for internally draining slopes. ii. For RA2, RA3, RA4, RA5, RA7, RA8, RA9, RA10 ≤15%. c) Final rehabilitated landforms including back-filled pits (N2 and S1 voids) but excluding residual voids are assessed as geotechnically stable by an AQP with a factor of safety (FOS) of 1.5. d) Overburden dumps in which the base of the spoil is not inundated have critical FOS values ≥ 1.5, and the base of spoil with risk of inundation have FOS between 1.3 - 1.5. e) No tunnel erosion or fissures present in areas subject to subsidence. f) Bed and banks of subsidence drainage structures are stable. g) No bed and bank erosion within watercourses as a result of or associated with subsidence or subsidence management. h) No cracking or destabilisation present in bed or banks of watercourses as a result of subsidence or subsidence management. i) Subsidence areas that may be subject to flooding are designed to withstand flood stresses compromising structural or erosional stability. j) Vegetation shows preferred pasture species (3P grasses) diversity ≥ 4. k) Minimum 70% established and persistent vegetative ground cover, comprising 50% palatable perennial pasture species. l) Presence of rocks, logs or other effective erosion control cover is limited to 30% of total vegetative groundcover. m) Achievement of following as per Guidelines for Agricultural Land Evaluation in Queensland: Land class 4 – RA1, RA6 (Marginal grazing) Land class 3 – RA2, RA3, RA4, RA5, RA7, RA8, RA9, RA10 (grazing)

		n) Weed presence is less than 10% of total vegetative groundcover. o) Restricted invasive plants (as defined in the *Biosecurity Act 2014* Qld) comprise ≤5% of vegetation groundcover. p) Infrastructure to be transitioned to a landholder will be deemed fit for purpose and accepted, by signed agreement, with the landholder. q) Rehabilitation is resilient to fire and grazing pressures. **Soil quality, Erosion and Retained Infrastructure** r) Growth media quality meets the parameters outlined in **RM7.b).** s) No evidence of erosion classified as 'moderate' or 'severe' as defined by **Appendix 2: Erosion classification framework.** t) The final landform design demonstrates that rates of erosion are <5 t/ha/yr. u) Evidence of scouring, overtopping, sedimentation or destabilisation in or associated with erosion and sediment control and engineered drainage structures, limited to minor classification as per **Appendix 2: Erosion classification framework**. v) Any erosion present will not compromise the achievement of a PMLU to a stable condition. w) Water storages (RA11) contain suitable water quality for native wildlife and/or livestock ingestion and achieve the water quality criteria outlined in **Appendix 4: Surface water quality limits**. x) Water storages are safe for native animals and stock access and have vegetated banks. y) An independent AQP certifies achievement of RM8. a) to RM8.z).

Section E – Non-use management areas

(IA1) Improvement area 1

Non-use management area (NUMA)					
Improvement area	IA1				
Relevant activities	Pit Voids and Water Storage				
Total size (ha)	382.4				
Commencement of first milestone: MM1	11/12/2027				
NUMA	Voids and Water Storage, including FoS Setback, Fence and Highwall Bund				
Date area is available	11/12/2027	11/12/2028	11/12/2031	11/12/2034	11/12/2038
Cumulative area available (ha)	79.3	156.2	156.2	197.8	382.4
Milestone completed by	10/12/2028	10/12/2031	10/12/2034	10/12/2038	10/12/2043
Milestone Reference	**Cumulative area achieved (ha)**				
MM1	79.3	156.2	156.2	197.8	382.4
MM2					19.0
MM3	79.3	105.9	156.2	178.7	382.4
MM4		105.9	156.2	178.7	382.4

Improvement area milestones

Milestone reference	Management milestone	Milestone criteria
MM1	Achievement of structural stability	a) Highwall and end wall landforms (where not backfilled) must: i. Prevent the ingress of floodwater into the void; ii. Be geotechnically stable. b) The following slope geometry achieved for highwall and end wall (where not backfilled): i. Competent (unweathered) rock slopes are overall 275% (70°) with 35 m high batters; and 10m wide bench at the base of each batter; ii. Non-competent (weathered) rock slopes are overall 100% (45°) and 10 m wide bench at the base of weathering; iii. The uppermost layer of soil and extremely weathered rock are battered back to overall 27° (50%) and protected from surface runoff to minimise gullying; iv. Low-wall void slopes battered to a maximum overall angle of 100% (45°) in incompetent rock. c) Following slope geometry achieved for low wall spoil: i. Slopes battered to an overall angle of 73% (36˚) or angle of repose in incompetent rock. d) Walls / slopes assessed as stable by an AQP (geotechnical engineer) (FoS ≥1.2 or ≥1.5 for E1 pit). e) Residual voids are not subject to inundation from floodwaters up to and including the 0.1% AEP. f) The risk associated with a probable maximum flood (PMF) event with respect to residual voids must also be considered in final landform design. g) AQP assesses that the existing smoky creek N1 and S1 levees incorporated into the final landform provide flood protection to N1 pit and S2 pit at the minimum 0.1% AEP level + 0.5m freeboard. h) Levees and abandonment bunds have appropriate scour protection to sustain flood velocities of minimum 0.1% AEP and consider PMF flood stress as advised by AQP based on a risk assessment completed in accordance with **PRCP Condition 4**.

		i) The location of the voids and associated safety bunds does not cause instability or degradation to the land outside the NUMA. j) Residual voids must not overtop. k) An AQP demonstrates with monitoring of water quality, water level within void and modelling data, that the residual void/s act as groundwater sinks post-closure. l) An AQP certifies achievement of MM1.a) to MM1.i) and MM1.k).
MM2	Installation of cover system (in-pit tailings)	a) Tailings have consolidated and are considered safe by an AQP for installing the cover system. b) An AQP to determine appropriate detailed cover design for installation, including non-acid forming (NAF) spoil placed in a minimum 1m thick layer over consolidated tailings. c) An AQP certify installation of cover system as designed per MM2.b). d) Installed cover displays erosional and geotechnical stability. e) Installed cover is effective in mitigating the potential for interaction of contaminants from tailings storage areas with the surrounding environment, up until when the natural water level rises in the N1 void to create a water cap. f) An independent AQP certifies achievement of MM2.b) to MM2.e).
MM3	Achievement of surface requirements / access controls	a) Safety bund setback distance is in accordance with calculated geotechnical FoS of ≥1.5 and achieves a minimum distance of 15 m. b) The safety bund is constructed around the perimeter of the final void to prevent access to the residual void, in accordance with engineering requirements including: i. Constructed from non-weathered dumped rockfill where possible; ii. A minimum 2m in height; iii. A minimum of 5m base width; iv. Not greater than 1 in 1.5 batters. c) Fencing installed at nominated offset from safety bund (nominally a four-strand barbed stock fence). d) Safety signage (design in accordance with Australian Standard) is erected at 100m intervals along the fence. e) No public access to highwall or end wall areas. f) An AQP certifies achievement of MM3.a) to MM3.e).

MM4	Achievement of sufficient improvement	a) The highwall landform has been constructed in accordance with the final design by an AQP. b) Appropriate safety infrastructure at the geotechnical set-back distance has been installed to prevent access to the NUMA. c) Annual monitoring shows exclusion fences and bunds present remain effective. d) The residual void is safe to humans and livestock. e) The final void is geotechnically stable including: i. Walls / slopes assessed as stable by an AQP (geotechnical engineer) (FoS ≥1.2 or ≥1.5 for E1 pit) ii. Drainage measures and structures have been appropriately established and are directing overland flow away from the highwall edge iii. Erosion and sediment control measures have been installed and are operating as per design f) The residual void meets the criteria set out in **Appendix 7: Final Void Dimensions** g) Risk from the void is as low as reasonably practical (ALARP) in accordance with the latest version of AS/NZS ISO 31000:2009 Risk Management and certified by an AQP. h) Residual voids are monitored for water level six monthly, for 10 years in conjunction with **PRCP Condition 15** to demonstrate residual void sink behaviour. i) The water level and quality in the void continually show that it does not and will not cause environmental harm to the receiving environment, and continue to act as a sink, as demonstrated by groundwater modelling and monitoring of groundwater level and quality. **Note:** here **PRCP Condition 12** groundwater quality results applicable to demonstrate 'no harm' criteria and **PRCP Condition 15** and **MM4.h)** applicable for residual void sink behaviour). j) Voids retain minimum 0.1% AEP flood immunity, supported by flood modelling re-run at end of life and calibrated against the final landform. k) Erosion of the landform within the NUMA area will not negatively impact on the stability of any adjacent rehabilitation areas, or their ability to sustain their PMLU. l) An independent AQP certifies achievement of MM4.a) to MM4.k).

Appendicies

Appendix 1- Pasture grazing seeding mix

Common Name	Scientific Name	Seeding Rate (kilograms per hectare (kg/ha))
King Bluegrass	*Dichanthium queenslandicum*	Minimum total seed rate of 10-15kg/ha; must include 4 palatable perennial pasture species. Must also include up to 50% native species
Black Speargrass	*Heteropogon contortus*	
Sabi Grass	*Urochloa mosambicensis*	
Rhodes Grass	*Chloris gayana*	
Kangaroo grass	*Themeda triandra*	
Gayndah Buffel grass	*Cenchrus ciliaris*	
Butterfly Pea	*Clitoria ternatea*	
Round-leafed Cassia	*Chamaecrista rotundifolia*	
Red Natal Grass	*Melenis repens*	
Sugar-drip Sorghum	*Sorghum sp.*	
Japanese Millet	*Echnochloa esculenta*	
River She-Oak	*Casuarina cunninghamiana*	
Narrow-leaved Ironbark	*Eucalyptus crebra*	

Appendix 2 - Erosion classification framework

Erosion classification	Minor	Moderate	Severe
Sheet erosion	Shallow soil deposits downslope	Partial exposure of roots; moderate soil deposits downslope.	Loss of surface horizon; subsoil exposure; root exposure; substantial soil deposits downslope.
Rill erosion (<0.3m deep)	<15 rills per transect*	15 - 30 rills per transect*	>30 rills per transect*
Gully erosion (>0.3m deep)	Absent	Absent	Present
Tunnel erosion	Absent	Absent	Present
Mass movement	Absent	Absent	Present

Source: NCST (2024) *Australian Soil and Land Survey Field Handbook, 4th edition*. The National Committee on Soil and Terrain. CSIRO Publishing, Collingwood, Australia.
*Transect 100 m across the contour (Source: Tongway, D. J. and Hindley, N. L. 2005. Landscape Function Analysis: Procedures for Monitoring and Assessing Landscapes. CSIRO Publishing, Canberra, Australia.)

Appendix 3- Surface water monitoring locations

Monitoring Points	Receiving Waters Location Description	Easting (GDA94 – Zone 55)	Northing (GDA94 – Zone 55)
Upstream Background Monitoring Points			
Monitoring Point 1	W6 – Smoky Creek upstream (u/s)	619082	7571899
Monitoring Point 2	W7 – Billy's Gully u/s	620330	7568146
Downstream Monitoring Points			
Monitoring Point 4	W4 - Billy's Gully 1340 meters downstream of RP2	616415.04	7566527.5
Monitoring Point 5	W5 - Smoky Creek 750 meters Downstream of RP1	614925.04	7569302.5

Appendix 3.1 – Figure 1 Surface water monitoring locations

ML
Waterway
Railway
Road
Final Landform Contours
Upstream Surface Water Monitoring Location
Downstream Surface Water Monitoring Location

N

0 500 1,000 1,500 2,000 2,500
Meters

stanmore

Surface Water Monitoring Locations
Figure 1

Appendix 4 – Surface water quality limits

Quality Characteristic	Unit	Limit	
pH	pH units	6.5-8.5	Upper Isaac River WQO
Electrical conductivity	µS/cm	720	Upper Isaac River WQO - baseflow
Sulfate	mg/L	25	Upper Isaac River WQO
Turbidity	NTU	50	Upper Isaac River WQO
Aluminum (Dissolved)	µg/L	55	ANZG 2018
Antimony (Dissolved)	µg/L	9	ANZG 2018
Arsenic (Dissolved)	µg/L	13	ANZG 2018
Iron (Dissolved)	µg/L	290	Site-specific
Mercury (Dissolved)	µg/L	0.06	ANZG 2018
Molybdenum (Dissolved)	µg/L	34	ANZG 2018
Selenium (Dissolved)	µg/L	5	ANZG 2018
Silver (Dissolved)	µg/L	0.05	ANZG 2018
Total recoverable hydrocarbons (C6-C9)	µg/L	20	
Total recoverable hydrocarbons (C10-C36)	µg/L	100	
Major ions Calcium, chloride, potassium, magnesium, sodium, bicarbonate, carbonate	Mg/L	For interpretation purposes only	

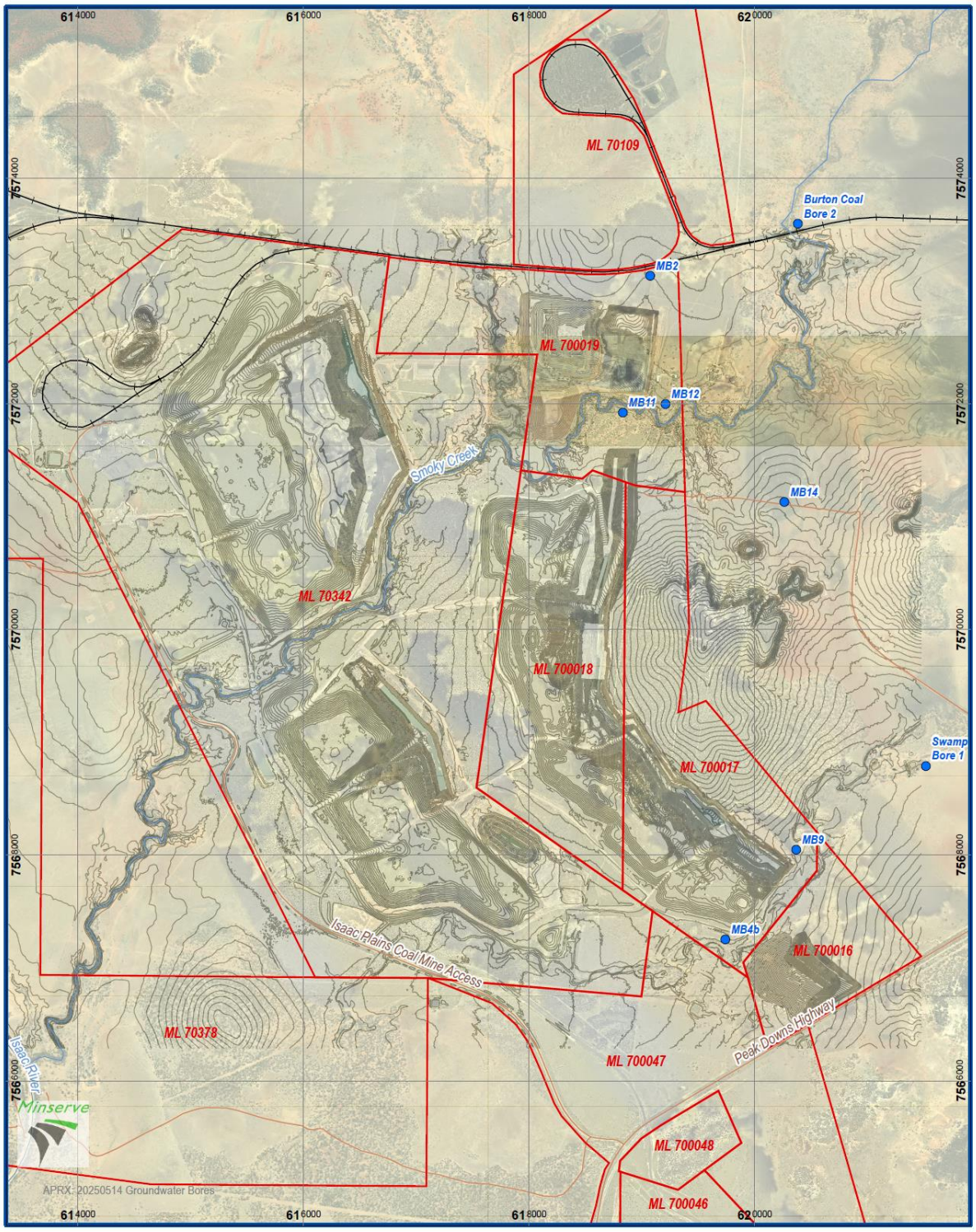
Notes:

- All metals and metalloids must be measured as ‘dissolved’ (from analysis of a field filtered sample) and total (unfiltered).
- Limits for metals and metalloids apply to dissolved results.
- DEHP (2011) Upper Isaac River Sub Basin WQO – surface water
- ANZG (2018) Aquatic ecosystem protection for moderately disturbed system (95% protection)

Appendix 5 - Groundwater monitoring locations and frequency

Monitoring Point	Location		Surface RL	Total Depth	Screen interval (mbgl)	Hydro stratigraphic Unit	Monitoring frequency	Monitoring parameter
	Easting (GDA94 – Zone 55)	Northing (GDA94 – Zone 55)						
MB2	619074	7573137	242.7	51.9	48.7 – 51.6	Rangal Coal Measures	Quarterly	Level
MB11	618832	7571924	231.8	5.0	3.0 – 4.0	Tertiary sediments	Quarterly	Level
MB12	619210	7572000	239.5	129	126 – 128	Rangal Coal Measures	Quarterly	Level
MB4b	619740	7567253	233.9	12.4	9.4 – 12.4	Rangal Coal Measures	Quarterly	Level
MB9	620368	7568049	239.5	80.5	77.5 – 80.5	Rangal Coal Measures	Quarterly	Level
MB14	620263	7571132	257.3	24	20 – 23	Tertiary basalt	Quarterly	Level
Swamp bore 1	621518	7568790	245.9	55.0	24.0 – 55.1	Rewan Group	Quarterly	Quality and level
Burton Coal bore 2	620383	7573599	240.8	37.0	30.3 – 34.6	Rewan Group	Quarterly	Quality and level

Appendix 5.1- Figure 2 – Groundwater monitoring locations



ML
Waterway
Railway
Road
Groundwater Monitoring Location
Final Landform Contours

N

0 500 1,000 1,500 2,000 2,500
Meters

stanmore

Groundwater Monitoring Locations
Figure 2

Appendix 6 - Groundwater quality limits

Parameter	Unit	Limits	Source
pH	pH Units	7.0-8.5	Site-specific
Electrical Conductivity	µS/cm	12,300	Site-specific
Sulfate	mg/L	130	Site-specific
Aluminum (Dissolved)	µg/L	55	ANZG 2018
Antimony (Dissolved)	µg/L	1	Site-specific
Arsenic (Dissolved)	µg/L	13	ANZG 2018
Iron (Dissolved)	µg/L	300	ANCG
Mercury (Dissolved)	µg/L	0.06	ANZG 2018
Molybdenum (Dissolved)	µg/L	1	Site-specific
Total Petroleum Hydrocarbons C6-C9	µg/L	20	Maximum
Total Petroleum Hydrocarbons C10-C36	µg/L	50	Maximum
Selenium (Dissolved)	µg/L	5	ANZG 2018
Silver (Dissolved)	µg/L	0.05	ANZG 2018
Major ions Calcium, chloride, potassium, magnesium, sodium, bicarbonate, carbonate	mg/L	For interpretation purposes only	

Notes:

- All metals and metalloids must be measured as ‘dissolved’ (from analysis of a field filtered sample) and total (unfiltered).
- Limits for metals and metalloids apply to dissolved results.
- ANZG (2018) Aquatic ecosystem protection for moderately disturbed system (95% protection)

Appendix 7 – Final Void Dimensions

Residual Void	Residual Void Area (Inclusive of safety bunds)	Maximum Void Depth
N1	116.6	110 m
S2	59.0	90 m
E1	25.6	80 m
E2/E3/E4	148.4	140 m
E5	32.8	80 m

END OF PRCP SCHEDULE

APPENDIX B ANNUAL GROUNDWATER REVIEW (2020)

C&R CONSULTING
Geochemical & Hydrobiological Solutions Pty Ltd
ABN 72 077 518 784

Underground Coal Gasification / Coal Seam Gas Investigations
Mineralogical, Geological, Petrographic and Soils Services
Hydrogeomorphic and Palaeogeomorphic Evaluations
Terrestrial and Aquatic Fauna and Flora Surveys
Climate History and Extreme Events Analysis
Contaminated Site and Mine Water Analysis
Environmental Compliance and Monitoring
Estuarine and Marine Water Assessments
Registered Research and Development
Surface and Groundwater Hydrology

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ISAAC PLAINS COMPLEX

2020 Annual Groundwater Review

REPORT PREPARED FOR:

stanmore IP Coal

Date: May 2021

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21/05/2021	21/05/2021
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SUMMARY OF RELEVANT INFORMATION

Project Title	2020 Annual Groundwater Review
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1. INTRODUCTION

1.1 OBJECTIVES

This document provides a review of the groundwater monitoring results from the Isaac Plains Complex (IPC) from May 2019 to December 2020 (inclusive), as per the current environmental authority (EA) (EPML00932713), effective from 27 July 2020.

The EA states that:

Condition C40: Monitoring and reporting

A Groundwater Management and Monitoring Program for all stages of the authorised mining activities on site must be developed, certified and implemented by a suitably qualified person;

a) have all determinations of groundwater quality monitoring and groundwater biological monitoring be performed by a suitably qualified person; and

b) be able to detect a change in groundwater quality values and levels due to activities that are part of the authorised mining activities.

***Condition C41**:*

The Groundwater Management and Monitoring Program required by Condition C40 and the data collected must be reviewed on an annual basis by a suitably qualified person. The review must:

a) include the assessment of groundwater levels and quality data;

b) assess the suitability of the groundwater monitoring network, including an assessment of whether groundwater parameter trigger values for compliance bores are required for all groundwater aquifers potentially impacted by the authorised mining activities; and

c) be in a report submitted to the administering authority within twenty-eight (28) days of receiving annual groundwater data.

***Condition C42**:*

Groundwater must be monitored at the locations and frequencies defined in Table 11: Groundwater monitoring locations frequency for the standing water levels and the parameters identified in Table 12: Groundwater contaminant triggers. Results and analysis of groundwater monitoring must be submitted annually to the administering authority with the report required by Condition C41(c).

Table 1: EA Table 11 – Groundwater monitoring locations and frequency.

Monitoring Point	Location		Surface RL	Hydro stratigraphic Unit	Screening interval (mbgl)	Monitoring frequency
	Easting (GDA94 – Zone 55)	Northing (GDA94 – Zone 55)				
Burton Coal Bore 2	620383	7573599	240.8	Rewan Group	30.3 – 34.6	Quarterly
Swamp Bore 1 (referred to as Swamp Bore 2 in the EA)	621518	7568790	245.9	Rewan Group	24.0 – 55.1	Quarterly
MB1	618793	7572214	236.4	Rangal Coal Measures	22.5 – 28.4	Quarterly
MB2	619074	7573137	242.7	Rangal Coal Measures	48.7 – 51.6	Quarterly
MB3	619047	7568473	253.0	Rangal Coal Measures	49.7 – 52.6	Quarterly
MB4a	620351	7567479	237.6	Quaternary Colluvium / Tertiary Sediments	7.8 – 10.7	Quarterly
MB4b	619740	7567253	233.9	Rangal Coal Measures	9.4 – 12.4	Quarterly
MB8	619105	7571149	245.9	Rangal Coal Measures	117.3 – 120.3	Quarterly
MB9	620368	7568049	239.5	Rangal Coal Measures	77.5 – 80.5	Quarterly
MB10	620368	7568046	239.5	Tertiary Basalt	21.0 – 27.0	Quarterly
MB11	618832	7571924	232.3	Tertiary Sediments	3.0 – 4.0	Quarterly
MB12	619210	7572000	239.5	Rangal Coal Measures	126.0 – 128.0	Quarterly
MB13	619367	7571035	249.7	Rangal Coal Measures	95.0 – 97.0	Quarterly
MB14	620263	7571132	257.3	Tertiary Basalt	20.0 – 23.0	Quarterly
MB15	620633	7568080	242.9	Rangal Coal Measures	115.0 – 119.0	Quarterly
MB16	620670	7568599	245.6	Tertiary Sediments	8.0 – 11.0	Quarterly

Table 2: EA Table 12 – Groundwater contaminant triggers.

Parameter	Unit	Trigger Values – Swamp Bore 1 (referred to as Swamp Bore 2 in the EA)	Trigger Values – Burton Coal Bore 2	Limit Type
Aluminum	µg/L	10	10	Maximum
Antimony	µg/L	1	1	Maximum
Arsenic	µg/L	2	4	Maximum
Calcium	mg/L	580	195	Maximum
Chloride	mg/L	3500	2050	Maximum
Carbonate	mg/L	1	7	Maximum
Total Dissolved Solids	mg/L	7585	4500	Maximum
Electrical Conductivity	µS/cm	9500	7320	Maximum
Bicarbonate	mg/L	94	820	Maximum
Iron	µg/L	1000	230	Maximum
Magnesium	mg/L	165	265	Maximum
Mercury	µg/L	0.1	0.1	Maximum
Molybdenum	µg/L	1	1.0	Maximum
Total Petroleum Hydrocarbons C6-C9	µg/L	20	20	Maximum
Total Petroleum Hydrocarbons C10-C36	µg/L	50	50	Maximum
pH	pH units	7.1 – 7.8	7.0 – 8.3	Minimum / Maximum
Potassium	mg/L	25	8	Maximum
Selenium	µg/L	10	10	Maximum
Silver	µg/L	1	1	Maximum
Sulfate	mg/L	150	130	Maximum
Sodium	mg/L	1275	990	Maximum
Suspended Solids (Total)	mg/L	37	52	Maximum

1.2 MINE LOCATION AND DESIGN

IPC is located within the Isaac Regional Council on both freehold land and state leasehold land in Central Queensland, approximately 10 km to the north-east of Moranbah and 140 km south-west of Mackay (

Figure 1). The project is situated immediately north of the Peak Downs Highway, between Moranbah and Coppabella, and has a rail loop off the south of the Goonyella Branch Rail Line (

Figure 1).

IPC was placed in care and maintenance by Vale S. A. and Sumitomo Corporation in December 2014. In July 2015, ownership of the mine was transferred from Vale S. A. and Sumitomo Corporation to Stanmore IP Coal Pty Ltd (Stanmore), with mining operations recommencing in January 2016.

The original IPC mining lease (ML70342) comprises pits N1, N2, S1, S2 and S3. These pits are north of the Isaac River and upstream of the Isaac River-Smoky Creek confluence, with Smoky Creek bisecting the ML70342 lease area. Most mining at IPC is open-cut and based on a strip-mining technique, with waste removed by a combination of cast blasting, dozing, dragline spoiling and/or truck and excavator removal.

In 2018, Stanmore was granted the approval to commence additional open-cut operations in mining leases located to the east of the original ML70342 mining lease. This expansion of IPC operations into leases ML700016, ML700017, ML700018 and ML700019 commenced in the second half of 2018, and is referred to as Isaac Plains East (IPE).

Isaac Plains East Extension (IPEE) was granted EPBC approval on 4th Dec 2020, which includes further land on leases ML700016, ML700017, ML700018 and ML700019. Operations commenced in these new areas in December 2020.

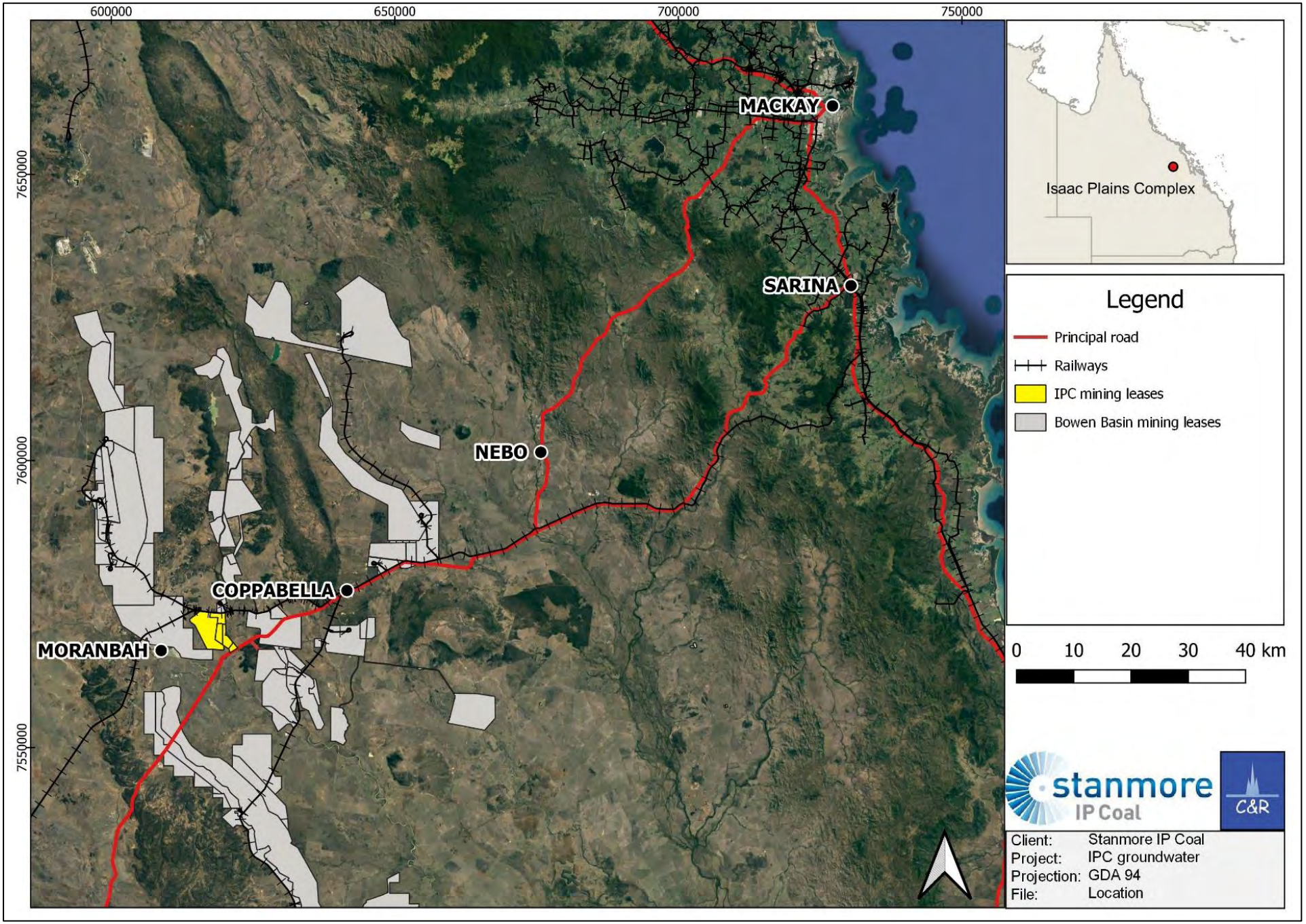

Figure 1: IPC location and mining leases.

2. SITE CONDITIONS

2.1 CLIMATE

The climate in Central Queensland is seasonally arid. Rainfall in the area is notoriously unreliable in its intensity and duration, both temporally and spatially. Intense rainfall events throughout the summer months (wet season) dominate the climate cycle (Figure 2). Most of these rainfall events occur in distinct, spatially separated cells across the landscape. Intense rainfall events are typically associated with tropical cyclone activity on the coast, and the remnant low pressure systems that move inland.

Far less rainfall is experienced throughout the dry season, with less than 35% of total rain typically falling in the winter months (May to October). Evaporation tends to exceed rainfall for almost all days of the year except during intense rainfall events, as indicated by the monthly averages (Figure 2). The extended dry season causes baking and crusting of surface soils. These processes lead to greatly reduced infiltration through surface soils unless suitable pre-wetting is provided by gentle rain prior to the wet season. If pre-wetting rains have not occurred, more than 90% of rainfall can eventuate as runoff throughout catchments, altering stage-discharge relationships within waterways.

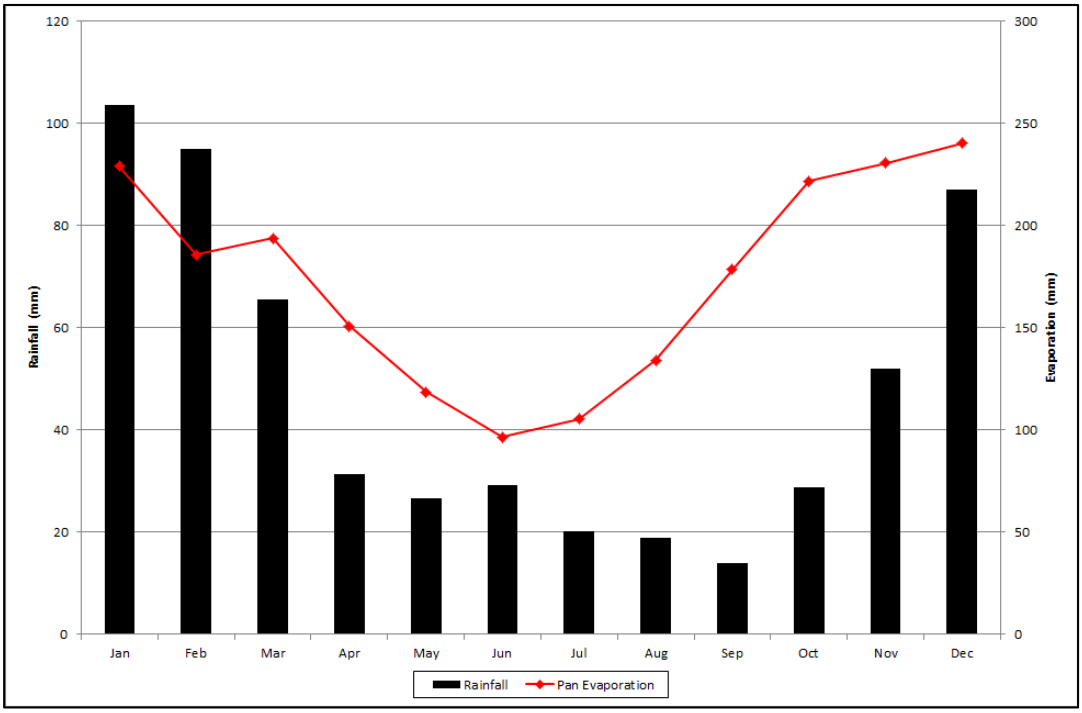

Figure 2: Average monthly rainfall and evaporation values for the region.

2.2 SOILS

Several soil types are located within the IPC mining leases. These are described in the *Integrated Isaac Plains Project Amalgamated Environmental Impact Statement* (Matrix+, 2009) and include:

- A1 Alluvial sandy duplex soil.
- A2 Red duplex with thin, sandy clay loam overlying hard, coarse-structured, brown clay.

- B1 Uniform grey/brown clays with areas of gilgai on flat to gently undulating plains.
- B2 Sandy uniform clay or thin red/brown duplex soils overlying weathered shale/mudstone on undulating plains. Sandy surface is often gravelly.
- B3 Crusting and often gravely sand clays associated with mesa scree slopes.
- B4 Melon-holed clay lowlands.
- B5 Hard-setting, gravely, brown clay.
- E1 Sandy duplex on undulating plains.
- R1 Residual low hill of lateritised basalt.

These soil types can be grouped into the following three broad categories under the Australian Soil Classification system (Ashton and McKenzie, 2001): brown Sodosols, red Chromosols and Vertisols.

2.2.1 SODOSOLS (A1 B5 E1)

This soil type occupies older alluvial plains associated with the Isaac River. It occurs on flat plains and is susceptible to occasional flooding. Soils are uniform, silty clays and mostly clear of vegetation. Nutrient levels are strong within the surface 30-40 cm layer. However, levels decrease below this depth. The surface structure is fine, sandy clay over a silty clay profile with substantial rooting depth. The soil is not reactive, although the stratified, alluvial nature of the medium is such that it should not be used for water holding structures. Material below 30 cm with the B2 horizon may be slightly sodic and should therefore be avoided.

2.2.2 CHROMOSOLS (A2 B2 B3)

This soil occupies mid- to upper-slope positions within undulating lands. The surface structure is firm and sandy, with ironstone gravel common. These soils have fairly hard-structured, light clay subsoils over weathered material, but appear to be well drained to at least 40 cm in most instances. Problems are associated with subsoil sodicity and salinity below 30 cm depth, with its coarse structure not assisting.

2.2.3 VERTISOLS (B1 & B4)

The soils are brown to grey, moderately well structured, generally non-cracking clays that support abundant buffel pasture. Saline and sodic conditions prevail immediately below 20 cm depth. Some of the area may include shallow (up to 15 cm deep) gilgai of brown, sandy clay interspersed with grey clay depressions. The surface structure is sandy and firm, with areas of ironstone gravel. In most instances, drainage is not impeded to 40 cm.

2.3 GEOLOGY

Most of the land surface is made up of deeply weathered profiles of Permian-Triassic rock, with *in situ* weathering, soil development and minor alluvium that, for the most part, conceal these rocks across the lease.

Tertiary-aged, poorly consolidated sandstone forms part of an earlier, thin sequence that covered much of the district. This sequence and older lithologies were eroded down to a flat surface (peneplain) that is capped with duricrust (ferricrete) or carbonate laterites. Locally, the sequence has been eroded back to a table top to the north, leaving behind mesas of sandstone on and around the lease.

Prior to and during this erosion period in the Tertiary, volcanic activity produced widespread basaltic lava flows. At least two basalt flows have taken advantage of an earlier deep river,

passing down the eastern length of the lease. Remnants of the lava flows persist in mesas east of the lease and part of the northern table top, while the remainder has been weathered down to the current alluvial flat developing across the site.

Thin coal beds exist as layers in packages of sedimentary beds called 'coal measures' which reflect the fact that coal seams split, thicken and thin, and are interfingered with other sediments at their time of formation. These sediments can include relatively porous sandstones conducive to groundwater flow. The coal beds themselves are frequently significant conduits to groundwater and provide local aquifer systems.

The economic coal measures at Isaac Plains are the Rangal Coal Measures and Fort Cooper Coal Measures. Both are part of the late Permian Blackwater Group. This group of rocks extends throughout the western half of the Bowen Basin.

2.4 HYDROGEOLOGY

There are five principal hydrostratigraphic units within the IPC tenement areas:

1. Quaternary alluvium/colluvium;
2. Tertiary sediments;
3. Tertiary basalt;
4. Triassic Rewan Group; and
5. Late Permian Rangal Coal Measures and Fort Cooper Coal Measures.

The Quaternary alluvium/colluvium and Tertiary sediments are associated with channel deposits of Smoky Creek and the Isaac River (Table 3 and Figure 3). In 2018, Klohn Crippen Berger (KCB) completed field investigations to assess the extent of the alluvium in relation to Smoky Creek. This followed instruction from the Department of Environment and Science (DES) that a monitoring bore must be installed to monitor the alluvium. However, when drilling adjacent to Smoky Creek for the monitoring bore, no alluvium was found to be present. The selection of this monitoring bore location was based on the mapped alluvium presented in the Mount Coolon 1:250,000 map sheet (where the alluvium is mapped as having an extent of up to about 500 m adjacent to Smoky Creek). As per the findings of the field investigation, KCB (2018) reported:

The extent of the sediments was identified to be limited to the water course channel as the channel is deeply incised, with the creek banks comprising weathered bedrock. Furthermore, outcrops of weathered bedrock occur within the channel of Smoky Creek, identifying the limited depth of unconsolidated sediments.

Tertiary basalt flows outcrop to the north-east of tenement ML70342, and some of these basalt flows constitute aquifers in several surrounding areas. Confinement of the late Permian strata is variable locally, depending on pressure distribution and depth. Stratigraphic descriptions for each unit are provided in Table 3. Surface distribution of each unit is complicated by numerous regional structures, including at least one syncline and several thrust faults truncating the eastward-dipping target beds. The aquifers of the Isaac Plains area are described in the following sections (Sections 2.4.1 to 2.4.3), with reference made to aquifer characteristics, groundwater flow and groundwater quality for each unit.

Table 3: Stratigraphic units of the Isaac Plains region.

Map Symbols#	Age	Group	Name/Formation	Short Description
Cza	Quaternary		Alluvium / Colluvium	Alluvium: mud, sand, minor gravel. Colluvium and residual soil: mud, sand, gravel##.
Czb	Cenozoic		Tertiary basalt	Basalt flows.
Czs*			Suttor Formation*	Sandstone, mudstone, claystone.
Ki*	Cretaceous		Unnamed*	Intrusives: granodiorite, diorite, gabbro.
TRr	Triassic	Rewan Group	Rewan Formation	Green lithic sandstone, green and red sandstone and mudstone.
Pwj	Late Permian	Blackwater Group	Rangal Coal Measures	Lithic sandstone, coal, siltstone, carbonaceous shale, mudstone (locally cherty), rare pebbly sandstone.
Pwt			Fort Cooper Coal Measures	Medium to coarse-grained volcanolithic sandstone, conglomerate, tuff, tuffaceous mudstone, coal, shale.
Pwb*			Moranbah Coal Measures*	Lithic sandstone, siltstone, shale, coal, mudstone, conglomerate.
Pb*		Back Creek Group*		Marine sandstone, siltstone, shale.

*Formation/unit is present outside the lease area and is not discussed at length in the text.

#Map symbols as per 1:100,000 geological maps Harrybrandt (8554) and Grosvenor Downs (8553) (Geological Survey of Queensland [GSQ], 2014; see Figure 3).

##Several generations of alluvium and colluvium exist, but only the older, more substantive one is mapped in Figure 3.

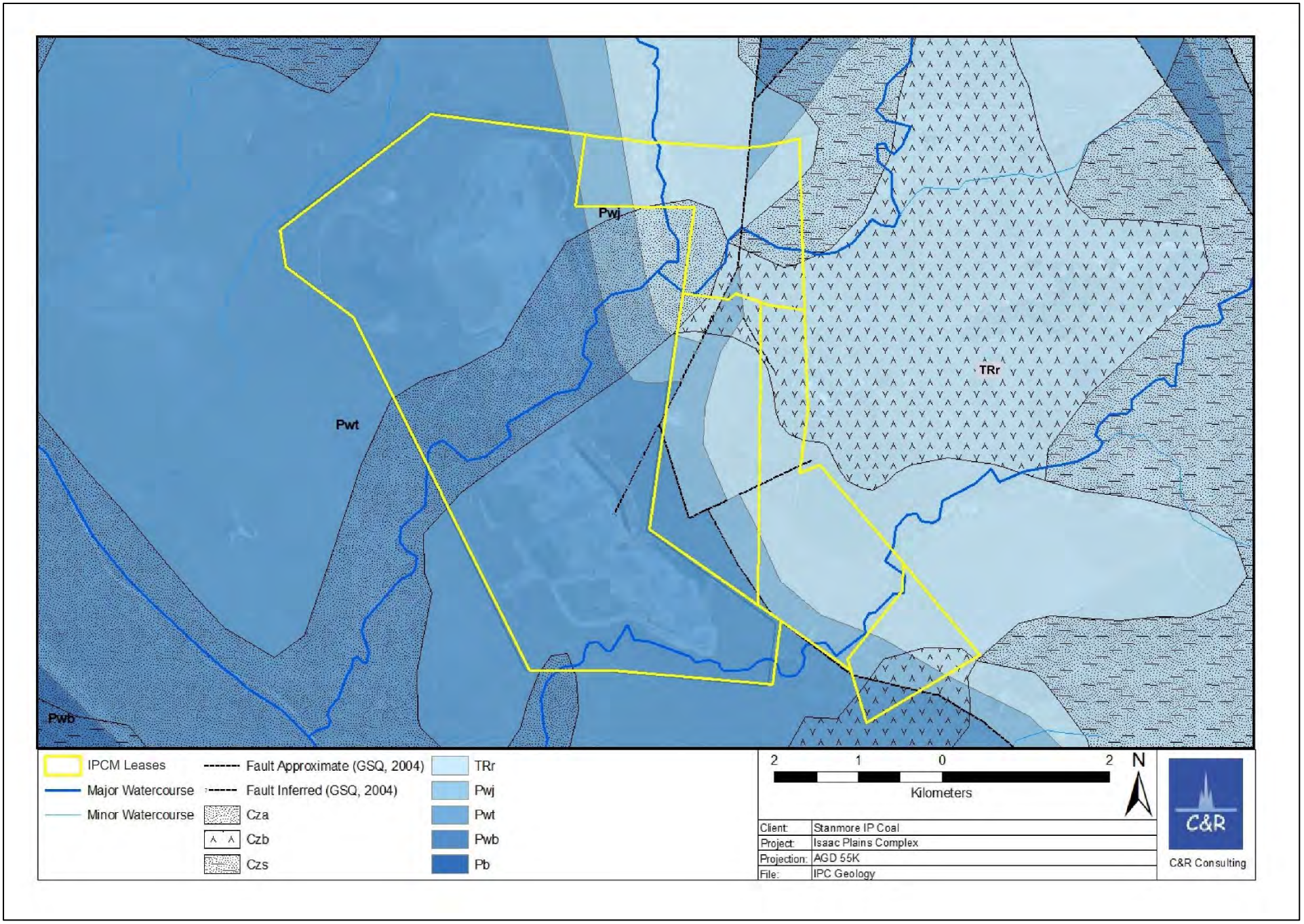

Figure 3: Major geological units for IPC.

2.4.1 QUATERNARY DEPOSITS

2.4.1.1 *Lithology*

Several generations of Quaternary palaeochannel sediment deposition resulted in a complex distribution of alluvial aquifers across the region. There are at least three Quaternary units present (Geological Survey of Queensland [GSQ], 2004):

1. Younger Quaternary alluvium;
2. Quaternary colluvium; and
3. Older Quaternary alluvium.

Of these, only the older Quaternary alluvium/colluvium, comprising a relatively thick deposit along the Isaac River and Smoky Creek, is shown in Figure 3 (map symbol Cza; see also Table 3). KCB (2018) found the extent of the Quaternary alluvium/colluvium was identified to be limited to the Smoky Creek watercourse channel, as the channel is deeply incised, with the creek banks comprising weathered bedrock. Furthermore, outcrops of weathered bedrock occur within the channel of Smoky Creek, identifying the limited depth of unconsolidated sediments.

The alluvial/colluvial deposits have very heterogeneous lithology, reflecting the depositional environment. In the area surrounding IPC, the alluvial/colluvial deposits of the Isaac River mainly consist of upward-fining packages of gravel, sand, silt and clay (Matrix+, 2009). The grainsize and textural variation of these sediments mean that hydraulic properties are extremely variable, but sandy units are generally of high hydraulic conductivity. The potential resource within these deposits is unknown and groundwater use from them is expected to be only for environmental purposes. The impacts from mining activities on these aquifers is expected to be limited to water quality impacts from discharge of excess waters from on-site dams.

2.4.1.2 *Quaternary Alluvium/Colluvium Aquifer Properties*

Typical thicknesses of the alluvial/colluvial aquifers in the IPC mining area range from 5 m to 19 m. However, monitoring bores indicate that the saturated thickness of the alluvial/colluvial aquifer is generally about 3 m (corresponding to an average water-table elevation of approximately 188 m AHD). Most exploration holes drilled into alluvial/colluvial sediments associated with the Isaac River, did not encounter significant groundwater supplies. Results from hydraulic testing of the alluvial/colluvial aquifer show a local hydraulic conductivity of 2.3 to 3.6 m/day.

2.4.1.3 *Groundwater Flow in Quaternary Alluvium/Colluvium Aquifers*

The alluvial/colluvial groundwater is typically recharged by flows in contemporary waterways during peak flows or floods (SKM, 2009), and/or from direct infiltration through overlying soil profiles during rainy months. Consequently, the rate of groundwater flow and height of the water table in these alluvial/colluvial aquifers are variable and annual recharge is not consistent.

Alluvial/colluvial groundwater quality found at a regional scale (e.g. the Isaac River catchment) suggests some mixing with groundwater from the underlying Late Permian strata (rather than regular recharge via direct rainfall or river flow), with electrical conductivity (EC) often greater than 10,000 µS/cm. The regional flow of groundwater within the Quaternary sediments is expected to be southwards and south-eastward, congruent with surface drainage. Groundwater discharge occurs mainly via evapotranspiration. However, it may also occur locally through baseflow to streams during dry periods. During peak river flow in the wet months, “gaining stream” conditions are precluded, meaning that baseflow does not occur (SKM, 2009).

2.4.1.4 *Groundwater Quality in the Quaternary Alluvium/Colluvium*

Groundwater of the alluvium/colluvium has variable quality, reflecting the highly localised flow paths that dominate this system. At a regional scale, (e.g. the Isaac River catchment), the alluvial/colluvial groundwater EC ranges from below 500 µS/cm to over 10,000 µS/cm (SKM, 2009).

At IPC, the groundwater quality of the alluvium/colluvium is not well constrained. This is due to the fact that the alluvium is quite discrete (refer to Section 2.4) and no groundwater-bearing alluvium has been found to date at IPC. Groundwater is measured in colluvial sediments at IPC, although sampling occurs at the contact with Tertiary sediments and is reflective of a mixture of Quaternary/Tertiary groundwater.

2.4.2 TERTIARY BASALT

2.4.2.1 *Lithology*

Cenozoic volcanic rocks (Czb), also referred to as Tertiary basalt, outcrop to the east of the Isaac Plains Mine, near the Wotonga homestead (Matrix+, 2009). These volcanics probably represent the most southerly extent of basalt flows from the Nebo Province (Stephenson *et al*., 1980) and are predominantly mafic (basaltic) but also include trachyte, rhyolite, tuff and high level intrusives mapped outside of the lease area (PW Baker & Associates, 2011). The volcanics mostly overlie the late Permian succession of the Bowen Basin and have an inverted topography associated with tributary drainage that is locally occupying an ancestral watercourse of the Isaac River. At least nine basalt flows are observed in GSQ drilling. These are encountered in the Drake and Grosvenor boreholes. The Tertiary basalt regionally underlies Quaternary sediments of the Suttor and Isaac River catchments, except where partially exhumed by weathering (Stephenson et al., 1980).

2.4.2.2 *Basalt Aquifer Properties*

The Tertiary basalt flows across the region constitute shallow fractured rock aquifers that are known to be used for local supplies of stock and domestic water (SKM, 2009). Typically, basalt aquifers are characterised by a network of cooling fractures that are often not well connected (exhibiting anisotropy of hydraulic conductivity), so the resultant groundwater yield is unpredictable. There is a productive Tertiary basalt aquifer to the north-east of IPC, adjacent to the Broadlea Mine, which hosts a large volume of groundwater (refer to section 2.4.2.4). Apart from this distant basalt aquifer (adjacent to Broadlea Mine), the hydraulic characteristics of the basalt flows proximal to the Isaac Plains Mine area are not yet quantified.

2.4.2.3 *Groundwater Flow in Basalt*

As the lateral extents of the basalt flows of the region are not completely known, and they are not spatially contiguous over large areas, groundwater flow in this Tertiary basalt unit is likely localised rather than regional. Further, much of the thickness of basalt flows are close to the surface and may be unsaturated, or only saturated when the watertable rises in response to recharge periods. Ephemeral and local flow, mainly via sub-vertical recharge and discharge, is expected to be the dominant flow mechanism in the Tertiary basalt.

2.4.2.4 *Groundwater Quality in Basalt*

Fractures within a basalt flow proximal to the Broadlea Mine are anticipated to contain about 11,000 ML of relatively good quality water, with EC ranging between 760 µS/cm and 5,300 µS/cm. However, the lateral extent of the reservoir is not known. Apart from the Broadlea basalt flow, the utility of the basalt aquifer in other areas is usually associated with relatively low yields and poor water quality.

2.4.3 LATE PERMIAN COAL MEASURES

2.4.3.1 *Lithology*

The two main late Permian units in the region are the older Fort Cooper Coal Measures and the younger Rangal Coal Measures (Figure 3 and Table 3). The late Permian stratigraphy described in this section is relevant to the entire area, but pertains directly to rocks intercepted by drilling and mining at IPC.

Coal mining at IPC targets the Leichhardt seam of the Rangal Coal Measures, which comprises interbedded units of lithic sandstone, coal, siltstone, carbonaceous shale, mudstone and pebbly sandstone. Within the IPC lease, the Leichhardt seam is found between 60 m and 230 m below ground level, and is approximately 3.5 m thick as a whole (as it splits to an upper and lower seam in the northern part of the lease). Strata dip of the Rangal Coal Measures in the IPC lease is approximately 6° to 7° to the east.

2.4.3.1.1 Sandstone and Siltstone Above Target Coal

The regional late Permian sedimentary rock succession is extensive and underlies the Quaternary alluvium/colluvium and Tertiary basalt cover (PW Baker & Associates, 2011). The late Permian succession comprises sandstone, siltstone, mudstone, shale and coal (PW Baker & Associates, 2011). Both the Rangal Coal Measures and the Fort Cooper Coal Measures are dominated by lithic sandstones. However, the Fort Copper Coal Measures can be distinguished from the Rangal Coal Measures due to the presence of significant volcanolithic content (tuff and tuffaceous mudstone).

2.4.3.1.2 Target Coal Seam

The Leichardt coal seam, the target of IPC mining, may arguably be considered an aquifer, given the characteristics referred to in section 2.4.3.4. The coal seam is generally 3.5 m thick and dips to the east across the site.

2.4.3.1.3 Lithic Sandstone Below Target Coal

The typical units that underlie the Leichardt seam are late Permian fine to medium, quartz-lithic sandstone interbedded with siltstone and carbonaceous mudstone. The sandstone beds are typically carbonate-cemented, with moderate to high porosity.

2.4.3.2 *Late Permian Aquifer Properties*

The late Permian coal measures provide modest groundwater supplies for livestock and agricultural uses in the region (Matrix+, 2009), where extraction rates are generally limited to approximately 0.5 L/s (PW Baker & Associates, 2011). Borehole logs reveal that V-notch flow rates from sandstones range between 0.15 L/s (78 m depth in bore E7550027R) and 5.0 L/s (126 m depth in bore E7550050R). Logs from monitoring bores, installed in 2004, penetrating the Leichardt seam indicate that it had yields ranging from moderate (2.17 L/s at 126 m in E755273P-C4) to very poor (0.03 L/s at 42 m in E755272P-C3).

Permeability of the late Permian units is hindered by the intercalation of sandstone with mudstone and siltstone, in contrast to the more permeable alluvium/colluvium and basalt aquifers (Matrix+, 2009). Generally, coal seams form high hydraulic conductivity zones within these systems, as the bedding planes, fractures, joints and cleats allow faster water movement compared to the surrounding sandstone and siltstone. The Leichardt seam has a hydraulic conductivity in the vicinity of 0.0005 m/day, about five times higher than that of the late Permian host rocks.

2.4.3.3 *Groundwater Flow in Late Permian Aquifers*

The regional flow patterns, recharge and discharge mechanisms of the Late Permian units of the Isaac River region are not well known or constrained. Considering the groundwater flow patterns in the overlying alluvium/colluvium and basalt, recharge to the late Permian rocks is expected to be restricted to wet periods, with several sequential wet periods required for effective recharge. In a previous groundwater review, C&R Consulting (C&R) surmised that a two-month cumulative rainfall total of approximately 400 mm is needed for recharge to occur in the nearby, overlying sandstone of the Triassic Rewan Formation (C&R, 2013). Recharge may occur through direct infiltration in areas where the late Permian rocks are exposed or close to the surface, and/or through inter-aquifer flow if vertical hydraulic gradients allow.

Very little is known about the variation of potentiometric water levels in the region with depth. However, there are available data that can constrain some details of vertical flow, as there is evidence for upward vertical gradients during winter to the south of IPC (Matrix+, 2009, their Section 7, Table 7-1). This indicates that some discharge may occur as upward flow from late Permian units into the overlying alluvium (or other sediment) and this may support baseflow to streams in winter months. A similar pattern may also exist near some creek reaches in the IPC area.

Given the aquifer characteristics, lateral flow within the coal measures is likely to be slow. Flow is assumed to be approximately south-eastward and southward, in keeping with the catchment orientation and the direction of Isaac River drainage. This is consistent with an interpolated map of groundwater levels in the region (Matrix+, 2009, their Section 7, page 13) and the data relevant to this review. Generally, groundwater ingress into the pits at Isaac Plains is minimal, confirming the slow-flow anticipated by the low permeability.

2.4.3.4 *Groundwater quality in Late Permian Aquifers*

Groundwater from the late Permian coal measures south of IPC is known to be of sodium-chloride-bicarbonate type and there is a trend of increasing solute concentration heading southwards (Matrix+, 2009, their Section 7, page 12). This confirms the assumption of regional groundwater flow from north to south, whereby length of residence time and degree of water-rock interaction increase along the flow path. The EC of groundwater in the late Permian aquifers ranges from 11,000 µS/cm to 41,000 µS/cm, with an average EC of 21,000 µS/cm (Matrix+, 2009, their Section 7, page 12).

The Leichardt coal seam may be termed an aquifer. However, the quality of the groundwater is generally poor, with an EC of 8,000 µS/cm to 20,000 µS/cm. Based on the observed ECs, combined with poor to moderate flow rates and a thin expression (about 2 m thick), the Leichardt seam is an unusable aquifer (PW Baker & Associates, 2011; E3 Consulting Australia Pty Ltd, 2011).

2.5 GROUNDWATER-DEPENDENT ECOSYSTEMS

Groundwater-dependent ecosystems (GDEs) are defined by the Department of Environment and Energy (DoEE) as '*natural ecosystems that require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services*' (Richardson et al., 2011).

The broad types of GDEs are:

- Ecosystems dependent on surface expression of groundwater;
- Ecosystems dependent on subsurface presence of groundwater; and
- Subterranean ecosystems.

A review of the potential for GDEs in the vicinity of IPC was undertaken by Ecological Survey & Management (EcoSM) as part of the terrestrial ecology assessment to support the *Environmental Assessment Report – Isaac Plains East Project* (Hansen Bailey, 2016). EcoSM identified that the GDE mapping provided in the GDE atlas produced by the Australian Bureau of Meteorology is not consistent with the hydrogeological setting of the Isaac Plains area. EcoSM also states that the IPE area does not contain a suitable, shallow groundwater supply and, therefore, concludes that there are no GDEs within the vicinity of the project area.

In December 2020, Stanmore gained approval from the Australian Government Department of Agriculture, Water and the Environment to proceed with the Isaac Plains East Extension (IPEE). As part of the approvals process, Stanmore completed further studies into potential GDE's and subsequent impacts, within the project area which were completed by 3d Environmental (2020). Smoky Creek and Billy's Gully GDE were found to be at low to insignificant risk for all potential impact pathway resulting for the IPEE project. However, Stanmore has implemented mitigation measures under the Groundwater Dependent Ecosystem Management and Monitoring Plan (GDEMMP) (3d Environmental, 2020b). Four shallow bores, constructed in November 2020, target the alluvium besides Billy's Gully. The seasonality of these bores measures they are likely to produce water only during flow events in the wet season. The GDEMMP states, the imperatives of GDE monitoring bores are to:

- Confirm linkages between recharge of the alluvial aquifer and surface flows.
- Establish the period of saturation, including saturated thickness of the alluvial aquifer and lags in recharge following surface water flows.
- Identify natural; groundwater quality parameters to provide a baseline dataset for comparison to water quality of surface flows.
- Identify the degree to which the alluvial aquifer is utilised by vegetation (typically through analysis of stable isotopes) on a seasonal basis.
- Identify ecological response to aquifer recharge including correlations between alluvial aquifer recharge, LAI, LWP, NDVI and climate data.

3. GROUNDWATER MONITORING NETWORK

Previous to gaining environmental approval to mine the eastern mining leases at IPC (ML700016, ML700017, ML700018 and ML700019), only two groundwater bores (Burton Coal Bore 2 and Swamp Bore 1) were monitored as a requirement of the existing EA. Following the approval of an EA amendment (24 January 2018) for the mining activities on the additional leases, a more extensive monitoring network has been developed, targeting various aquifer systems present within the eastern mining leases. This 2018 monitoring network has been expanded with the release of the latest EA amendment (27 July 2020), to account for the replacement of existing monitoring bores that are due to be decommissioned.

The details of the bores included in the current IPC groundwater monitoring programme are summarised in Table 4, with their spatial distribution shown in Figure 4.

Historically, the groundwater network at IPC has consisted of both 'reference' and 'observation' bores. As mining has progressed to the east, some of these bores have been decommissioned and it is anticipated that further decommissioning will occur as mining advances further (Table 4). As twelve designated reference bores have been selected to provide ongoing baseline data during mine operations at IPC (Table 4), to maintain this number of designated reference bores, all decommissioned reference bores either have been or will be replaced. The current monitoring network at IPC consists of twelve reference bores and five observation bores (Table 4).

For the current IPC bore network, bore assessments were completed on Burton Coal Bore 2 and Swamp Bore 1 in June 2018, including downhole camera surveys to confirm bore construction details. The construction details of monitoring bores MB1, MB2, MB4a, MB4b, MB7, MB8, MB9, MB10, MB11, MB12 and MB14 were sourced from QLD Government '*Groundwater Information Bore Reports*'.

Construction details of GDEMB1, GDEMB2, GDEMB3 and GDEMB4 were obtained from C&R, who recently installed these shallow (<5 m deep) observation bores that are not formally included in the groundwater management and monitoring plan (GMMP). The shallow GDE bores will be monitoring as per the GDEMMP (3d Environmental, 2020b).

At IPC, there are currently naming inconsistencies between the EA tables (Tables 11, 12, and 13), the GMMP and the field data. For instance:

- All field data referenced as MB9b refers to the bore stated within the EA as MB10.
- Swamp Bore 1 has been misnamed in the EA as Swamp Bore 2. Field verification has confirmed this.
- The hydrostratigraphic unit of MB4b is incorrectly referred to as the Rangal Coal Measures in the EA, although this shallow bore has been screened in the Quaternary sediments as per the bore report.

It is imperative that IPC amend all documents to align with a consistent naming convention for each monitoring bore to improve the integrity and reporting of the collected groundwater data.

Installation of monitoring bore MB11 was a requirement of Condition C42 of the IPC EA. Based on the regional geological mapping of the 1:250,000 Mount Coolon geology map sheet, the location of MB11 (identified in the EA) was anticipated to target the Quaternary alluvium. However, during the drilling of this bore, no alluvium was encountered. To date, no data have been captured for this bore as it has remained dry since installation (and, therefore, throughout the reporting period).

Table 4: Groundwater monitoring bores at IPC.

Monitoring Point	Aquifer Type	Easting (GDA 94)	Northing (GDA 94)	Surface RL (mAHD)	Monitoring Purpose
IPC Reference Bores (EA Table 11)					
Burton Coal Bore 2	Rewan Group	620383	7573599	240.8	Monitoring groundwater trigger levels as per EA **C43** and EA **C44**
Swamp Bore 1 (referred to as Swamp Bore 2 in the EA)	Rewan Group	621518	7568790	245.9	Monitoring groundwater trigger levels as per EA **C43** and EA **C44**
MB1	Rangal Coal Measures	618793	7572214	236.4	*To be decommissioned.* Used for monitoring groundwater in the target coal seam
MB2	Rangal Coal Measures	619074	7573137	242.7	Monitoring groundwater in the target coal seam
MB4a	Quaternary Colluvium / Tertiary Sediments	620351	7567479	237.6	*To be decommissioned.* Used for monitoring groundwater in the Quaternary / Tertiary sediments. Insufficient water, replaced by MB4b
MB4b	Quaternary Colluvium / Tertiary Sediments[1]	619740	7567253	233.9	*To be decommissioned.* Used for monitoring groundwater in the Quaternary / Tertiary sediments
MB8	Rangal Coal Measures	619105	7571149	245.9	*To be decommissioned.* Used for monitoring groundwater in the target coal seam
MB9	Rangal Coal Measures	620368	7568049	239.5	*To be decommissioned.* Used for monitoring groundwater in the target coal seam
MB10	Tertiary Basalt	620368	7568046	239.5	*To be decommissioned.* Used for monitoring groundwater in the Tertiary basalt
MB11	Tertiary Sediments / Weathered Rewan Group	618832	7571924	232.3	Monitoring groundwater in the Tertiary Sediments / Weathered Rewan Group. Insufficient water (dry)
MB12	Rangal Coal Measures	619210	7572000	239.5	*Replacement for MB1* to monitor groundwater in the target coal seam

Monitoring Point	Aquifer Type	Easting (GDA 94)	Northing (GDA 94)	Surface RL (mAHD)	Monitoring Purpose
MB14	Tertiary Basalt	620263	7571132	257.3	*Replacement for MB10* to monitor groundwater trigger levels as per EA **C44**
IPC To Be Commissioned Reference Bores (EA Table 11)					
MB13	Rangal Coal Measures	619367	7571035	249.7	*Replacement for MB8* to monitor groundwater in the target coal seam
MB15	Rangal Coal Measures	620633	7568080	242.9	*Replacement for MB9* to monitor groundwater in the target coal seam
MB16	Tertiary Sediments	620670	7568599	245.6	*Replacement for MB4b* to monitor trigger levels as per EA **C44**
IPC Designated Observation Bores					
MB7	Rangal Coal Measures	617537	7569064	237.4	Monitoring groundwater in advance of mine operations
GDEMB01	Quaternary Alluvium	621780	7569179	TBA[2]	Monitoring groundwater-dependent ecosystems
GDEMB02	Quaternary Alluvium	620436	7568168	TBA	Monitoring groundwater-dependent ecosystems
GDEMB03	Quaternary Alluvium	620022	7567230	TBA	Monitoring groundwater-dependent ecosystems
GDEMB04	Quaternary Alluvium	619754	7567165	TBA	Monitoring groundwater-dependent ecosystems
IPC Decommissioned Reference Bores (EA Table 11)					
MB3	Rangal Coal Measures	619047	7568473	253.0	Monitoring groundwater in advance of mine operations
IPC Decommissioned Observation Bores					
MB5	Rangal Coal Measures	618507	7570878	241.8	Monitoring groundwater in advance of mine operations
MB6	Tertiary Basalt	619374	7567545	235.7	Monitoring groundwater in the Tertiary basalt
C1	Rangal Coal Measures	616545	7571999	235.7	Monitoring groundwater in advance of mine operations
AC1	Rangal Coal Measures	616573	7571997	235.8	Monitoring groundwater in advance of mine operations
BC095	Rangal Coal Measures	616507	7571995	236.7	Monitoring groundwater in advance of mine operations

[1] MB4b has been screened in the Quaternary colluvium / Tertiary sediments as per the bore report. However, Table 11 of the EA states that the hydrostratigraphic unit is the Rangal Coal Measures.

[2] TBA = To be advised, as the bore has yet to be surveyed.

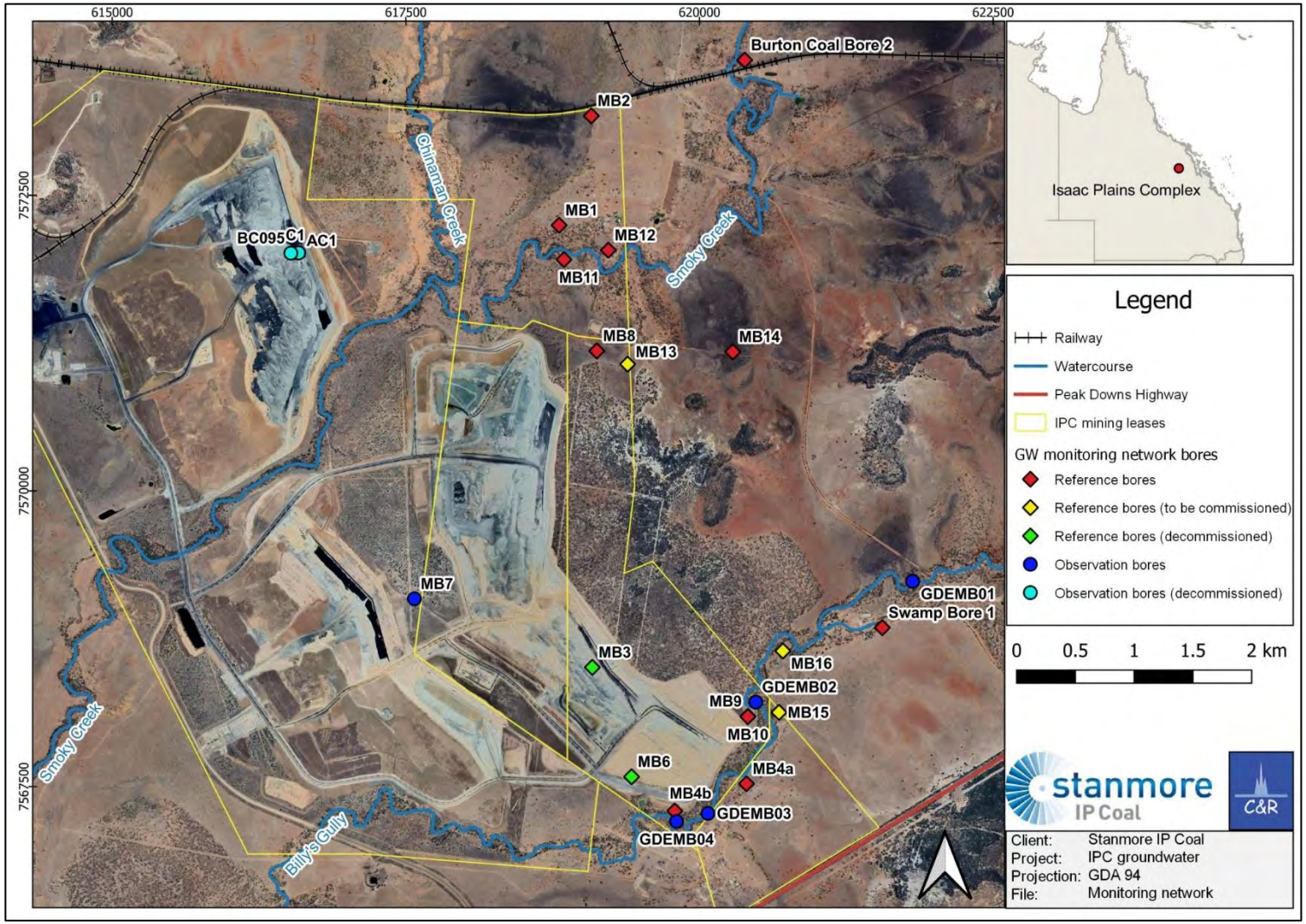

Figure 4: IPC groundwater monitoring network.

4. GROUNDWATER LEVELS

In accordance with EA Condition C40, IPC implemented the GMMP on 29 June 2019.

Standing water levels are measured as part of the groundwater monitoring procedure prior to undertaking water quality sampling. The measurement of standing water levels provides an insight into the nature of the aquifer systems (recharge and discharge points) and any potential impacts of mining activities. Standing water levels are captured by measuring the depth to water that is then subtracted from the reference datum height of the monitoring bore casing. This calculation provides the ability to gain a relative level in m Australian Height Datum (m AHD).

The reporting period for this annual review includes groundwater samples collected between May 2019 and December 2020 (inclusive), with results displayed in Figure 5.

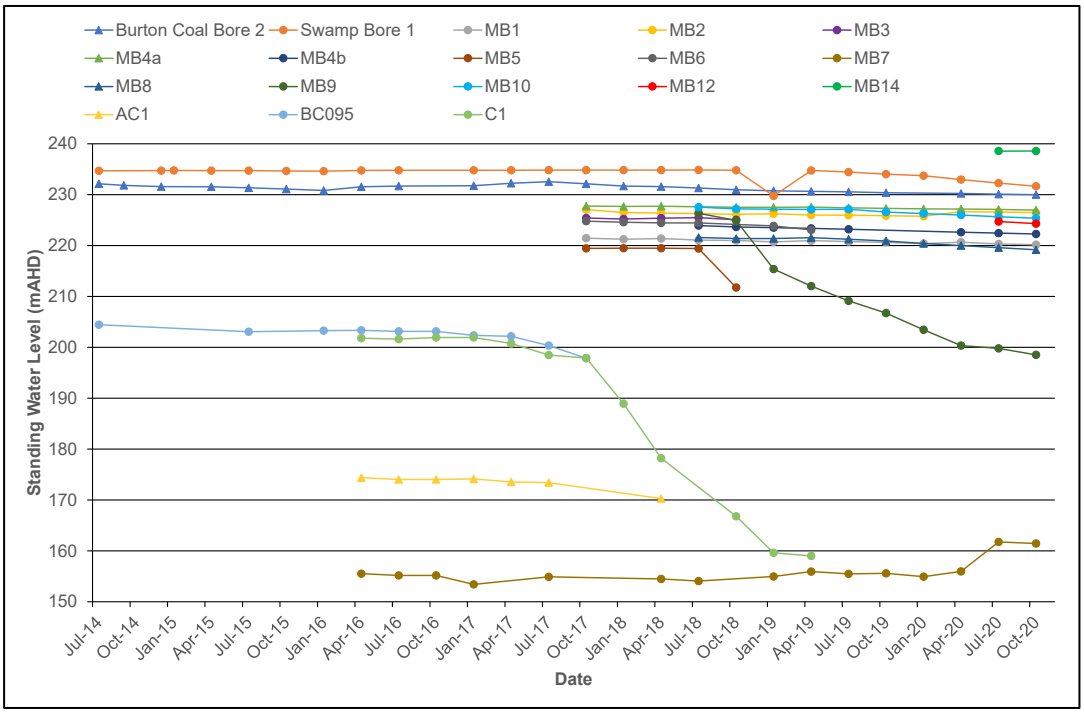

Figure 5: Standing water level variation across the groundwater monitoring network.

4.1 REWAN FORMATION

Burton Coal Bore 2 and Swamp Bore 1 are screened within the Rewan Formation and are situated to the northeast and east of IPC mining operations, respectively (Figure 4). Groundwater flow direction within the aquifer system suggests these bores are considered upstream of any potential groundwater impact that could be attributed to the IPC operation.

Throughout the reporting period, Burton Coal Bore 2 has remained stable, with very little variation in standing water level (Figure 5). In comparison, Swamp Bore 1 displays a steady downward trend over the reporting period, with the standing water level decreasing by 2.79 m (Figure 5). The downward trend in Swamp Bore 1 is likely to be caused by a dry period between 2018 and 2020, as well as groundwater extraction from the adjacent (<5 m away) farmer's bore that sources groundwater for stock-drinking water.

4.2 RANGAL COAL MEASURES

The IPC monitoring bores screened within the Rangal Coal Measures show a substantial variation in standing water level behaviour between monitoring bores (Figure 5). This variation is mainly attributed to the advancement of mining operations and the proximity of some bores to the open-cut voids.

Five bores, decommissioned prior to the current reporting period, displayed a significant drawdown in standing water levels (before being decommissioned). These bores include BC095, AC1, C1, MB3 and MB5 (Figure 5). Two operating reference bores, MB8 and MB9, displayed drawdowns of 2.07 m and 10.63 m respectively, during the reporting period. These standing water level decreases, in all of the aforementioned bores, can be attributed to a zone of depressurisation occurring around the mining voids that has consequently altered the flow direction of the coal seam aquifer. The presence of this zone of depressurisation existing around the mining voids is further evidenced by the reasonably steady standing water levels recorded in up-gradient monitoring bores MB1, MB2, MB12 and MB14. These bores are positioned further away from the open-cut voids (Figure 4).

Observation bore MB7 is located close to the highwall of the southern open-cut voids (Figure 4). The southern voids ceased full mining operations in 2018, whereby MB7 historically displayed steady standing water levels until April 2020 when the water level started to increase (Figure 5). During the reporting period, the standing water level in MB7 has increased by 5.94 m, responding to the increasing accumulation of stored water within the adjacent southern voids.

Note: MB8 and MB9 are respectively referred to as MB8b and MB9a within all field and analysis documentation.

4.3 TERTIARY BASALT

IPC currently monitor two bores that target the Tertiary Basalt aquifer. MB10 and MB14 are located south-east of mining operations and close to Billy's Gully (Figure 4). A third monitoring bore, MB6 was monitored between October 2017 and April 2019 before being decommissioned.

While operational, MB6 showed a steady decline in standing water level, with a total decrease of 1.72 m, associated with the progression of mining towards this down-gradient bore. Further, MB10 recorded a 1.77 m drawdown during the reporting period, also indicating a mining-induced water level decrease. MB14 was installed during the second quarter of 2020 and has only had two field measurements recorded so far, both of which are within 0.01 m of each other, indicating that this bore is effectively stable (Figure 5).

Note: MB10 is referred to as MB9b within all field and analysis documentation.

4.4 QUATERNARY COLLUVIUM / TERTIARY SEDIMENTS

MB4a and MB4b are screened within the boundary between the Quaternary colluvium and Tertiary sediments. The drawdown on both MB4a and MB4b is minor (0.45 m and 0.93 m, respectively), indicating that neither site is strongly affected by mining. As both bores are screened in shallow, unconsolidated sediments, the observed drawdown is more likely attributable to rainfall (given the dry period between 2018 and 2020). Monitoring bore MB11 is screened in the Tertiary sediments (and weathered Rewan Group) and has no standing water level data, as this bore was dry during commissioning (June 2018) and has remained so ever since.

Four shallow (<5 m deep) bores GDEMB01, GDEMB02, GDEMB03 and GDEMB04 were constructed and screened in the Quaternary alluvium during November/December 2020 to monitor GDEs. These bores were dry during construction and have remained so during the reporting period.

Note: The hydrostratigraphic unit for MB4b is incorrectly labelled as the Rangal Coal Measures in EA Table 11.

5. GROUNDWATER CHARACTERISTICS

The IPC groundwater monitoring network currently targets four different aquifer systems across and surrounding the mining operations at IPC, with a major focus on activities within the eastern mining leases. Each aquifer system (i.e. Rangal Coal Measures, Rewan Group, Tertiary basalt, Quaternary alluvium/colluvium) displays different groundwater quality. The variation in groundwater quality characteristics can be attributed to the aquifer depth, locality, geology and the nature of its recharge.

The reporting period for this annual review includes groundwater samples collected between May 2019 and December 2020 (inclusive), with the number of samples collected from each bore/aquifer presented in Table 5. Refer to Appendix 1 for all certificates of analyses referred to within this report.

Table 5: Number of samples collected per bore during the reporting period.

Monitoring Point	Aquifer Type	Number of Samples
EA Table 11 – Reference Bores		
Burton Coal Bore 2	Rewan Group	5
Swamp Bore 1	Rewan Group	6
MB1	Rangal Coal Measures	6
MB2	Rangal Coal Measures	6
MB4a	Quaternary Colluvium / Tertiary Sediments	6
MB4b	Quaternary Colluvium / Tertiary Sediments	3
MB8	Rangal Coal Measures	6
MB9	Rangal Coal Measures	6
MB10	Tertiary Basalt	6
MB11	Tertiary Sediments / Weathered Rewan Group	0
MB12	Rangal Coal Measures	2
MB14	Tertiary Basalt	2
IPC Designated Observation Bores		
MB7	Rangal Coal Measures	6
GDEMB01	Quaternary Alluvium	0
GDEMB02	Quaternary Alluvium	0
GDEMB03	Quaternary Alluvium	0
GDEMB04	Quaternary Alluvium	0

5.1 REWAN FORMATION

The two monitoring bores (Burton Coal Bore 2 and Swamp Bore 1) that target the Rewan Formation display very similar water quality characteristics in terms of pH, EC and total dissolved solids (TDS), substantiated by the low standard deviation (SD) and coefficient of variance (c_v) values presented in Table 6. Generally, the dissolved metal concentrations for both bores are similar, with most results below the limit of reporting (LOR).

Historically, Burton Coal Bore 2 has displayed a more diluted TDS concentration than Swamp Bore 1. However, over recent years (2017-2020), the geochemical difference has decreased, with the average divergence marginally above 500 mg/L over the current reporting period. During the reporting period, the lowest observed TDS value was 4,750 mg/L (Table 6). Consequently, both Swamp Bore 1 and Burton Coal Bore 2 do not meet the TDS livestock drinking water guideline value (<4,000 mg/L) stipulated within the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ; ANZECC and ARMCANZ, 2000).

5.2 RANGAL COAL MEASURES

The largest portion of the groundwater monitoring network (six monitoring bores) targets the Rangal Coal Measures within the IPC leases. Across the six monitoring bores, there is a large variation of screen depths, ranging from the shallowest (MB1) at 22.5 m depth to the deepest (MB12) starting at 126 m depth. This variation in screen depths (and depth of coal) is recognised as a significant influence of the varying water quality characteristics observed within the monitoring network, substantiated by the relatively high SD and c_v values (Table 6).

Generally, the water quality in the Rangal Coal Measures decreases below about 50 m, whereby the shallowest bore (MB1, screened at 22 m) has an average TDS value around 2,000 mg/L, whilst the second shallowest bore (MB2, screened at 48m) has an average TDS value of around 4,500 mg/L. All of the deeper bores (MB2, MB7, MB8, MB9 and MB12) have average TDS values ranging between approximately 7,500 mg/L and 15,500 mg/L. Interestingly, the highest TDS average (15,542 mg/L) is in a mid-level, 77 m deep bore (MB9), whilst some of the deeper bores (MB7 and MB12), screened at 126 m, have lower TDS averages of 7,411 mg/L and 9,000 mg/L, respectively.

Figure 6 displays the ionic composition variation within the Rangal Coal Measures, with MB1 and MB2 distinctly different from the other monitoring bores within the same aquifer. The total cation and anion levels recorded in MB1 and MB2 are consistently less than levels in the rest of the Rangal Coal Measures bores. MB1 and MB2 are both quite shallow, screened at 22 m and 48 m, respectively. Therefore, it is likely that the ionic composition is influenced by rainwater in these two bores, which is why they are different to the deeper bores. This observation that rainwater is influencing the bores is further substantiated by the fact that carbonate levels are elevated in both MB1 and MB2, whereas in the rest of the bores they are quite low (Figure 6). Regardless of this geochemical difference, of all the Rangal Coal Measures monitoring bores, only MB1 meets the TDS livestock drinking water guideline value (<4,000 mg/L) stipulated within ANZECC and ARMCANZ (2000).

Note: MB8 and MB9 are referred to as MB8b and MB9a, respectively, within all field and analysis documentation.

Table 6: Groundwater characteristics from each formation monitored over the reporting period.

Aquifer System		pH	Electrical Conductivity	Chloride	Sulphate	Calcium	Magnesium	Sodium	Potassium	TDS @180°C	Suspended Solids	Bicarbonate	Carbonate
	Unit		µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	LOR	0.01	1	1	1	1	1	1	1	10	5	1	1
Rewan Group	Count	11	11	11	11	11	11	11	11	11	11	11	11
	Minimum	7.14	7,320	2,160	100	192	117	877	5	4,750	3	49	0.5
	Mean	7.47	8,292	2,743	115	393	200	1,029	14	5,622	4	323	0.5
	Maximum	8.18	9,150	3,160	130	600	311	1,170	23	6,800	12	700	0.5
	Standard Deviation	0.28	760	419	11	172	88	86	9	800	4	308	0
	Coefficient of Variance	4%	9%	15%	9%	44%	44%	8%	60%	14%	79%	96%	0%
Rangal Coal Measures	Count	32	32	32	32	32	32	32	32	32	32	32	32
	Minimum	7.07	3,210	817	1	80	95	416	3	1,860	3	97	0.5
	Mean	7.53	11,333	3,836	149	287	214	1,878	14	7,652	23	380	0.9
	Maximum	8.30	24,500	8,650	605	773	638	4,430	24	18,300	214	859	10
	Standard Deviation	0.29	6,400	2,423	185	190	155	1,124	7	4,776	45	250	1.8
	Coefficient of Variance	4%	56%	63%	124%	66%	72%	60%	52%	62%	170%	66%	195%
Quaternary Colluvium / Tertiary Sediments	Count	9	9	9	9	9	9	9	9	9	9	9	9
	Minimum	6.74	30,700	10,600	378	81	461	6,830	3	19,700	793	361	0.5
	Mean	7.35	44,822	16,689	759	465	1,455	8,939	3	34,233	7,693	649	2.4
	Maximum	8.31	53,100	19,900	983	730	2,130	10,700	5	47,900	35,400	1,270	18
	Standard Deviation	0.54	10,408	4,472	276	288	738	1,485	1	10,981	10,975	392	5.8
	Coefficient of Variance	7%	23%	27%	36%	62%	51%	17%	21%	32%	143%	60%	239%
Tertiary Basalt	Count	8	8	8	8	8	8	8	8	8	8	8	8
	Minimum	7.81	2,820	593	106	46	84	412	6	1,580	3	339	0.5
	Mean	8.04	3,429	862	117	61	114	504	9	2,000	18	427	5.8
	Maximum	8.53	4,300	1,140	130	80	135	665	12	2,520	64	582	43
	Standard Deviation	0.24	479	172	8	9	16	85	2	291	23	74	15
	Coefficient of Variance	3%	14%	20%	7%	16%	14%	17%	24%	15%	129%	17%	259%

Table 6 continued: Groundwater characteristics from each formation monitored at IPC over the reporting period.

Aquifer System		Dissolved Aluminium	Dissolved Antimony	Dissolved Arsenic	Dissolved Molybdenum	Dissolved Selenium	Dissolved Silver	Dissolved Iron	Dissolved Mercury	C6 - C9 Fraction	C10 - C36 Fraction (sum)
	Unit	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L
	LOR	0.01	0.001	0.001	0.001	0.01	0.001	0.05	0.0001	20	50
Rewan Group	Count	11	11	11	11	11	11	11	11	11	11
	Minimum	0.005	0.0005	0.0005	0.0005	0.005	0.0005	0.025	0.00005	10	25
	Mean	0.005	0.0005	0.0008	0.0009	0.005	0.0005	0.134	0.00005	10	25
	Maximum	0.005	0.0005	0.0020	0.0020	0.005	0.0005	0.540	0.00005	10	25
	Standard Deviation	0	0	0.0006	0.0006	0	0	0.172	0	0	0
	Coefficient of Variance	0%	0%	79%	69%	0%	0%	128%	0%	0%	0%
Rangal Coal Measures	Count	32	32	32	32	32	32	32	32	32	32
	Minimum	0.005	0.0005	0.0005	0.0005	0.005	0.0005	0.025	0.00005	10	25
	Mean	0.006	0.0005	0.0086	0.0032	0.005	0.0005	0.592	0.00005	10	25
	Maximum	0.03	0.0010	0.0320	0.0140	0.005	0.0005	2.520	0.00005	10	25
	Standard Deviation	0.004	0.0001	0.0109	0.0033	0	0	0.601	0	0	0
	Coefficient of Variance	76%	17%	127%	104%	0%	0%	101%	0%	0%	0%
Quaternary Colluvium / Tertiary Sediments	Count	9	9	9	9	9	9	9	9	9	9
	Minimum	0.025	0.0025	0.0025	0.0025	0.025	0.0025	0.025	0.00005	10	25
	Mean	0.056	0.0025	0.0025	0.0039	0.025	0.0025	0.038	0.00005	10	71
	Maximum	0.300	0.0025	0.0025	0.0080	0.025	0.0025	0.070	0.00005	10	380
	Standard Deviation	0.092	0	0	0.0022	0	0	0.019	0	0	117
	Coefficient of Variance	165%	0%	0%	57%	0%	0%	51%	0%	0%	166%
Tertiary Basalt	Count	8	8	8	8	8	8	8	8	8	8
	Minimum	0.005	0.0005	0.0010	0.0010	0.005	0.0005	0.025	0.00005	10	25
	Mean	0.006	0.0005	0.0025	0.0106	0.005	0.0005	0.032	0.00005	10	34
	Maximum	0.010	0.0005	0.0060	0.0150	0.005	0.0005	0.080	0.00005	10	100
	Standard Deviation	0.002	0	0.0018	0.0058	0	0	0.019	0	0	27
	Coefficient of Variance	31%	0%	71%	54%	0%	0%	61%	0%	0%	77%

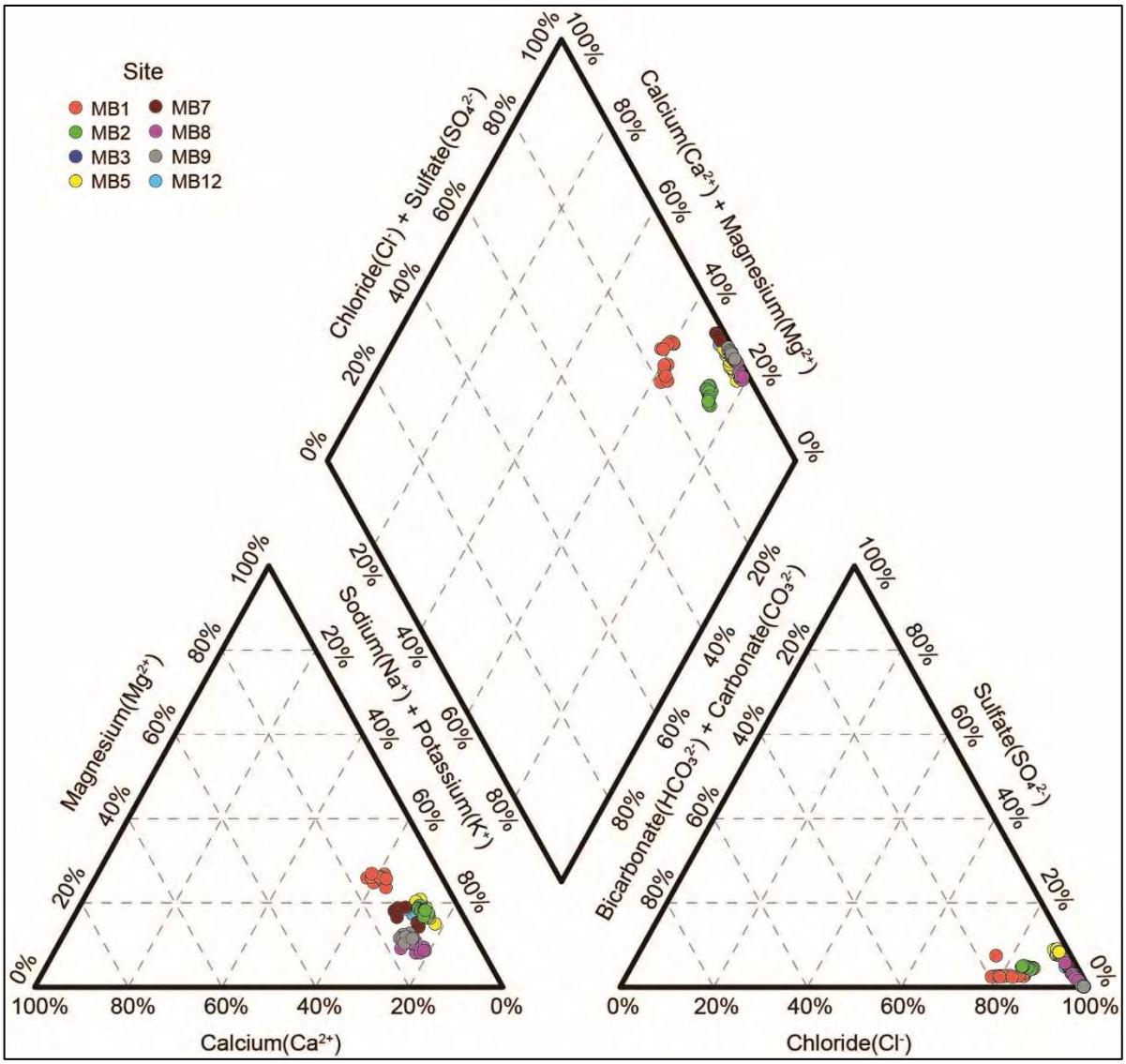

Figure 6: Difference in ionic composition of monitoring bores within the Rangal Coal Measures.

5.3 QUATERNARY COLLUVIUM / TERTIARY SEDIMENTS

Although there are seven monitoring bores in the Quaternary colluvium / Tertiary sediments at IPC, only two of these bores (MB4a and MB4b) actually contain water. Consequently, nine samples were taken in total (six from MB4a and three from MB4b). The two monitoring bores display similar water quality characteristics in terms of pH, EC and TDS, substantiated by the low SD and c_v values (Table 6). Generally, the dissolved metal concentrations for both bores are similar, with most results below the LOR.

MB4a recorded hydrocarbon concentrations above the LOR on two separate occasions during the reporting period. MB4a recorded 80 µg/L within the C29–C36 fraction in July 2019. This hydrocarbon concentration is considered to be below the level of concern. In addition, all subsequent C29–C36 fraction results from this bore were below the LOR. MB4a recorded 380 µg/L within the C10–C14 fraction in October 2020. It is unclear whether this measurement is due to contamination during sampling (as the sample was bailed) or attributable to the decomposition of organic matter. Because this elevated measurement

was the last of the reporting period, it is recommended that bore MB4a is monitored closely during the 2021 reporting period to provide further explanation of the result.

The water quality within the Quaternary/Tertiary sediments is poor, with TDS ranging between approximately 30,000 mg/L and 55,000 mg/L. Therefore, both MB4a and MB4b do not meet the TDS livestock drinking water guideline value (<4,000 mg/L) stipulated within the ANZECC and ARMCANZ (2000).

5.4 TERTIARY BASALT

The Tertiary basalt aquifer contains the best-quality groundwater across the IPC leases, with an average TDS of 2,000 mg/L (Table 6). Two monitoring bores (MB10 and MB14) target the basalt aquifer, with respective screen intervals of 21-27 m and 20-23 m. These two monitoring bores display similar water quality characteristics in terms of pH, EC and TDS, substantiated by the low SD and c_v values (Table 6). Generally, the dissolved metal concentrations for both bores are similar, with most results below the LOR.

MB14 recorded 100 µg/L within the C29–C36 fraction in July 2020. This measurement was recorded during the first sampling event after construction of the bore. It is therefore likely that the hydrocarbon was introduced during the construction process. This measurement is not of concern, also all hydrocarbon concentrations were recorded below LOR in the subsequent sampling event (October 2020).

The water quality within the Tertiary basalt is better than all of the other aquifers at IPC, with TDS ranges between approximately 1,000 mg/L and 2,500 mg/L. Therefore, both MB10 and MB14 meet the TDS livestock drinking water guideline value (<4,000 mg/L) stipulated within the ANZECC and ARMCANZ (2000).

Note: MB10 is referred to as MB9b within all field and analysis documentation.

6. EA COMPLIANCE

6.1 GROUNDWATER LEVELS

The IPC EA requires standing water level to be measured on a quarterly basis. Condition C44 states:

*If groundwater levels for the bores identified in **Table 13: Groundwater level monitoring** exceed any of the trigger level thresholds identified in **Table 13: Groundwater level monitoring** the environmental authority holder must:*

a) notify the administering authority via WaTERS or the pollution hotline within seven (7) days of receiving the analysis results;

b) complete an investigation into the potential for environmental harm.

Table 7: Groundwater level fluctuation trigger threshold (EA Table 13).

Monitoring Location	Trigger Level Threshold (m)	Monitored Unit
Burton Coal Bore 2	2	Rewan Group
Swamp Bore 1[1]	5	Rewan Group
MB14	1	Tertiary Basalt
MB16[2]	5	Tertiary Sediments

[1] Swamp Bore 1 is referred to as Swamp Bore 2 in EA Table 13.

[2] MB16 constructed late April 2021.

The compliance assessment against triggers stipulated within Table 7 only takes into consideration standing water levels measured in the reporting period between May 2019 and December 2020. Burton Coal Bore 2, Swamp Bore 1 and MB14 fluctuated by 0.57 m, 2.79 m and 0.01 m, respectively. Therefore, in accordance with EA Condition C44, IPC did not exceed the fluctuation trigger thresholds for any of the mandated monitoring bores (Figure 7).

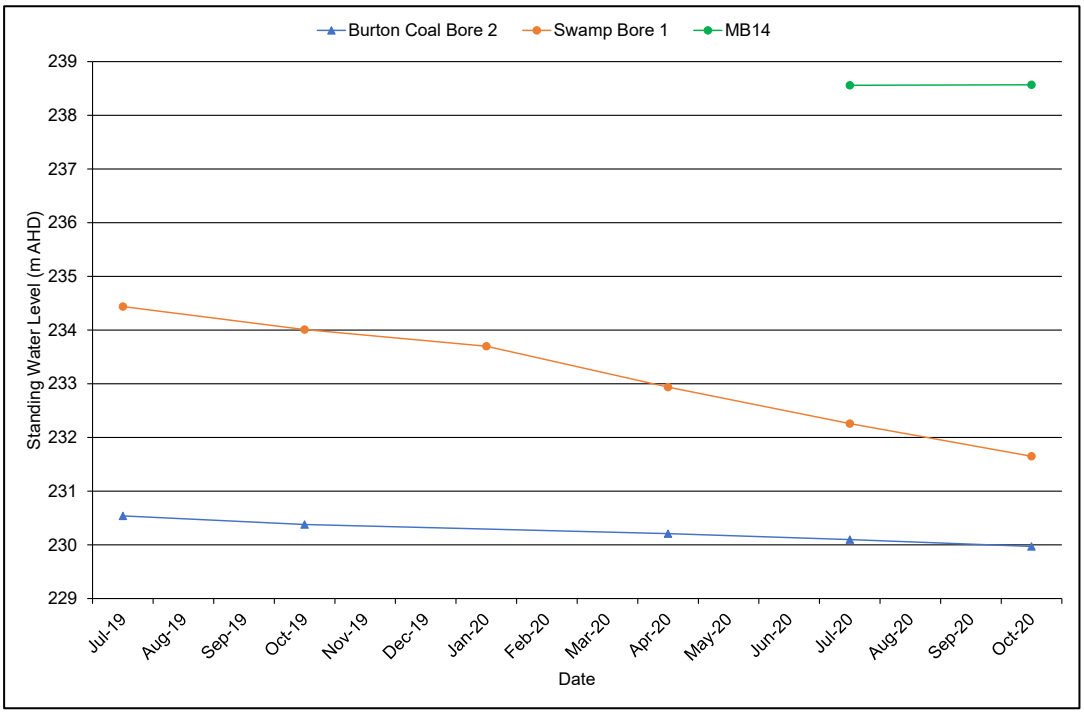

Figure 7: Groundwater level fluctuations for applicable monitoring bores.

6.2 GROUNDWATER CHARACTERISTICS

The IPC EA requires groundwater quality characteristics to be determined on a quarterly basis. Condition **C43** states:

*If groundwater quality characteristics in Burton Coal Bore 2 or Swamp Bore 1 exceed any of the trigger levels identified in **Table 12: Groundwater contaminant triggers** the environmental authority holder must:*

a) notify the administering authority via WaTERS or the pollution hotline within seven (7) days of receiving the analysis results;

b) complete an investigation into the potential for environmental harm.

The compliance assessment against triggers stipulated in Table 8 and Table 9 only takes into consideration groundwater quality characteristics measured in the reporting period (between May 2019 and December 2020).

Table 8: Burton Coal Bore 2 water quality and compliance with EA Table 12. Exceedances are highlighted in red and bold font.

Parameter	Unit	LOR	EA Contaminant Trigger	23/07/2019	22/10/2019	28/04/2020	22/07/2020	26/10/2020
pH	pH units	0.01	**7.0 < > 8.3**	7.14	7.43	8.18	7.45	7.2
EC	µS/cm	1	**7320**	**7,320**	**7,430**	**7,520**	**7,660**	**7,620**
Chloride	mg/L	1	**2050**	**2,160**	**2,280**	**2,310**	**2,290**	**2,540**
Sulphate	mg/L	1	**130**	112	100	105	110	101
Calcium	mg/L	1	**195**	**213**	192	193	**245**	**233**
Magnesium	mg/L	1	**265**	**286**	**274**	**287**	**299**	**311**
Sodium	mg/L	1	**990**	955	877	932	**1010**	**990**
Potassium	mg/L	1	**8**	5	5	5	6	6
TDS @180°C	mg/L	10	**4500**	**4,940**	**4,790**	**4,770**	**4,750**	**5,020**
TSS	mg/L	5	**52**	BLOR	BLOR	BLOR	BLOR	12
Bicarbonate	mg/L	1	**820**	700	616	645	648	609
Carbonate	mg/L	1	**7**	BLOR	BLOR	BLOR	BLOR	BLOR
Aluminum	mg/L	0.01	**0.01**	BLOR	BLOR	BLOR	BLOR	BLOR
Antimony	mg/L	0.001	**0.001**	BLOR	BLOR	BLOR	BLOR	BLOR
Arsenic	mg/L	0.001	**0.004**	BLOR	BLOR	0.002	BLOR	BLOR
Molybdenum	mg/L	0.001	**0.001**	BLOR	BLOR	BLOR	BLOR	BLOR
Selenium	mg/L	0.01	**0.01**	BLOR	BLOR	BLOR	BLOR	BLOR
Silver	mg/L	0.001	**0.001**	BLOR	BLOR	BLOR	BLOR	BLOR
Iron	mg/L	0.05	**0.23**	BLOR	BLOR	BLOR	BLOR	BLOR
Mercury	mg/L	0.0001	**0.0001**	BLOR	BLOR	BLOR	BLOR	BLOR
C6 - C9 Fraction	µg/L	20	**20**	BLOR	BLOR	BLOR	BLOR	BLOR
C10 - C36 Fraction (sum)	µg/L	50	**50**	BLOR	BLOR	BLOR	BLOR	BLOR

BLOR = Below the limit of reporting.

Table 9: Swamp Bore 1 water quality and compliance with EA Table 12. Exceedances are highlighted in red and bold font.

Parameter	Unit	LOR	**EA Contaminant Trigger**	23/07/2019	22/10/2019	21/01/2020	28/04/2020	22/07/2020	26/10/2020
pH	pH units	0.01	**7.1 < > 7.8**	7.39	7.46	7.44	7.70	7.50	7.30
EC	µS/cm	1	**9500**	9,010	8,780	8,860	9,150	9,010	8,850
Chloride	mg/L	1	**3500**	3,160	3,050	3,110	3,140	3,030	3,100
Sulphate	mg/L	1	**150**	130	113	128	121	130	119
Calcium	mg/L	1	**580**	556	520	520	515	**600**	536
Magnesium	mg/L	1	**165**	125	117	117	122	126	132
Sodium	mg/L	1	**1275**	1,100	1,050	1,060	1,070	1,170	1,110
Potassium	mg/L	1	**25**	22	21	21	21	23	22
TDS @180°C	mg/L	10	**7585**	6,800	6,380	6,430	6,460	5,890	5,610
TSS	mg/L	5	**37**	BLOR	BLOR	10	7	BLOR	BLOR
Bicarbonate	mg/L	1	**94**	56	49	57	67	52	49
Carbonate	mg/L	1	**1**	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
Aluminum	mg/L	0.01	**0.01**	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
Antimony	mg/L	0.001	**0.001**	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
Arsenic	mg/L	0.001	**0.002**	BLOR	BLOR	BLOR	BLOR	BLOR	**0.002**
Molybdenum	mg/L	0.001	**0.001**	BLOR	**0.001**	**0.002**	BLOR	**0.001**	**0.002**
Selenium	mg/L	0.01	**0.01**	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
Silver	mg/L	0.001	**0.001**	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
Iron	mg/L	0.05	**1.00**	0.28	0.28	0.20	0.54	BLOR	BLOR
Mercury	mg/L	0.0001	**0.0001**	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
C6 - C9 Fraction	µg/L	20	**20**	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
C10 - C36 Fraction (sum)	µg/L	50	**50**	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR

BLOR = Below the limit of reporting.

6.2.1 BURTON COAL BORE 2

The water quality of Burton Coal Bore 2 has been assessed against the groundwater contaminant trigger levels stipulated within EA Table 12 (Table 8). Numerous groundwater contaminant limits have been exceeded during the reporting period, with values surpassing designated limits (Table 8). It can be established that these exceedances are inter-related and associated with natural processes and climatic conditions (increased evapotranspiration / decreased rainfall), and are not a result of mining impacts (Appendix 2).

In recent years, the TDS within Burton Coal Bore 2 has been steadily increasing, with concentrations at 2,160 mg/L in October 2017 and at 5,020 mg/L in October 2020, an overall increase of 2,860 mg/L (Figure 8). This increase in TDS is an indication of a change within the cation and anion balance within the groundwater supplying Burton Coal Bore 2. The progression of this concentration can be tracked through the use of the Piper diagram (Figure 9), with data points separated into the year of collection.

Figure 9 shows that the Burton Coal Bore 2 is consistent with a sodium-chloride water type, although the ratio of these two elements has altered between 2010 and 2019. Water quality analyses performed in the initial years of IPC display similar concentrations of sodium and chloride. However, the composition has altered in recent years, displaying a chloride-dominated system, with sodium providing a lesser share of the ionic balance. Therefore, it is not unusual that the recent exceedances in the Burton Coal Bore 2 (Table 8) all relate to increases in TDS, EC, cation and anion levels.

Results from a Pearson correlation analysis reveal that the observed trends in TDS are significantly and inversely correlated to the standing water levels ($r = -0.92$, $n = 32$, $p < 0.001$). This correlation is evident in Figure 8, showing a clear relationship between the TDS and standing water level (note: values for standing water level were reversed for visual purposes). Given this correlation, it is expected that the recent dry period (2018-2020) has had the effect of concentrating the dissolved solids in the aquifer system. The increasing trend of TDS concentrations indicates that water is being lost from the system (confirmed by the SWL decline), whilst dissolved salts remain and are more concentrated due to reduced dilution.

The observed trends in TDS, EC, ionic concentrations and standing water level are highly indicative of evapotranspiration processes (sum of evaporation and plant transpiration). Burton Coal Bore 2 is located within the riparian corridor of Smoky Creek, surrounded by remnant vegetation consisting of large, deep-rooted trees. Standing water levels in the bore are known to be relatively shallow, with water levels as shallow as 7.27 m below ground level. The combination of deep tree roots and capillary action can draw water from depths (accounting for the water loss), in turn lowering the zone of saturation and concentrating salts.

The current increasing trend in TDS, EC, cation and anion levels is therefore inferred to be an expression of the climatic conditions in the area, and not a result of IPC mining activities. The groundwater contaminant limits for Burton Coal Bore 2 need to be recalculated to allow for such natural variations.

No other parameters exceeded the contaminant trigger values for Burton Coal Bore 2 during the reporting period (Table 8).

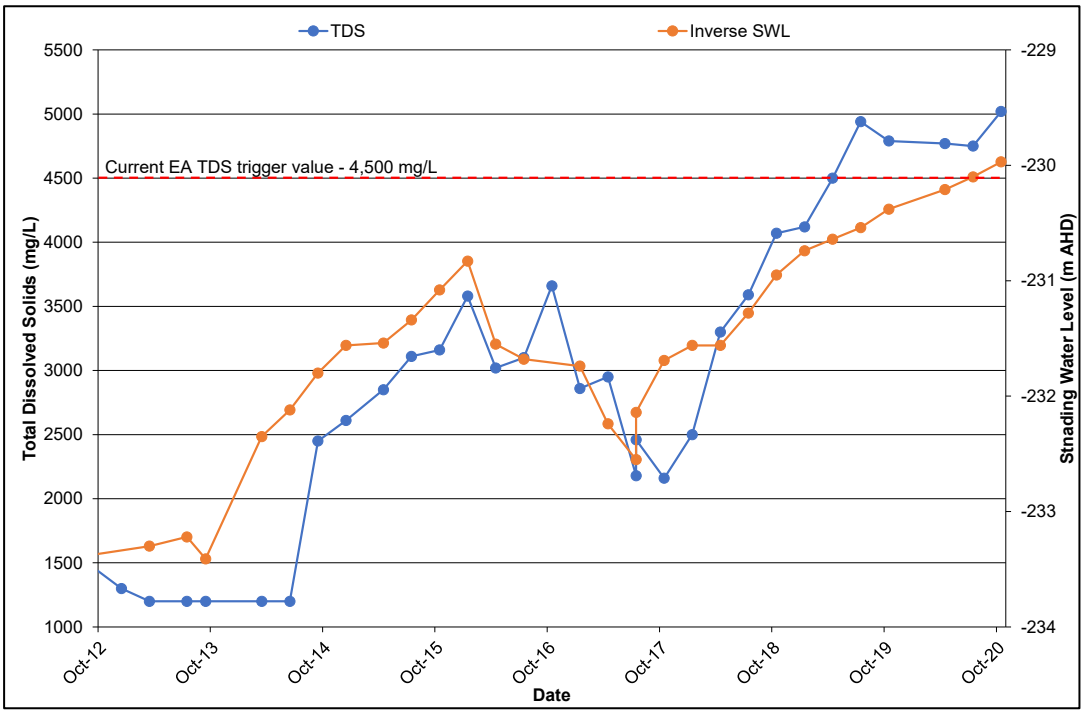

Figure 8: Total dissolved solids and inverse standing water level in Burton Coal Bore 2.

Note: Values for standing water level have been reversed for visual purposes.

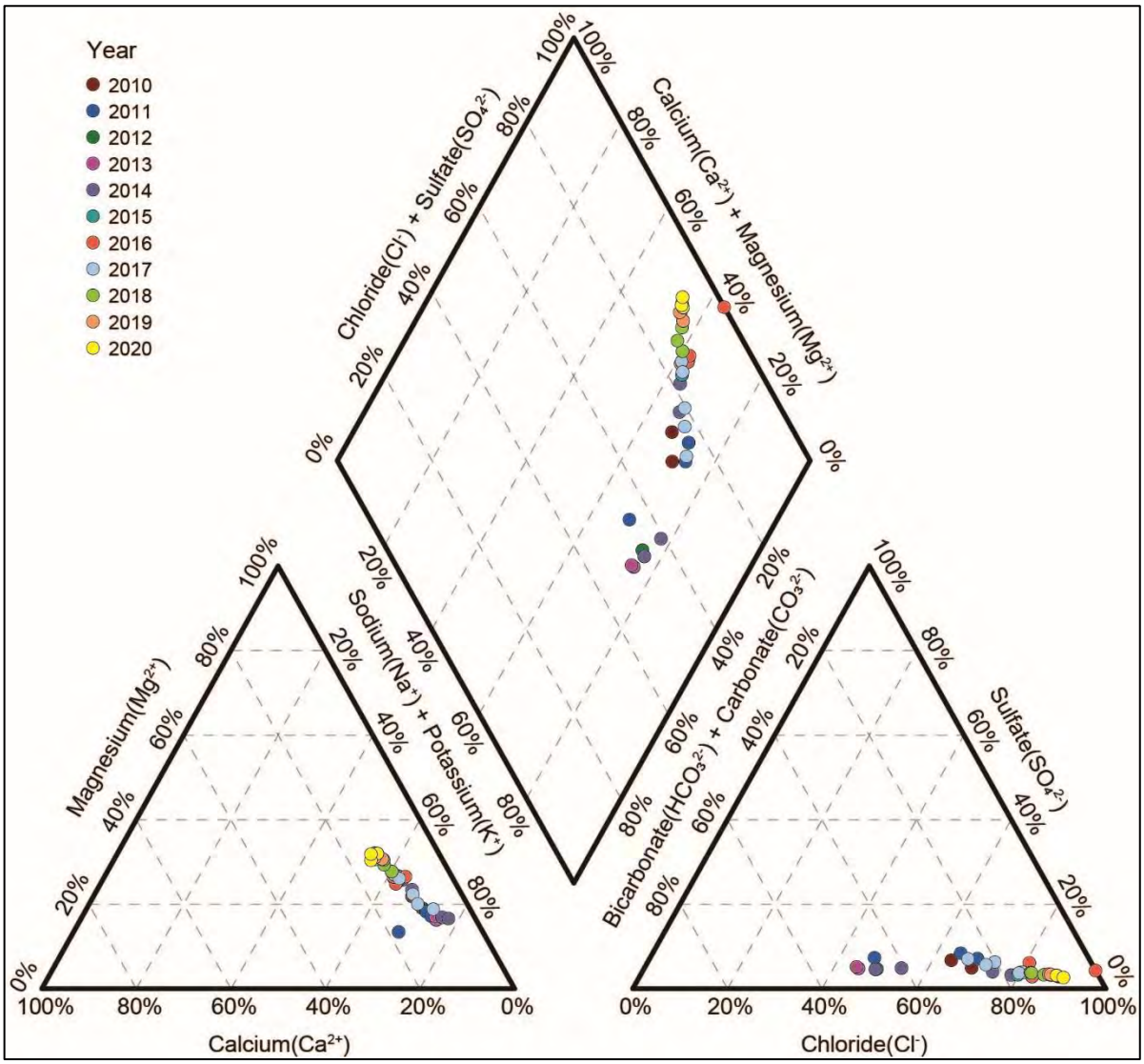

Figure 9: Ionic composition variation within Burton Coal Bore 2.

6.2.2 SWAMP BORE 1

The water quality of Swamp Bore 1 has been assessed against the groundwater contaminant trigger levels stipulated for the bore in EA Table 12 (Table 9). Few groundwater contaminant limits have been exceeded during the reporting period. All of the exceedances are either at the trigger level or only marginally above it. Therefore, it is assumed that the exceedances are natural variations within the groundwater and not a result of mining impacts.

Five exceedances occurred in dissolved metal concentrations during the reporting period, four of these for molybdenum and one for arsenic (Table 9). Two of the molybdenum exceedances were at the EA molybdenum trigger level of 0.001 mg/L, corresponding to the LOR for dissolved molybdenum. The other two molybdenum exceedances were at 0.002 mg/L. The single arsenic exceedance is at the EA arsenic trigger level of 0.002 mg/L and only marginally above the dissolved arsenic LOR of 0.001 mg/L. Given all of these exceedances are either at, or marginally above the LOR for dissolved molybdenum and dissolved arsenic, they are still within the limits of analytical uncertainty. Therefore, the aforementioned dissolved metal results may not actually be exceedances, but potential anomalies in the individual analyses.

Calcium exceeded the EA calcium trigger level (580 mg/L) in July 2020, with a value of 600 mg/L recorded (Table 9). Swamp Bore 1 has an extensive monitoring history (37 data points), with results dating back to 2010. Whilst measurements above 580 mg/L are sporadic, they are not uncommon (19% above the trigger level). In addition, the historic water composition within Swamp Bore 1 remains in a tight cluster (Figure 10). Therefore, the (marginal) exceedance of the contaminant trigger limit for calcium is attributed to natural variation observed in the groundwater system, and not a potential influence from mining activities.

No other parameters exceeded the contaminant trigger values for Swamp Bore 1 during the reporting period (Table 9).

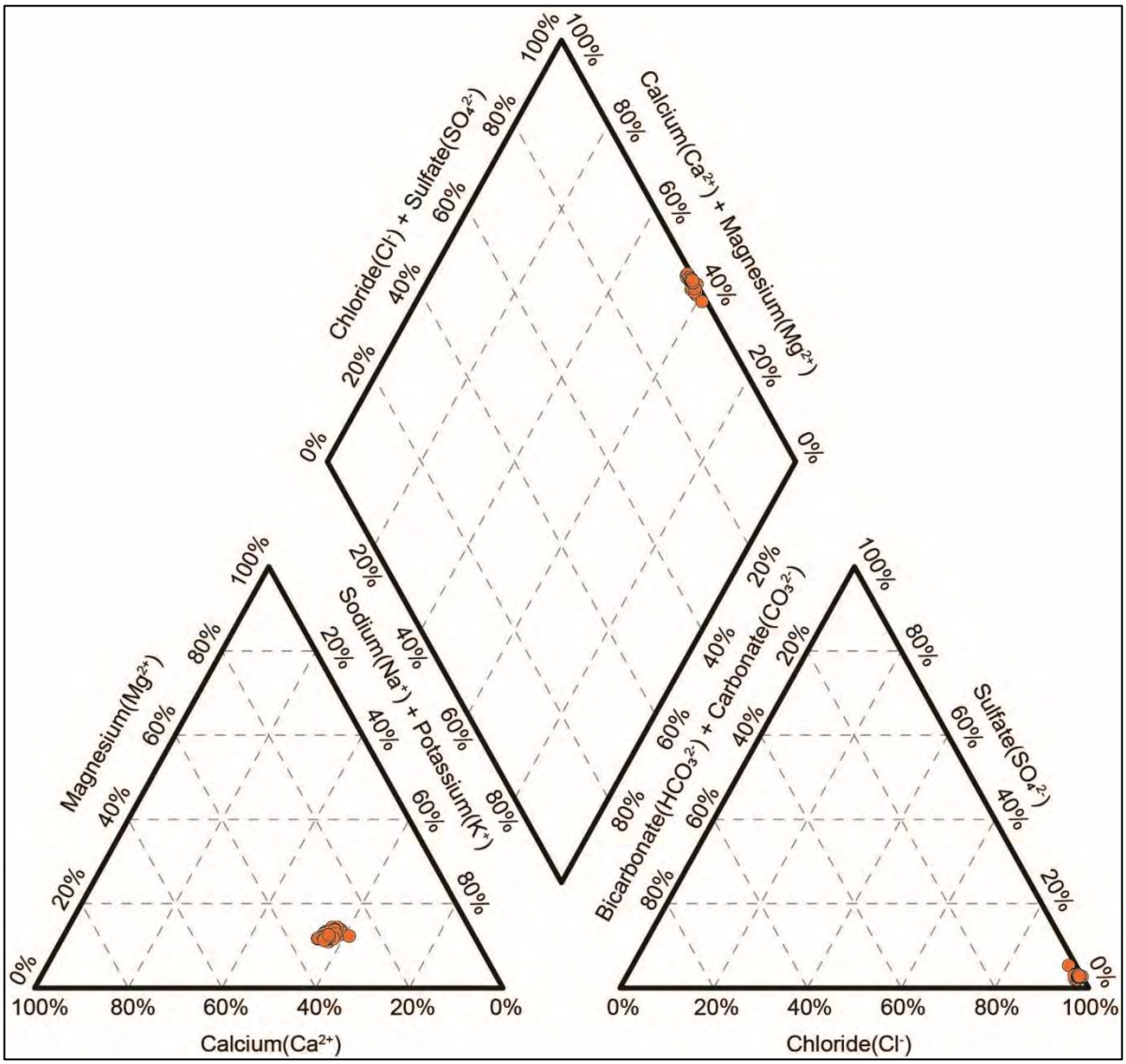

Figure 10: Ionic composition of Swamp Bore 1.

7. GROUNDWATER TRIGGER VALUES

The current EA *Table 12: Groundwater contaminant triggers* were developed for Swamp Bore 1 and Burton Coal Bore 2 from historical data collected between September 2013 and April 2019. The trigger values were determined by calculating the 80th percentile plus one standard deviation, and then rounding the result to the nearest significant figure. Subsequent monitoring has been able to provide an additional six data points for Swamp Bore 1, with a total sample size of 29 data points, and five additional datapoints for Burton Coal Bore 2, with a total sample size of 28 data points.

Upon review of the dataset, most parameters for Swamp Bore 1 have not changed. Therefore, it is deemed that the Swamp Bore 1 EA triggers levels are appropriate. Conversely, Burton Coal Bore 2 displays an increasing trend in TDS, EC and associated cations and anions. This trend can be attributed to climatic conditions and natural processes (refer to Section 6.2.1). As such, it is recommended that the EA groundwater trigger levels be amended to account for these changes in Burton Coal Bore 2. The proposed EA amendments provided in Table 10 have been determined by calculating the 80th percentile plus one standard deviation for the 28 Burton Coal Bore 2 data points (from September 2013 to October 2020), with the resulting value rounded to the nearest significant figure.

Table 10: Proposed updates to EA *Table 12 Groundwater contaminant triggers*. Changes are highlighted in blue and bold font.

			Burton Coal Bore 2	
Parameter	Unit	LOR	**Current Trigger Values**	**Amended Trigger Values**
pH	pH units	0.01	7.0 < > 8.3	7.0 < > 8.3
EC	µS/cm	1	7320	**9020**
Chloride	mg/L	1	2050	**2780**
Sulphate	mg/L	1	130	130
Calcium	mg/L	1	195	**260**
Magnesium	mg/L	1	265	**360**
Sodium	mg/L	1	990	**1110**
Potassium	mg/L	1	8	8
TDS @180°C	mg/L	10	4500	**5560**
TSS	mg/L	5	52	52
Bicarbonate	mg/L	1	820	820
Carbonate	mg/L	1	7	7
Aluminum	mg/L	0.01	0.01	0.01
Antimony	mg/L	0.001	0.001	0.001
Arsenic	mg/L	0.001	0.004	0.004
Molybdenum	mg/L	0.001	0.001	0.001
Selenium	mg/L	0.01	0.01	0.01
Silver	mg/L	0.001	0.001	0.001
Iron	mg/L	0.05	0.23	0.23
Mercury	mg/L	0.0001	0.0001	0.0001
C6 - C9 Fraction	µg/L	20	20	20
C10 - C36 Fraction (sum)	µg/L	50	50	50

8. CONCLUSION AND RECOMMENDATIONS

The 2020 IPC groundwater review incorporates all groundwater data collected from May 2019 to December 2020 (inclusive). This groundwater review is based on the existing groundwater network, incorporating twelve reference bores and five observation bores, targeting multiple aquifer systems, including the Rangal Coal Measures, Rewan Group, Tertiary basalt, Tertiary sediments and Quaternary alluvium/colluvium.

Groundwater level monitoring was conducted in all bores, exposing a steady decline in standing water level in most bores (refer to Section 0). This general decline is attributed to the ongoing dry period (2018-2020). Several bores in the Rangal Coal Measures displayed a substantial decline in standing water level as mining activities approached. This was anticipated and most of these bores were decommissioned and replaced by new bores further afield. Groundwater level triggers referenced in the IPC EA only apply to three existing bores (with the fourth and final bore recently installed in late April 2021). These include Swamp Bore 1, Burton Coal Bore 2 and MB14. IPC did not exceed the fluctuation trigger threshold for any of these EA-mandated water level monitoring bores (refer to Section 6.1).

Monitoring of groundwater quality characteristics was conducted in all bores, targeting multiple aquifer systems, with the best-quality water contained within the Tertiary basalt. The Tertiary basalt meets the TDS livestock drinking water guideline value (<4,000 mg/L) stipulated within ANZECC and ARMCANZ (2000), whereas all the other systems do not meet this threshold. For the first sampling event in a recently constructed Tertiary basalt bore (MB14), a hydrocarbon concentration of 100 µg/L was measured in the C29–C36 fraction. This concentration is deemed below the level of concern and was most likely caused by the construction process. Further, the subsequent sampling event at MB14 recorded all hydrocarbon concentrations below the LOR.

The highest TDS (and, consequently, EC) is contained within the Quaternary colluvium / Tertiary sediments, with all values above 19,000 mg/L. Therefore, the water quality is considered poor. In addition, one of the Quaternary colluvium / Tertiary sediment monitoring bores (MB4a) recorded two separate hydrocarbon concentrations at or above the LOR during the reporting period. The first measurement of 80 µg/L within the C29–C36 fraction (July 2019) is below the level of concern, especially as subsequent sampling rounds returned concentrations below detection limits. Conversely, the second measurement of 380 µg/L within the C10–C14 fraction (October 2020) is potentially of concern. It is recommended that bore MB4a is monitored closely during the 2021 reporting period to provide further explanation of the result, with the elevated concentration possibly resulting from either contamination during sampling or decomposition of organic material.

Trigger levels of groundwater quality characteristics, referenced in the IPC EA, apply to only two bores (Swamp Bore 1 and Burton Coal Bore 2), both of which are screened within the Rewan Group. Swamp Bore 1 recorded six exceedances of the trigger threshold, one for calcium and five for dissolved metals (four exceedances for molybdenum and one for arsenic). The calcium exceedance is only marginally (20 mg/L) above the threshold and most likely attributable to natural variation within the groundwater. The dissolved metal exceedances are also minimal (either at or slightly above the LOR), and are within the limits of analytical uncertainty, requiring further monitoring to decipher whether or not contamination is occurring. The second bore, Burton Coal Bore 2, recorded numerous exceedances of trigger values associated with TDS, EC and ionic concentrations. However, these exceedances are all interrelated and associated with natural processes and climatic conditions (refer to Section 6.2.1).

In recent years, the TDS, EC and ionic concentrations within Burton Coal Bore 2 have been steadily increasing. Therefore, it is not unexpected that all of the exceedances of

groundwater quality characteristic at Burton Coal Bore 2 during the reporting period are attributed to these interrelated parameters. The increase in TDS (and, consequently, EC) is indicative of a change within the cation and anion balance within the groundwater surrounding Burton Coal Bore 2. These increases can be directly related to the decline in standing water level in Burton Coal Bore 2 (refer to Section 6.2.1). Therefore, it is expected that the recent dry period (2018-2020) has had the effect of concentrating the dissolved solids in the aquifer system during a concomitant decrease in water volume. Therefore, the observed trends in TDS, EC, ionic concentrations and standing water level in Burton Coal Bore 2 are symptomatic of natural evapotranspirative processes and recent climatic conditions.

The groundwater contaminant limits for Burton Coal Bore 2 need to be recalculated to allow for the aforementioned natural processes. Updated groundwater contaminant limits have been ascertained for Burton Coal Bore 2, adopting the same method utilised for the original values (80th percentile plus one standard deviation, rounded to the nearest significant figure). These updates to the contaminant limits were calculated using a larger, more representative dataset, containing an additional 20 months of results from the 2019-2020 reporting period. Although the dataset is more representative, the calculation methodology used for the trigger values remains stringent and, consequently, IPC may continue to exceed the site-specific limits (especially in the case of Burton Coal Bore 2). If continual exceedances are recorded, it is recommended that IPC discuss a trigger level review with DES. Such a review may include undertaking further groundwater assessments or the possible application of a different calculation method when determining contaminant trigger limits.

Whilst unrelated to EA compliance, it must be noted that the current monitoring network nomenclature is not aligned across the relevant documentation, including the EA, GMMP and third-party groundwater sample reports (refer to Section 3). To maintain the integrity of the data collected, it is highly recommended that the naming conventions be addressed immediately and aligned within all relevant documentation. Alignment of monitoring bore details should include surveyed coordinate locations, surveyed reduced levels (in m AHD) for surface and top of casing levels, hydrostratigraphic unit, screened interval, and a standardised naming identification. C&R understands that this recommendation has been addressed in the latest EA amendment completed by Stanmore.

The IPC groundwater monitoring network extensively covers the aquifer systems that may be potentially impacted by mining operations and therefore meets the requirements stipulated in EA Condition C40.

9. REFERENCES

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3d Environmental (2020a) *Isaac Plains East Extension Project – Groundwater Dependent Ecosystem (GDE) Management and Monitoring Plan*. For Stanmore IP Coal Pty Ltd.

3d Environmental (2020b) *Isaac Plains East Extension Project – Groundwater Dependent Ecosystem Assessment*. For Stanmore IP Coal Pty Ltd.

Appendix 1 – Certificate of Analysis

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1918178**	Page	: 1 of 12
Client	: **STANMORE IP COAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: BELINDA PARFITT	Contact	: Anna Riddell
Address	: GPO BOX 2602 BRISBANE QLD 4001	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 07 4816 7444	Telephone	: +61 7 4952 5795
Project	: IPCM	Date Samples Received	: 26-Jul-2019 09:30
Order number	: P1002091	Date Analysis Commenced	: 26-Jul-2019
C-O-C number	: ----	Issue Date	: 05-Aug-2019 12:27
Sampler	: SCOTT AULSEBROOK		
Site	: ----		
Quote number	: TV/005/19		
No. of samples received	: 17		
No. of samples analysed	: 11		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Santusha Pandra	Organic Chemist	Brisbane Organics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Ek067G (Total Phosphorus as P): Sample EB1918178_004 (MB7) was diluted due to matrix interference. LOR adjusted accordingly.
- TDS by method EA-015 may bias high due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.
- EG035T (Total Mercury): Positive mercury results have been confirmed by re-extraction and re-analysis.
- It is recognised that EG020-T (Total Metals by ICP-MS) is less than EG020-F (Dissolved Metals by ICP-MS) for some samples. However, the difference is within experimental variation of the methods.
- EG020-T (Total Metals by ICP-MS): Limit of reporting raised for some samples due to matrix interference.
- EG020-F (Dissolved Metals by ICP-MS): Limit of reporting raised due to matrix interference.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	BC2	SB1	MB7	MB1	MB2
			Client sampling date / time	23-Jul-2019 07:30	23-Jul-2019 16:00	24-Jul-2019 10:30	23-Jul-2019 10:00	23-Jul-2019 08:55
Compound	CAS Number	LOR	Unit	EB1918178-001	EB1918178-002	EB1918178-004	EB1918178-006	EB1918178-007
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.14	7.39	7.07	7.33	7.25
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	7320	9010	24100	3420	7870
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	4940	6800	17700	1890	4550
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	19	<5	16
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	700	56	490	581	859
Total Alkalinity as CaCO3	----	1	mg/L	700	56	490	581	859
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	112	130	556	35	167
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	2160	3160	8440	827	2540
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	213	556	717	88	132
Magnesium	7439-95-4	1	mg/L	286	125	555	104	173
Sodium	7440-23-5	1	mg/L	955	1100	3930	483	1310
Potassium	7440-09-7	1	mg/L	5	22	21	3	8
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.03	<0.01	<0.01
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	0.007	0.032
Barium	7440-39-3	0.001	mg/L	0.104	0.205	0.357	0.128	0.136
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.014	0.001	0.002
Rubidium	7440-17-7	0.001	mg/L	0.010	0.034	0.037	0.003	0.013
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	5.49	8.50	46.0	2.14	4.48
Iron	7439-89-6	0.05	mg/L	<0.05	0.28	0.55	0.15	1.69
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.06	0.04	0.15	0.01	0.13

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	BC2	SB1	MB7	MB1	MB2
			Client sampling date / time	23-Jul-2019 07:30	23-Jul-2019 16:00	24-Jul-2019 10:30	23-Jul-2019 10:00	23-Jul-2019 08:55
Compound	CAS Number	LOR	Unit	EB1918178-001	EB1918178-002	EB1918178-004	EB1918178-006	EB1918178-007
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	**0.001**	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	**0.002**	**0.006**	**0.032**
Barium	7440-39-3	0.001	mg/L	**0.102**	**0.204**	**3.45**	**0.124**	**0.136**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	**0.018**	**0.001**	**0.002**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	**5.28**	**8.32**	**46.3**	**2.04**	**4.33**
Iron	7439-89-6	0.05	mg/L	**0.20**	**0.47**	**1.40**	**0.16**	**1.85**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.2**	<0.1	**0.1**	**0.5**	**0.5**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.01	**0.03**	<0.05	<0.01	**0.03**
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**77.2**	**93.0**	**259**	**35.7**	**92.3**
ø Total Cations	----	0.01	meq/L	**75.8**	**86.4**	**253**	**34.0**	**78.0**
ø Ionic Balance	----	0.01	%	**0.92**	**3.64**	**1.27**	**2.34**	**8.38**
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	BC2	SB1	MB7	MB1	MB2
			Client sampling date / time	23-Jul-2019 07:30	23-Jul-2019 16:00	24-Jul-2019 10:30	23-Jul-2019 10:00	23-Jul-2019 08:55
Compound	CAS Number	LOR	Unit	EB1918178-001	EB1918178-002	EB1918178-004	EB1918178-006	EB1918178-007
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**110**	**121**	**113**	**119**	**108**
Toluene-D8	2037-26-5	2	%	**98.6**	**93.6**	**97.1**	**95.9**	**98.3**
4-Bromofluorobenzene	460-00-4	2	%	**94.9**	**96.8**	**97.0**	**99.9**	**96.2**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB4A	MB4B	MB8B	MB9A	MB9B
			Client sampling date / time	24-Jul-2019 07:00	23-Jul-2019 17:30	23-Jul-2019 11:55	23-Jul-2019 16:05	23-Jul-2019 17:00
Compound	CAS Number	LOR	Unit	EB1918178-009	EB1918178-010	EB1918178-013	EB1918178-014	EB1918178-015
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	6.82	7.57	7.43	7.51	7.87
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	53100	31500	12300	11000	2820
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	41500	19900	8090	7600	1580
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	7530	7480	6	23	6
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	437	1270	219	106	582
Total Alkalinity as CaCO3	----	1	mg/L	437	1270	219	106	582
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	965	401	130	1	130
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	19500	10600	4270	3890	593
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	643	90	314	316	46
Magnesium	7439-95-4	1	mg/L	1940	461	114	138	84
Sodium	7440-23-5	1	mg/L	10300	7240	2070	1660	412
Potassium	7440-09-7	1	mg/L	3	3	13	19	6
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.05	<0.05	<0.01	<0.01	0.01
Antimony	7440-36-0	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	<0.005	<0.005	0.003	<0.001	0.002
Barium	7440-39-3	0.001	mg/L	0.257	0.213	0.682	9.29	0.030
Molybdenum	7439-98-7	0.001	mg/L	<0.005	<0.005	0.004	<0.001	0.014
Rubidium	7440-17-7	0.001	mg/L	0.005	<0.005	0.025	0.030	0.011
Selenium	7782-49-2	0.01	mg/L	<0.05	<0.05	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	22.0	7.06	20.3	13.2	0.881
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.11	0.70	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	36.6	57.3	0.48	1.70	0.19

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB4A	MB4B	MB8B	MB9A	MB9B
			Client sampling date / time	24-Jul-2019 07:00	23-Jul-2019 17:30	23-Jul-2019 11:55	23-Jul-2019 16:05	23-Jul-2019 17:00
Compound	CAS Number	LOR	Unit	EB1918178-009	EB1918178-010	EB1918178-013	EB1918178-014	EB1918178-015
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.031	0.018	0.004	0.003	0.002
Barium	7440-39-3	0.001	mg/L	0.483	0.734	0.670	8.92	0.033
Molybdenum	7439-98-7	0.001	mg/L	0.015	0.010	0.005	0.001	0.016
Selenium	7782-49-2	0.01	mg/L	<0.05	<0.05	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	22.9	7.35	19.8	12.6	0.843
Iron	7439-89-6	0.05	mg/L	78.4	132	0.72	3.72	0.29
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	0.3	0.6	0.2	0.2	0.2
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	1.11	1.99	<0.01	0.10	0.10
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	579	333	128	112	31.1
ø Total Cations	----	0.01	meq/L	640	357	115	99.8	27.3
ø Ionic Balance	----	0.01	%	5.00	3.58	4.98	5.69	6.48
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	80	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	80	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	150	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	150	<100	<100	<100	<100

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB4A	MB4B	MB8B	MB9A	MB9B
			Client sampling date / time	24-Jul-2019 07:00	23-Jul-2019 17:30	23-Jul-2019 11:55	23-Jul-2019 16:05	23-Jul-2019 17:00
Compound	CAS Number	LOR	Unit	EB1918178-009	EB1918178-010	EB1918178-013	EB1918178-014	EB1918178-015
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**124**	**114**	**121**	**111**	**119**
Toluene-D8	2037-26-5	2	%	**94.5**	**96.5**	**96.5**	**98.6**	**94.0**
4-Bromofluorobenzene	460-00-4	2	%	**97.5**	**96.1**	**98.5**	**96.8**	**96.3**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IPCM GW Duplicate	----	----	----	----
			Client sampling date / time	23-Jul-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1918178-017	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.45**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**12300**	----	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**8000**	----	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	**11**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**224**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**224**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**128**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**4250**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**310**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**113**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**2040**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**13**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.004**	----	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.682**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.004**	----	----	----	----
Rubidium	7440-17-7	0.001	mg/L	**0.025**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	**20.0**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.11**	----	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.47**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IPCM GW Duplicate	----	----	----	----
			Client sampling date / time	23-Jul-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1918178-017	--------	--------	--------	--------
				Result	----	----	----	----
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.004**	----	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.681**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.005**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	**19.5**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.68**	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.2**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.02**	----	----	----	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**127**	----	----	----	----
ø Total Cations	----	0.01	meq/L	**114**	----	----	----	----
ø Ionic Balance	----	0.01	%	**5.48**	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	----	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IPCM GW Duplicate	----	----	----	----
			Client sampling date / time	23-Jul-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1918178-017	--------	--------	--------	--------
				Result	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	----	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	----	----	----	----
Toluene	108-88-3	2	µg/L	<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
^ Total Xylenes	----	2	µg/L	<2	----	----	----	----
^ Sum of BTEX	----	1	µg/L	<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L	<5	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	113	----	----	----	----
Toluene-D8	2037-26-5	2	%	99.2	----	----	----	----
4-Bromofluorobenzene	460-00-4	2	%	96.8	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1927085**	Page	: 1 of 12
Client	: **STANMORE IP COAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: BELINDA PARFITT	Contact	: Anna Riddell
Address	: GPO BOX 2602 BRISBANE QLD 4001	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 07 4816 7444	Telephone	: +61 7 4952 5795
Project	: IPCM	Date Samples Received	: 25-Oct-2019 09:30
Order number	: P1002091	Date Analysis Commenced	: 25-Oct-2019
C-O-C number	: ----	Issue Date	: 01-Nov-2019 14:08
Sampler	: SCOTT AULSEBROOK		
Site	: ----		
Quote number	: TV/005/19		
No. of samples received	: 15		
No. of samples analysed	: 11		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Sarah Ashworth	Laboratory Manager - Brisbane	Brisbane Organics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG020-F (Dissolved Metals by ICP-MS) & EG020-T (Total Metals by ICP-MS): Limit of reporting raised for sample EB1927085-007(MB4A) due to matrix interference.
- TDS by method EA-015 may bias high due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.
- It is recognised that EG020-T (Total Metals by ICP-MS) is less than EG020-F (Dissolved Metals by ICP-MS) for some samples. However, the difference is within experimental variation of the methods.
- EK067G (Total Phosphorous as P): Some samples were diluted due to matrix interference. LOR adjusted accordingly.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	BC2	MB7	MB1	MB2
			Client sampling date / time	22-Oct-2019 15:15	22-Oct-2019 16:35	23-Oct-2019 09:30	23-Oct-2019 13:00	22-Oct-2019 17:40
Compound	CAS Number	LOR	Unit	EB1927085-001	EB1927085-002	EB1927085-003	EB1927085-005	EB1927085-006
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.46	7.43	7.38	7.59	7.57
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	8780	7430	23500	4040	7580
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	6380	4790	16600	2350	4500
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	14	<5	<5
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	49	616	459	491	766
Total Alkalinity as CaCO3	----	1	mg/L	49	616	459	491	766
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	113	100	559	46	154
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	3050	2280	8650	1080	2150
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	520	192	646	117	114
Magnesium	7439-95-4	1	mg/L	117	274	566	122	162
Sodium	7440-23-5	1	mg/L	1050	877	3870	520	1240
Potassium	7440-09-7	1	mg/L	21	5	20	4	7
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.002	0.003	0.025
Barium	7440-39-3	0.001	mg/L	0.208	0.137	0.292	0.222	0.141
Molybdenum	7439-98-7	0.001	mg/L	0.001	<0.001	0.001	0.002	0.002
Rubidium	7440-17-7	0.001	mg/L	0.030	0.009	0.033	0.004	0.012
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	8.29	5.33	45.7	2.64	4.02
Iron	7439-89-6	0.05	mg/L	0.28	<0.05	0.71	0.16	1.59
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.04	0.16	0.09	0.01	0.06

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	BC2	MB7	MB1	MB2
			Client sampling date / time	22-Oct-2019 15:15	22-Oct-2019 16:35	23-Oct-2019 09:30	23-Oct-2019 13:00	22-Oct-2019 17:40
Compound	CAS Number	LOR	Unit	EB1927085-001	EB1927085-002	EB1927085-003	EB1927085-005	EB1927085-006
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.002	0.004	0.025
Barium	7440-39-3	0.001	mg/L	0.222	0.155	3.49	0.259	0.149
Molybdenum	7439-98-7	0.001	mg/L	0.002	<0.001	0.022	0.004	0.003
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	9.13	5.93	51.3	2.98	4.35
Iron	7439-89-6	0.05	mg/L	0.40	0.58	1.27	0.21	1.85
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	0.2	0.1	0.4	0.5
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	0.02	0.01	<0.05	0.02	0.04
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	89.4	78.7	265	41.2	79.2
ø Total Cations	----	0.01	meq/L	81.8	70.4	248	38.6	73.1
ø Ionic Balance	----	0.01	%	4.43	5.56	3.35	3.30	3.95
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	BC2	MB7	MB1	MB2
			Client sampling date / time	22-Oct-2019 15:15	22-Oct-2019 16:35	23-Oct-2019 09:30	23-Oct-2019 13:00	22-Oct-2019 17:40
Compound	CAS Number	LOR	Unit	EB1927085-001	EB1927085-002	EB1927085-003	EB1927085-005	EB1927085-006
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	98.4	101	97.3	74.7	92.5
Toluene-D8	2037-26-5	2	%	97.9	98.8	93.7	92.8	96.1
4-Bromofluorobenzene	460-00-4	2	%	106	108	103	98.2	100

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB4A	MB9A	MB9B	MB8B	IPCM GW Duplicate
			Client sampling date / time	22-Oct-2019 13:20	22-Oct-2019 12:40	22-Oct-2019 11:30	23-Oct-2019 11:30	23-Oct-2019 09:35
Compound	CAS Number	LOR	Unit	EB1927085-007	EB1927085-009	EB1927085-010	EB1927085-012	EB1927085-014
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.16	7.66	8.04	7.69	7.40
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	49300	10700	3780	11800	23600
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	39100	7160	2200	7890	16600
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	830	<5	45	9	10
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	383	99	375	169	454
Total Alkalinity as CaCO3	----	1	mg/L	383	99	375	169	454
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	842	2	111	87	561
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	19900	3840	1010	4180	8610
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	578	287	63	280	650
Magnesium	7439-95-4	1	mg/L	1760	137	110	116	568
Sodium	7440-23-5	1	mg/L	8900	1620	540	2000	3880
Potassium	7440-09-7	1	mg/L	5	19	9	13	20
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.05	<0.01	<0.01	<0.01	<0.01
Antimony	7440-36-0	0.001	mg/L	<0.005	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	<0.005	<0.001	0.001	0.004	0.001
Barium	7440-39-3	0.001	mg/L	0.222	8.78	0.032	0.975	0.296
Molybdenum	7439-98-7	0.001	mg/L	<0.005	0.001	0.012	0.006	0.002
Rubidium	7440-17-7	0.001	mg/L	0.016	0.028	0.015	0.024	0.035
Selenium	7782-49-2	0.01	mg/L	<0.05	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.005	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	22.3	11.8	1.23	16.4	44.2
Iron	7439-89-6	0.05	mg/L	<0.05	0.70	<0.05	0.09	0.71
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	6.20	0.09	1.21	0.26	0.08

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB4A	MB9A	MB9B	MB8B	IPCM GW Duplicate
			Client sampling date / time	22-Oct-2019 13:20	22-Oct-2019 12:40	22-Oct-2019 11:30	23-Oct-2019 11:30	23-Oct-2019 09:35
Compound	CAS Number	LOR	Unit	EB1927085-007	EB1927085-009	EB1927085-010	EB1927085-012	EB1927085-014
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.005	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	**0.007**	<0.001	**0.001**	**0.004**	**0.002**
Barium	7440-39-3	0.001	mg/L	**0.229**	**9.76**	**0.052**	**1.10**	**3.21**
Molybdenum	7439-98-7	0.001	mg/L	**0.007**	**0.001**	**0.014**	**0.012**	**0.002**
Selenium	7782-49-2	0.01	mg/L	<0.05	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.005	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	**22.2**	**13.3**	**1.42**	**18.4**	**51.4**
Iron	7439-89-6	0.05	mg/L	**11.8**	**0.98**	**1.96**	**0.36**	**1.21**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.3**	**0.2**	**0.2**	**0.2**	**0.1**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**90.7**	**0.01**	**0.19**	<0.05	<0.05
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**586**	**110**	**38.3**	**123**	**264**
ø Total Cations	----	0.01	meq/L	**561**	**96.5**	**35.9**	**111**	**248**
ø Ionic Balance	----	0.01	%	**2.23**	**6.67**	**3.20**	**5.24**	**2.96**
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB4A	MB9A	MB9B	MB8B	IPCM GW Duplicate
			Client sampling date / time	22-Oct-2019 13:20	22-Oct-2019 12:40	22-Oct-2019 11:30	23-Oct-2019 11:30	23-Oct-2019 09:35
Compound	CAS Number	LOR	Unit	EB1927085-007	EB1927085-009	EB1927085-010	EB1927085-012	EB1927085-014
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**74.2**	**73.7**	**92.8**	**95.7**	**95.1**
Toluene-D8	2037-26-5	2	%	**94.4**	**95.5**	**94.6**	**96.6**	**97.1**
4-Bromofluorobenzene	460-00-4	2	%	**102**	**103**	**99.6**	**102**	**103**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Field Blank	----	----	----	----
			Client sampling date / time	23-Oct-2019 18:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1927085-015	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**5.98**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	<1	----	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	<10	----	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**2**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**2**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	<1	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	----	----	----	----
Rubidium	7440-17-7	0.001	mg/L	<0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	**0.001**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	----	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Field Blank	----	----	----	----
			Client sampling date / time	23-Oct-2019 18:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1927085-015	--------	--------	--------	--------
				Result	----	----	----	----
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	<0.001	----	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.01	----	----	----	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**0.04**	----	----	----	----
ø Total Cations	----	0.01	meq/L	<0.01	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	----	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Field Blank	----	----	----	----
			Client sampling date / time	23-Oct-2019 18:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1927085-015	--------	--------	--------	--------
				Result	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	----	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	----	----	----	----
Toluene	108-88-3	2	µg/L	<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
^ Total Xylenes	----	2	µg/L	<2	----	----	----	----
^ Sum of BTEX	----	1	µg/L	<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L	<5	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	71.4	----	----	----	----
Toluene-D8	2037-26-5	2	%	96.8	----	----	----	----
4-Bromofluorobenzene	460-00-4	2	%	101	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB2001883**	Page	: 1 of 12
Client	: **STANMORE IP COAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: BELINDA PARFITT	Contact	: Anna Riddell
Address	: GPO BOX 2602 BRISBANE QLD 4001	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 07 4816 7444	Telephone	: +61 7 4952 5795
Project	: IPCM	Date Samples Received	: 23-Jan-2020 11:50
Order number	: P1002091	Date Analysis Commenced	: 24-Jan-2020
C-O-C number	: ----	Issue Date	: 03-Feb-2020 15:11
Sampler	: LIAM HAMERSVELD		
Site	: ----		
Quote number	: TV/005/19 v3		
No. of samples received	: 12		
No. of samples analysed	: 12		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Matt Frost	Assistant Laboratory Manager	Brisbane Organics, Stafford, QLD
Sarah Ashworth	Laboratory Manager - Brisbane	Brisbane Organics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- It is recognised that EG020-T (Total Metals by ICP-MS) is less than EG020-F (Dissolved Metals by ICP-MS) for some samples. However, the difference is within experimental variation of the methods.
- EG020-T (Total Metals by ICP-MS): Limit of reporting raised for sample MB4A (EB2001883-004) due to matrix interference.
- EG020-F (Dissolved Metals by ICP-MS): Limit of reporting raised for sample MB4A (EB2001883-004) due to matrix interference.
- EK067G (Total Phosphorous as P): Some samples were diluted due to matrix interference (Salinity). LOR adjusted accordingly.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	MB1	MB2	MB4A	MB9A
			Client sampling date / time	21-Jan-2020 17:40	21-Jan-2020 09:50	21-Jan-2020 09:10	21-Jan-2020 16:30	21-Jan-2020 15:20
Compound	CAS Number	LOR	Unit	EB2001883-001	EB2001883-002	EB2001883-003	EB2001883-004	EB2001883-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.44	7.45	7.26	6.74	7.49
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	8860	3210	7400	52600	10600
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	6430	1890	4590	39300	7270
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	10	<5	<5	1210	5
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	57	478	741	361	104
Total Alkalinity as CaCO3	----	1	mg/L	57	478	741	361	104
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	128	35	162	983	4
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	3110	817	1960	19700	3830
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	520	80	109	702	296
Magnesium	7439-95-4	1	mg/L	117	95	159	1910	145
Sodium	7440-23-5	1	mg/L	1060	416	1220	9940	1670
Potassium	7440-09-7	1	mg/L	21	4	7	4	20
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.05	<0.01
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.005	<0.001
Arsenic	7440-38-2	0.001	mg/L	<0.001	0.003	0.023	<0.005	<0.001
Barium	7440-39-3	0.001	mg/L	0.703	0.212	0.158	0.223	8.80
Molybdenum	7439-98-7	0.001	mg/L	0.002	0.011	0.002	<0.005	0.003
Rubidium	7440-17-7	0.001	mg/L	0.030	0.004	0.012	0.007	0.029
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.05	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.005	<0.001
Strontium	7440-24-6	0.001	mg/L	9.82	2.34	4.68	25.0	14.1
Iron	7439-89-6	0.05	mg/L	0.20	<0.05	1.16	<0.05	0.48
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.10	0.08	0.03	7.01	0.13

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	MB1	MB2	MB4A	MB9A
			Client sampling date / time	21-Jan-2020 17:40	21-Jan-2020 09:50	21-Jan-2020 09:10	21-Jan-2020 16:30	21-Jan-2020 15:20
Compound	CAS Number	LOR	Unit	EB2001883-001	EB2001883-002	EB2001883-003	EB2001883-004	EB2001883-005
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.005	<0.001
Arsenic	7440-38-2	0.001	mg/L	**0.001**	**0.003**	**0.024**	**0.006**	<0.001
Barium	7440-39-3	0.001	mg/L	**0.701**	**0.205**	**0.158**	**0.241**	**8.07**
Molybdenum	7439-98-7	0.001	mg/L	**0.002**	**0.012**	**0.003**	<0.005	**0.003**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.05	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.005	<0.001
Strontium	7440-24-6	0.001	mg/L	**8.96**	**2.11**	**4.30**	**24.8**	**12.4**
Iron	7439-89-6	0.05	mg/L	**0.46**	**0.18**	**1.36**	**11.8**	**0.78**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	**0.5**	**0.5**	**0.3**	**0.2**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.10**	**0.02**	**0.03**	**0.24**	<0.05
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**91.5**	**33.3**	**73.5**	**583**	**110**
ø Total Cations	----	0.01	meq/L	**82.2**	**30.0**	**71.8**	**625**	**99.8**
ø Ionic Balance	----	0.01	%	**5.36**	**5.24**	**1.17**	**3.42**	**4.92**
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	MB1	MB2	MB4A	MB9A
			Client sampling date / time	21-Jan-2020 17:40	21-Jan-2020 09:50	21-Jan-2020 09:10	21-Jan-2020 16:30	21-Jan-2020 15:20
Compound	CAS Number	LOR	Unit	EB2001883-001	EB2001883-002	EB2001883-003	EB2001883-004	EB2001883-005
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	102	98.3	104	123	120
Toluene-D8	2037-26-5	2	%	97.0	97.8	96.2	96.2	95.6
4-Bromofluorobenzene	460-00-4	2	%	101	100	99.6	103	101

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB9B	IPCM GW Field Blank	IPCM Trip Blank	MB8B	MB7
			Client sampling date / time	21-Jan-2020 14:50	21-Jan-2020 17:50	20-Jan-2020 08:00	22-Jan-2020 18:20	23-Jan-2020 09:40
Compound	CAS Number	LOR	Unit	EB2001883-006	EB2001883-007	EB2001883-008	EB2001883-009	EB2001883-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.15	6.72	----	7.47	7.23
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	3550	<1	----	11500	20500
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	2120	<10	----	8200	12200
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	10	<5	----	20	<5
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	411	5	----	103	309
Total Alkalinity as CaCO3	----	1	mg/L	411	5	----	103	309
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	115	<1	----	12	323
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	923	<1	----	4150	7230
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	57	<1	----	281	433
Magnesium	7439-95-4	1	mg/L	107	<1	----	139	376
Sodium	7440-23-5	1	mg/L	496	<1	----	1840	3430
Potassium	7440-09-7	1	mg/L	8	<1	----	15	18
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	----	<0.01	<0.01
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.002	<0.001	----	0.003	<0.001
Barium	7440-39-3	0.001	mg/L	0.040	<0.001	----	2.36	0.646
Molybdenum	7439-98-7	0.001	mg/L	0.014	<0.001	----	0.005	<0.001
Rubidium	7440-17-7	0.001	mg/L	0.013	<0.001	----	0.023	0.032
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	----	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	1.28	<0.001	----	14.0	41.3
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	----	<0.05	0.62
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.29	<0.01	----	0.30	0.02

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB9B	IPCM GW Field Blank	IPCM Trip Blank	MB8B	MB7
			Client sampling date / time	21-Jan-2020 14:50	21-Jan-2020 17:50	20-Jan-2020 08:00	22-Jan-2020 18:20	23-Jan-2020 09:40
Compound	CAS Number	LOR	Unit	EB2001883-006	EB2001883-007	EB2001883-008	EB2001883-009	EB2001883-010
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	**0.002**	<0.001	----	**0.004**	<0.001
Barium	7440-39-3	0.001	mg/L	**0.041**	<0.001	----	**2.36**	**1.50**
Molybdenum	7439-98-7	0.001	mg/L	**0.016**	<0.001	----	**0.006**	**0.001**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	----	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	**1.19**	<0.001	----	**11.8**	**35.6**
Iron	7439-89-6	0.05	mg/L	**0.52**	<0.05	----	**0.35**	**0.59**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.2**	<0.1	----	**0.3**	**0.1**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.11**	<0.01	----	<0.05	<0.05
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**36.6**	**0.10**	----	**119**	**217**
ø Total Cations	----	0.01	meq/L	**33.4**	<0.01	----	**106**	**202**
ø Ionic Balance	----	0.01	%	**4.58**	----	----	**5.99**	**3.49**
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	----	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	----	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	----	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	----	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	----	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	----	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	----	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	----	<100	<100

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB9B	IPCM GW Field Blank	IPCM Trip Blank	MB8B	MB7
			Client sampling date / time	21-Jan-2020 14:50	21-Jan-2020 17:50	20-Jan-2020 08:00	22-Jan-2020 18:20	23-Jan-2020 09:40
Compound	CAS Number	LOR	Unit	EB2001883-006	EB2001883-007	EB2001883-008	EB2001883-009	EB2001883-010
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	----	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	110	102	124	130	129
Toluene-D8	2037-26-5	2	%	99.1	99.7	95.0	93.5	96.6
4-Bromofluorobenzene	460-00-4	2	%	105	104	105	100	102

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IPCM GW Duplicate	Trip Blank	----	----	----
			Client sampling date / time	23-Jan-2020 09:50	20-Jan-2020 08:00	----	----	----
Compound	CAS Number	LOR	Unit	EB2001883-011	EB2001883-012	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.21**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**20500**	----	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**15000**	----	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**303**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**303**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**317**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**7310**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**421**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**366**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**3260**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**18**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.651**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	----	----	----	----
Rubidium	7440-17-7	0.001	mg/L	**0.032**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	**40.9**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.57**	----	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.05**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IPCM GW Duplicate	Trip Blank	----	----	----
			Client sampling date / time	23-Jan-2020 09:50	20-Jan-2020 08:00	----	----	----
Compound	CAS Number	LOR	Unit	EB2001883-011	EB2001883-012	--------	--------	--------
				Result	Result	----	----	----
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.001**	----	----	----	----
Barium	7440-39-3	0.001	mg/L	**1.26**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.002**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	**36.8**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.56**	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.1**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.05	----	----	----	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**219**	----	----	----	----
ø Total Cations	----	0.01	meq/L	**193**	----	----	----	----
ø Ionic Balance	----	0.01	%	**6.18**	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	----	----	----
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	----	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IPCM GW Duplicate	Trip Blank	----	----	----
			Client sampling date / time	23-Jan-2020 09:50	20-Jan-2020 08:00	----	----	----
Compound	CAS Number	LOR	Unit	EB2001883-011	EB2001883-012	--------	--------	--------
				Result	Result	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	----	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	----	----	----
Toluene	108-88-3	2	µg/L	<2	<2	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	<2	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	----	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	<2	----	----	----
^ Total Xylenes	----	2	µg/L	<2	<2	----	----	----
^ Sum of BTEX	----	1	µg/L	<1	<1	----	----	----
Naphthalene	91-20-3	5	µg/L	<5	<5	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	129	125	----	----	----
Toluene-D8	2037-26-5	2	%	94.4	97.4	----	----	----
4-Bromofluorobenzene	460-00-4	2	%	99.7	101	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB2010752**	Page	: 1 of 12
Client	: **STANMORE IP COAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: BELINDA PARFITT	Contact	: Anna Riddell
Address	: GPO BOX 2602 BRISBANE QLD 4001	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 07 4816 7444	Telephone	: +61 7 4952 5795
Project	: IPCM	Date Samples Received	: 01-May-2020 08:00
Order number	: P1002091	Date Analysis Commenced	: 01-May-2020
C-O-C number	: ----	Issue Date	: 08-May-2020 18:36
Sampler	: LIAM HAMERSVELD		
Site	: ----		
Quote number	: TV/005/19 v3		
No. of samples received	: 13		
No. of samples analysed	: 13		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Morgan Lennox		Brisbane Organics, Stafford, QLD
Sarah Ashworth	Laboratory Manager - Brisbane	Brisbane Organics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EK067G (Total Phosphorus as P): Some samples were diluted due to matrix interference. LOR adjusted accordingly.
- TDS by method EA-015 may bias high due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.
- EG035T (Total Mercury): Positive mercury results have been confirmed by re-extraction and re-analysis.
- EG020-F (Dissolved Metals by ICP-MS): Limit of reporting raised for some samples due to matrix interference.
- It is recognised that EG020-T (Total Metals by ICP-MS) is less than EG020-F (Dissolved Metals by ICP-MS) for some samples. However, the difference is within experimental variation of the methods.
- EG020-T (Total Metals by ICP-MS): Limit of reporting raised for some samples due to matrix interference.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	BC2	MB1	MB2	MB4A
			Client sampling date / time	28-Apr-2020 15:00	28-Apr-2020 14:40	28-Apr-2020 16:20	28-Apr-2020 17:30	28-Apr-2020 13:30
Compound	CAS Number	LOR	Unit	EB2010752-001	EB2010752-002	EB2010752-003	EB2010752-004	EB2010752-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.70	8.18	8.30	8.30	7.85
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	9150	7520	3760	7370	49700
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	6460	4770	2080	4330	41000
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	7	<5	30	6	1690
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	4	10	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	67	645	489	743	384
Total Alkalinity as CaCO3	----	1	mg/L	67	645	493	753	384
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	121	105	37	148	926
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	3140	2310	965	1930	19800
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	515	193	106	103	646
Magnesium	7439-95-4	1	mg/L	122	287	119	153	1980
Sodium	7440-23-5	1	mg/L	1070	932	488	1240	9780
Potassium	7440-09-7	1	mg/L	21	5	4	7	3
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.05
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.005
Arsenic	7440-38-2	0.001	mg/L	<0.001	0.002	0.002	0.027	<0.005
Barium	7440-39-3	0.001	mg/L	0.257	0.242	0.211	0.133	0.212
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	0.002	<0.005
Rubidium	7440-17-7	0.001	mg/L	0.032	0.010	0.003	0.012	0.005
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.05
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.005
Strontium	7440-24-6	0.001	mg/L	7.56	5.01	2.24	3.39	24.0
Iron	7439-89-6	0.05	mg/L	0.54	<0.05	0.07	1.27	0.06
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.15	0.07	0.73	0.12	35.7

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	BC2	MB1	MB2	MB4A
			Client sampling date / time	28-Apr-2020 15:00	28-Apr-2020 14:40	28-Apr-2020 16:20	28-Apr-2020 17:30	28-Apr-2020 13:30
Compound	CAS Number	LOR	Unit	EB2010752-001	EB2010752-002	EB2010752-003	EB2010752-004	EB2010752-005
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.005
Arsenic	7440-38-2	0.001	mg/L	**0.002**	**0.002**	**0.004**	**0.026**	**0.031**
Barium	7440-39-3	0.001	mg/L	**0.263**	**0.237**	**0.230**	**0.133**	**0.394**
Molybdenum	7439-98-7	0.001	mg/L	**0.001**	<0.001	**0.001**	**0.003**	**0.020**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.05
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.005
Strontium	7440-24-6	0.001	mg/L	**7.96**	**5.29**	**2.41**	**3.48**	**25.7**
Iron	7439-89-6	0.05	mg/L	**1.14**	**0.22**	**1.54**	**1.44**	**60.6**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	**0.0002**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	**0.2**	**0.5**	**0.6**	**0.3**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.03**	<0.01	**0.06**	**0.02**	**0.86**
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**92.4**	**80.2**	**37.8**	**72.6**	**585**
ø Total Cations	----	0.01	meq/L	**82.8**	**73.9**	**36.4**	**71.8**	**621**
ø Ionic Balance	----	0.01	%	**5.49**	**4.10**	**1.92**	**0.50**	**2.92**
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	BC2	MB1	MB2	MB4A
			Client sampling date / time	28-Apr-2020 15:00	28-Apr-2020 14:40	28-Apr-2020 16:20	28-Apr-2020 17:30	28-Apr-2020 13:30
Compound	CAS Number	LOR	Unit	EB2010752-001	EB2010752-002	EB2010752-003	EB2010752-004	EB2010752-005
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	82.8	94.3	99.4	100	106
Toluene-D8	2037-26-5	2	%	96.5	94.0	96.8	96.1	92.3
4-Bromofluorobenzene	460-00-4	2	%	93.0	98.7	102	100	99.9

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB4B	MB7	MB8B	MB9A	MB9B
			Client sampling date / time	29-Apr-2020 09:50	29-Apr-2020 09:10	29-Apr-2020 12:40	28-Apr-2020 13:00	28-Apr-2020 11:45
Compound	CAS Number	LOR	Unit	EB2010752-006	EB2010752-007	EB2010752-008	EB2010752-009	EB2010752-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.31	7.93	7.96	7.99	8.53
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	31000	20100	11500	10900	3480
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	20500	15200	7960	7740	1950
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	10500	13	72	76	<5
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	18	<1	<1	<1	43
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1090	263	98	100	384
Total Alkalinity as CaCO3	----	1	mg/L	1110	263	98	100	427
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	378	233	3	2	106
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	10800	7150	4170	3880	862
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	81	415	306	266	62
Magnesium	7439-95-4	1	mg/L	472	333	133	141	110
Sodium	7440-23-5	1	mg/L	6830	3300	1860	1710	509
Potassium	7440-09-7	1	mg/L	3	18	14	19	7
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.05	<0.01	<0.01	<0.01	<0.01
Antimony	7440-36-0	0.001	mg/L	<0.005	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	<0.005	0.001	0.004	<0.001	0.001
Barium	7440-39-3	0.001	mg/L	0.174	0.645	4.05	7.67	0.088
Molybdenum	7439-98-7	0.001	mg/L	0.005	0.003	0.002	0.002	0.015
Rubidium	7440-17-7	0.001	mg/L	<0.005	0.031	0.020	0.028	0.011
Selenium	7782-49-2	0.01	mg/L	<0.05	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.005	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	7.90	36.9	12.9	10.9	0.944
Iron	7439-89-6	0.05	mg/L	0.07	0.80	0.15	0.34	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	30.6	0.04	1.17	1.64	0.12

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB4B	MB7	MB8B	MB9A	MB9B
			Client sampling date / time	29-Apr-2020 09:50	29-Apr-2020 09:10	29-Apr-2020 12:40	28-Apr-2020 13:00	28-Apr-2020 11:45
Compound	CAS Number	LOR	Unit	EB2010752-006	EB2010752-007	EB2010752-008	EB2010752-009	EB2010752-010
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.005	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.017	0.001	0.004	0.002	0.001
Barium	7440-39-3	0.001	mg/L	0.409	1.45	4.12	7.75	0.094
Molybdenum	7439-98-7	0.001	mg/L	0.011	0.006	0.002	0.003	0.020
Selenium	7782-49-2	0.01	mg/L	<0.05	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.005	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	8.19	40.8	14.2	12.3	1.12
Iron	7439-89-6	0.05	mg/L	63.6	0.91	1.37	2.63	0.29
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	0.8	<0.1	0.2	0.2	0.3
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	0.94	<0.05	<0.05	0.12	0.12
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	335	212	120	111	35.0
ø Total Cations	----	0.01	meq/L	340	192	107	99.7	34.5
ø Ionic Balance	----	0.01	%	0.79	4.87	5.36	5.56	0.84
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB4B	MB7	MB8B	MB9A	MB9B
			Client sampling date / time	29-Apr-2020 09:50	29-Apr-2020 09:10	29-Apr-2020 12:40	28-Apr-2020 13:00	28-Apr-2020 11:45
Compound	CAS Number	LOR	Unit	EB2010752-006	EB2010752-007	EB2010752-008	EB2010752-009	EB2010752-010
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	103	101	99.9	104	102
Toluene-D8	2037-26-5	2	%	93.0	96.0	97.2	98.1	95.6
4-Bromofluorobenzene	460-00-4	2	%	99.7	102	102	105	101

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IPCM GW Duplicate	IPCM GW Field Blank	IPCM Trip Blank	----	----
			Client sampling date / time	29-Apr-2020 14:30	29-Apr-2020 09:15	24-Apr-2020 15:00	----	----
Compound	CAS Number	LOR	Unit	EB2010752-012	EB2010752-013	EB2010752-014	--------	--------
				Result	Result	Result	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.97**	**6.38**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**19900**	**1**	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**14300**	<10	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**270**	**5**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**270**	**5**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**231**	<1	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**7100**	<1	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**420**	<1	----	----	----
Magnesium	7439-95-4	1	mg/L	**331**	<1	----	----	----
Sodium	7440-23-5	1	mg/L	**3340**	<1	----	----	----
Potassium	7440-09-7	1	mg/L	**17**	<1	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.001**	<0.001	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.687**	<0.001	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.004**	<0.001	----	----	----
Rubidium	7440-17-7	0.001	mg/L	**0.031**	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	----	----	----
Strontium	7440-24-6	0.001	mg/L	**37.8**	<0.001	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.82**	<0.05	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.03**	<0.01	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IPCM GW Duplicate	IPCM GW Field Blank	IPCM Trip Blank	----	----
			Client sampling date / time	29-Apr-2020 14:30	29-Apr-2020 09:15	24-Apr-2020 15:00	----	----
Compound	CAS Number	LOR	Unit	EB2010752-012	EB2010752-013	EB2010752-014	--------	--------
				Result	Result	Result	----	----
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	----	----	----
Barium	7440-39-3	0.001	mg/L	**1.31**	<0.001	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.005**	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	----	----	----
Strontium	7440-24-6	0.001	mg/L	**43.5**	<0.001	----	----	----
Iron	7439-89-6	0.05	mg/L	**1.01**	<0.05	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.05	<0.01	----	----	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**210**	**0.10**	----	----	----
ø Total Cations	----	0.01	meq/L	**194**	<0.01	----	----	----
ø Ionic Balance	----	0.01	%	**4.10**	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	----	----
C10 - C14 Fraction	----	50	µg/L	<50	<50	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	<100	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	<50	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	<100	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	<100	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	<100	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IPCM GW Duplicate	IPCM GW Field Blank	IPCM Trip Blank	----	----
			Client sampling date / time	29-Apr-2020 14:30	29-Apr-2020 09:15	24-Apr-2020 15:00	----	----
Compound	CAS Number	LOR	Unit	EB2010752-012	EB2010752-013	EB2010752-014	--------	--------
				Result	Result	Result	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	----	----
Toluene	108-88-3	2	µg/L	<2	<2	<2	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	----	----
^ Total Xylenes	----	2	µg/L	<2	<2	<2	----	----
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	----	----
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	102	101	100	----	----
Toluene-D8	2037-26-5	2	%	96.7	98.6	97.5	----	----
4-Bromofluorobenzene	460-00-4	2	%	103	102	102	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB2019500**	Page	: 1 of 12
Client	: **STANMORE IP COAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: BELINDA PARFITT	Contact	: Anna Riddell
Address	: GPO BOX 2602 BRISBANE QLD 4001	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 07 4816 7444	Telephone	: +61 7 4952 5795
Project	: IPCM	Date Samples Received	: 24-Jul-2020 08:40
Order number	: P1002091	Date Analysis Commenced	: 24-Jul-2020
C-O-C number	: ----	Issue Date	: 31-Jul-2020 12:20
Sampler	: LIAM HAMERSVELD		
Site	: ----		
Quote number	: TV/005/19 v3		
No. of samples received	: 11		
No. of samples analysed	: 11		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Minh Wills	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Morgan Lennox		Brisbane Organics, Stafford, QLD
Santusha Pandra	Senior Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EK067G (Total Phosphorus as P): Some samples were diluted due to matrix interference. LOR adjusted accordingly.
- EP080: Total Xylenes is the sum of the reported concentrations of m&p-Xylene and o-Xylene at or above the LOR.
- Samples containing fine particulate matter less than 1.2 µm may bias low for TSS via EA025H.
- EG020-T (Total Metals by ICP-MS): Limit of reporting raised for sample MB4A (EB2019500-005) due to matrix interference.
- It is recognised that EG020T (Total Metals) is less than EG020F (Dissolved Metals) for sample MB4A (EB2019500-005). However, the difference is within experimental variation of the methods.
- EG020-F (Dissolved Metals by ICP-MS): Limit of reporting raised for sample MB4A (EB2019500-005) due to matrix interference.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	BC2	MB1	MB2	MB4A
			Client sampling date / time	22-Jul-2020 12:40	22-Jul-2020 13:50	22-Jul-2020 16:50	22-Jul-2020 14:50	22-Jul-2020 11:11
Compound	CAS Number	LOR	Unit	EB2019500-001	EB2019500-002	EB2019500-003	EB2019500-004	EB2019500-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.50	7.45	7.58	7.50	7.15
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	9010	7660	3380	7320	52700
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	5890	4750	1860	4100	39200
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	<5	16	793
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	52	648	518	766	392
Total Alkalinity as CaCO3	----	1	mg/L	52	648	518	766	392
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	130	110	36	146	960
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	3030	2290	817	1910	19900
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	600	245	94	134	629
Magnesium	7439-95-4	1	mg/L	126	299	102	159	1940
Sodium	7440-23-5	1	mg/L	1170	1010	514	1340	9610
Potassium	7440-09-7	1	mg/L	23	6	4	8	3
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.05
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.005
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.007	0.032	<0.005
Barium	7440-39-3	0.001	mg/L	0.274	0.149	0.147	0.134	0.192
Molybdenum	7439-98-7	0.001	mg/L	0.001	<0.001	0.005	0.003	0.008
Rubidium	7440-17-7	0.001	mg/L	0.032	0.011	0.004	0.012	0.008
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.05
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.005
Strontium	7440-24-6	0.001	mg/L	8.46	5.85	2.12	4.00	25.8
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.55	1.52	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.03	0.03	0.04	0.22	4.47

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	BC2	MB1	MB2	MB4A
			Client sampling date / time	22-Jul-2020 12:40	22-Jul-2020 13:50	22-Jul-2020 16:50	22-Jul-2020 14:50	22-Jul-2020 11:11
Compound	CAS Number	LOR	Unit	EB2019500-001	EB2019500-002	EB2019500-003	EB2019500-004	EB2019500-005
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.005
Arsenic	7440-38-2	0.001	mg/L	**0.001**	<0.001	**0.007**	**0.034**	**0.005**
Barium	7440-39-3	0.001	mg/L	**0.298**	**0.168**	**0.153**	**0.148**	**0.211**
Molybdenum	7439-98-7	0.001	mg/L	**0.002**	<0.001	**0.007**	**0.003**	<0.005
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.05
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.005
Strontium	7440-24-6	0.001	mg/L	**8.88**	**6.07**	**2.20**	**4.16**	**27.8**
Iron	7439-89-6	0.05	mg/L	**0.12**	**0.17**	**0.68**	**1.73**	**8.48**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	**0.2**	**0.5**	**0.5**	**0.3**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.09**	**0.02**	**0.04**	**0.04**	**0.13**
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**89.2**	**79.8**	**34.1**	**72.2**	**589**
ø Total Cations	----	0.01	meq/L	**91.8**	**80.9**	**35.5**	**78.3**	**609**
ø Ionic Balance	----	0.01	%	**1.42**	**0.67**	**2.01**	**4.01**	**1.67**
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	BC2	MB1	MB2	MB4A
			Client sampling date / time	22-Jul-2020 12:40	22-Jul-2020 13:50	22-Jul-2020 16:50	22-Jul-2020 14:50	22-Jul-2020 11:11
Compound	CAS Number	LOR	Unit	EB2019500-001	EB2019500-002	EB2019500-003	EB2019500-004	EB2019500-005
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	103	98.8	99.9	99.1	106
Toluene-D8	2037-26-5	2	%	97.3	97.2	98.1	101	97.6
4-Bromofluorobenzene	460-00-4	2	%	101	99.2	101	103	102

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB7	MB8B	MB9A	MB9B	IPCM GW Duplicate
			Client sampling date / time	22-Jul-2020 10:10	22-Jul-2020 07:50	22-Jul-2020 10:40	22-Jul-2020 09:40	22-Jul-2020 10:15
Compound	CAS Number	LOR	Unit	EB2019500-006	EB2019500-007	EB2019500-008	EB2019500-009	EB2019500-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.39	7.50	7.70	8.12	7.43
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	24000	11500	10900	4300	23900
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	16100	7160	6820	2520	16000
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	28	63	<5	<5
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	451	97	104	339	456
Total Alkalinity as CaCO3	----	1	mg/L	451	97	104	339	456
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	547	2	3	124	547
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	8260	4010	3760	1140	8230
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	773	402	345	80	758
Magnesium	7439-95-4	1	mg/L	540	129	136	127	527
Sodium	7440-23-5	1	mg/L	4260	1960	1820	665	4070
Potassium	7440-09-7	1	mg/L	22	16	20	9	22
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.002	0.008	<0.001	0.001	0.002
Barium	7440-39-3	0.001	mg/L	0.433	6.71	8.64	0.137	0.429
Molybdenum	7439-98-7	0.001	mg/L	0.001	0.001	0.001	0.012	0.001
Rubidium	7440-17-7	0.001	mg/L	0.040	0.023	0.032	0.016	0.039
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	50.2	15.8	13.0	1.43	49.1
Iron	7439-89-6	0.05	mg/L	0.57	<0.05	0.09	<0.05	0.54
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.04	0.48	1.25	0.13	0.04

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB7	MB8B	MB9A	MB9B	IPCM GW Duplicate
			Client sampling date / time	22-Jul-2020 10:10	22-Jul-2020 07:50	22-Jul-2020 10:40	22-Jul-2020 09:40	22-Jul-2020 10:15
Compound	CAS Number	LOR	Unit	EB2019500-006	EB2019500-007	EB2019500-008	EB2019500-009	EB2019500-010
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	**0.002**	**0.010**	**0.002**	**0.001**	**0.002**
Barium	7440-39-3	0.001	mg/L	**1.15**	**7.56**	**9.63**	**0.156**	**0.945**
Molybdenum	7439-98-7	0.001	mg/L	**0.002**	**0.001**	**0.001**	**0.015**	**0.002**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	**52.4**	**16.8**	**14.1**	**1.49**	**52.2**
Iron	7439-89-6	0.05	mg/L	**0.70**	**0.59**	**1.91**	**0.18**	**0.69**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.1**	**0.2**	**0.2**	**0.2**	**0.1**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.05	<0.05	**0.04**	**0.07**	<0.05
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**253**	**115**	**108**	**41.5**	**253**
ø Total Cations	----	0.01	meq/L	**269**	**116**	**108**	**43.6**	**259**
ø Ionic Balance	----	0.01	%	**2.96**	**0.54**	**0.06**	**2.45**	**1.20**
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB7	MB8B	MB9A	MB9B	IPCM GW Duplicate
			Client sampling date / time	22-Jul-2020 10:10	22-Jul-2020 07:50	22-Jul-2020 10:40	22-Jul-2020 09:40	22-Jul-2020 10:15
Compound	CAS Number	LOR	Unit	EB2019500-006	EB2019500-007	EB2019500-008	EB2019500-009	EB2019500-010
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**97.8**	**98.4**	**97.6**	**97.1**	**98.3**
Toluene-D8	2037-26-5	2	%	**97.0**	**99.7**	**98.4**	**98.5**	**99.4**
4-Bromofluorobenzene	460-00-4	2	%	**100**	**102**	**101**	**101**	**103**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IPCM GW Field Blank	----	----	----	----
			Client sampling date / time	22-Jul-2020 09:30	----	----	----	----
Compound	CAS Number	LOR	Unit	EB2019500-011	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**5.72**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	<1	----	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	<10	----	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**4**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**4**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	<1	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	----	----	----	----
Rubidium	7440-17-7	0.001	mg/L	<0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	<0.001	----	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	----	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IPCM GW Field Blank	----	----	----	----
			Client sampling date / time	22-Jul-2020 09:30	----	----	----	----
Compound	CAS Number	LOR	Unit	EB2019500-011	--------	--------	--------	--------
				Result	----	----	----	----
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	<0.001	----	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.01	----	----	----	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**0.08**	----	----	----	----
ø Total Cations	----	0.01	meq/L	<0.01	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	----	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IPCM GW Field Blank	----	----	----	----
			Client sampling date / time	22-Jul-2020 09:30	----	----	----	----
Compound	CAS Number	LOR	Unit	EB2019500-011	--------	--------	--------	--------
				Result	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	----	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	----	----	----	----
Toluene	108-88-3	2	µg/L	<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
^ Total Xylenes	----	2	µg/L	<2	----	----	----	----
^ Sum of BTEX	----	1	µg/L	<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L	<5	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	102	----	----	----	----
Toluene-D8	2037-26-5	2	%	98.4	----	----	----	----
4-Bromofluorobenzene	460-00-4	2	%	101	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB2020138**	Page	: 1 of 6
Client	: **STANMORE IP COAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: BELINDA PARFITT	Contact	: Anna Riddell
Address	: GPO BOX 2602 BRISBANE QLD 4001	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 07 4816 7444	Telephone	: +61 7 4952 5795
Project	: IPCM	Date Samples Received	: 31-Jul-2020 08:20
Order number	: P1002091	Date Analysis Commenced	: 03-Aug-2020
C-O-C number	: ----	Issue Date	: 07-Aug-2020 10:39
Sampler	: SCOTT AULSEBROOK		
Site	: ----		
Quote number	: TV/005/19 v3		
No. of samples received	: 3		
No. of samples analysed	: 3		

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Accreditation No. 825
Accredited for compliance with ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dave Gitsham	Metals Instrument Chemist	Brisbane Inorganics, Stafford, QLD
Diana Mesa	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Matt Frost	Assistant Laboratory Manager	Brisbane Organics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG020T (Total Metals by ICP-MS): Limit of reporting raised for sample MB4B (EB2020138-001) due to matrix interference.
- EK067G (Total Phosphorus as P): Sample EB2020138_002 (MB12) was diluted due to matrix interference. LOR adjusted accordingly.
- EP080: Where reported, Total Xylenes is the sum of the reported concentrations of m&p-Xylene and o-Xylene at or above the LOR.
- EP071TRH : Sample "EB2020708_01" shows poor duplicate results confirmed by re-extraction and re-analysis.
- EG035T (Total Mercury): Positive mercury results have been confirmed by re-extraction and re-analysis.
- It is recognised that EG020-T (Total Metals by ICP-MS) is less than EG020-F (Dissolved Metals by ICP-MS) for sample MB4B (EB2020138-001). However, the difference is within experimental variation of the methods.
- EG020-F (Dissolved Metals by ICP-MS): Limit of reporting raised for sample MB4B (EB2020138-001) due to matrix interference.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB4B	MB12	MB14	----	----
			Client sampling date / time	30-Jul-2020 11:30	30-Jul-2020 09:45	30-Jul-2020 06:50	----	----
Compound	CAS Number	LOR	Unit	EB2020138-001	EB2020138-002	EB2020138-003	--------	--------
				Result	Result	Result	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.70	7.43	7.81	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	30700	12300	2980	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	19700	7900	1740	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	35400	20	64	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1140	260	452	----	----
Total Alkalinity as CaCO3	----	1	mg/L	1140	260	452	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	406	205	119	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	10800	4360	731	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	87	280	58	----	----
Magnesium	7439-95-4	1	mg/L	505	277	130	----	----
Sodium	7440-23-5	1	mg/L	7150	2170	428	----	----
Potassium	7440-09-7	1	mg/L	3	23	12	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.05	<0.01	<0.01	----	----
Antimony	7440-36-0	0.001	mg/L	<0.005	<0.001	<0.001	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.005	0.002	0.003	----	----
Barium	7440-39-3	0.001	mg/L	0.193	0.481	0.052	----	----
Molybdenum	7439-98-7	0.001	mg/L	0.007	0.011	0.002	----	----
Rubidium	7440-17-7	0.001	mg/L	<0.005	0.042	0.017	----	----
Selenium	7782-49-2	0.01	mg/L	<0.05	<0.01	<0.01	----	----
Silver	7440-22-4	0.001	mg/L	<0.005	<0.001	<0.001	----	----
Strontium	7440-24-6	0.001	mg/L	8.64	16.3	1.29	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	0.32	0.08	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	170	0.08	2.73	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB4B	MB12	MB14	----	----
			Client sampling date / time	30-Jul-2020 11:30	30-Jul-2020 09:45	30-Jul-2020 06:50	----	----
Compound	CAS Number	LOR	Unit	EB2020138-001	EB2020138-002	EB2020138-003	--------	--------
				Result	Result	Result	----	----
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.005	<0.001	<0.001	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.047**	**0.003**	**0.003**	----	----
Barium	7440-39-3	0.001	mg/L	**2.55**	**1.32**	**0.062**	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.005	**0.014**	**0.002**	----	----
Selenium	7782-49-2	0.01	mg/L	<0.05	<0.01	<0.01	----	----
Silver	7440-22-4	0.001	mg/L	<0.005	<0.001	<0.001	----	----
Strontium	7440-24-6	0.001	mg/L	**12.4**	**16.4**	**1.30**	----	----
Iron	7439-89-6	0.05	mg/L	**270**	**0.77**	**4.45**	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	**0.0004**	<0.0001	<0.0001	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.6**	**0.2**	<0.1	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**11.0**	<0.05	**0.16**	----	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**336**	**132**	**32.1**	----	----
ø Total Cations	----	0.01	meq/L	**357**	**132**	**32.5**	----	----
ø Ionic Balance	----	0.01	%	**3.04**	**0.27**	**0.60**	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	----	----
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	----	----
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	----	----
C29 - C36 Fraction	----	50	µg/L	<50	<50	**100**	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	**100**	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	<100	**170**	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	**170**	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB4B	MB12	MB14	----	----
			Client sampling date / time	30-Jul-2020 11:30	30-Jul-2020 09:45	30-Jul-2020 06:50	----	----
Compound	CAS Number	LOR	Unit	EB2020138-001	EB2020138-002	EB2020138-003	--------	--------
				Result	Result	Result	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	----	----
Toluene	108-88-3	2	µg/L	<2	<2	<2	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	----	----
^ Total Xylenes	----	2	µg/L	<2	<2	<2	----	----
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	----	----
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**95.4**	**91.7**	**96.4**	----	----
Toluene-D8	2037-26-5	2	%	**114**	**96.4**	**104**	----	----
4-Bromofluorobenzene	460-00-4	2	%	**105**	**103**	**108**	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB2023609**	Page	: 1 of 12
Client	: **STANMORE IP COAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: BELINDA PARFITT	Contact	: Anna Riddell
Address	: GPO BOX 2602 BRISBANE QLD 4001	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 07 4816 7444	Telephone	: +61 7 4952 5795
Project	: IPCM	Date Samples Received	: 29-Oct-2020 12:00
Order number	: P1002091	Date Analysis Commenced	: 30-Oct-2020
C-O-C number	: ----	Issue Date	: 09-Nov-2020 09:13
Sampler	: LIAM HAMERSVELD		
Site	: ----		
Quote number	: TV/005/19 v4		
No. of samples received	: 16		
No. of samples analysed	: 14		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

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- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
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General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG020F (Dissolved Metals by ICP-MS): Limit of reporting raised due to matrix interference.
- EG020T (Total Metals by ICP-MS): Limit of reporting raised due to matrix interference.
- EK067G (Total Phosphorus as P): Some samples were diluted due to matrix interference. LOR adjusted accordingly.
- EP080: Where reported, Total Xylenes is the sum of the reported concentrations of m&p-Xylene and o-Xylene at or above the LOR.
- TDS by method EA-015 may bias high due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.
- It is recognised that EG020T (Total Metals) is less than EG020F (Dissolved Metals) for some samples. However, the difference is within experimental variation of the methods.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	BC2	MB1	MB2	MB4A
			Client sampling date / time	26-Oct-2020 12:00	26-Oct-2020 13:10	26-Oct-2020 15:40	26-Oct-2020 14:30	27-Oct-2020 12:50
Compound	CAS Number	LOR	Unit	EB2023609-001	EB2023609-002	EB2023609-003	EB2023609-004	EB2023609-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.30	7.20	7.38	7.39	6.85
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	8850	7620	3350	7250	52800
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	5610	5020	1970	4350	47900
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	12	11	15	3800
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	49	609	523	746	383
Total Alkalinity as CaCO3	----	1	mg/L	49	609	523	746	383
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	119	101	35	153	969
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	3100	2540	836	1900	19200
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	536	233	82	112	730
Magnesium	7439-95-4	1	mg/L	132	311	106	165	2130
Sodium	7440-23-5	1	mg/L	1110	990	484	1270	10700
Potassium	7440-09-7	1	mg/L	22	6	3	7	4
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	0.30
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.005
Arsenic	7440-38-2	0.001	mg/L	0.002	<0.001	0.008	0.028	<0.005
Barium	7440-39-3	0.001	mg/L	0.211	0.152	0.211	0.153	0.233
Molybdenum	7439-98-7	0.001	mg/L	0.002	<0.001	<0.001	0.003	<0.005
Rubidium	7440-17-7	0.001	mg/L	0.036	0.012	0.004	0.013	0.008
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.05
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.005
Strontium	7440-24-6	0.001	mg/L	8.69	6.17	2.10	3.63	25.4
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.07	0.21	0.06
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.04	0.01	0.03	0.07	8.84

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	BC2	MB1	MB2	MB4A
			Client sampling date / time	26-Oct-2020 12:00	26-Oct-2020 13:10	26-Oct-2020 15:40	26-Oct-2020 14:30	27-Oct-2020 12:50
Compound	CAS Number	LOR	Unit	EB2023609-001	EB2023609-002	EB2023609-003	EB2023609-004	EB2023609-005
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.005
Arsenic	7440-38-2	0.001	mg/L	0.002	<0.001	0.007	0.031	0.009
Barium	7440-39-3	0.001	mg/L	0.206	0.157	0.217	0.162	0.274
Molybdenum	7439-98-7	0.001	mg/L	0.001	<0.001	<0.001	0.002	<0.005
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.05
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.005
Strontium	7440-24-6	0.001	mg/L	8.59	6.14	2.04	3.70	24.7
Iron	7439-89-6	0.05	mg/L	0.11	0.08	0.11	0.49	14.6
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	0.2	0.5	0.5	0.3
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	0.07	0.02	<0.01	0.02	0.14
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	90.9	85.9	34.8	71.7	569
ø Total Cations	----	0.01	meq/L	86.4	80.4	33.9	74.6	677
ø Ionic Balance	----	0.01	%	2.51	3.30	1.19	1.98	8.65
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	380
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	380
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	310
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	310

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	BC2	MB1	MB2	MB4A
			Client sampling date / time	26-Oct-2020 12:00	26-Oct-2020 13:10	26-Oct-2020 15:40	26-Oct-2020 14:30	27-Oct-2020 12:50
Compound	CAS Number	LOR	Unit	EB2023609-001	EB2023609-002	EB2023609-003	EB2023609-004	EB2023609-005
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	**310**
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**116**	**118**	**125**	**118**	**124**
Toluene-D8	2037-26-5	2	%	**94.0**	**92.8**	**99.4**	**97.0**	**95.4**
4-Bromofluorobenzene	460-00-4	2	%	**108**	**106**	**114**	**107**	**110**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB7	MB8B	MB9A	MB9B	MB12
			Client sampling date / time	27-Oct-2020 11:30	26-Oct-2020 17:50	27-Oct-2020 15:50	27-Oct-2020 14:50	27-Oct-2020 08:40
Compound	CAS Number	LOR	Unit	EB2023609-007	EB2023609-008	EB2023609-009	EB2023609-010	EB2023609-012
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.22	7.45	7.43	7.96	7.20
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	24500	11000	10700	3460	13300
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	18300	8290	8120	2030	10100
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	34	214	12	16
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	466	111	103	418	352
Total Alkalinity as CaCO3	----	1	mg/L	466	111	103	418	352
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	605	6	3	113	321
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	8630	3910	3830	891	4580
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	630	318	296	58	323
Magnesium	7439-95-4	1	mg/L	638	140	152	108	314
Sodium	7440-23-5	1	mg/L	4430	1880	1860	557	2240
Potassium	7440-09-7	1	mg/L	23	16	21	8	24
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.004	0.011	0.001	0.006	0.029
Barium	7440-39-3	0.001	mg/L	0.315	7.63	8.55	0.132	0.764
Molybdenum	7439-98-7	0.001	mg/L	0.004	0.001	0.001	0.015	0.005
Rubidium	7440-17-7	0.001	mg/L	0.045	0.023	0.034	0.014	0.039
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	54.7	13.6	11.5	1.26	15.7
Iron	7439-89-6	0.05	mg/L	1.02	0.10	0.56	<0.05	2.52
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.03	0.28	1.38	0.64	0.03

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB7	MB8B	MB9A	MB9B	MB12
			Client sampling date / time	27-Oct-2020 11:30	26-Oct-2020 17:50	27-Oct-2020 15:50	27-Oct-2020 14:50	27-Oct-2020 08:40
Compound	CAS Number	LOR	Unit	EB2023609-007	EB2023609-008	EB2023609-009	EB2023609-010	EB2023609-012
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	**0.004**	**0.008**	**0.002**	**0.005**	**0.029**
Barium	7440-39-3	0.001	mg/L	**0.793**	**7.63**	**9.21**	**1.31**	**0.870**
Molybdenum	7439-98-7	0.001	mg/L	**0.004**	<0.001	**0.001**	**0.011**	**0.003**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	**56.0**	**13.5**	**12.2**	**1.07**	**15.5**
Iron	7439-89-6	0.05	mg/L	**1.11**	**0.44**	**2.88**	**1.31**	**2.50**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.1**	**0.2**	**0.2**	**0.3**	**0.1**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.05	**0.02**	**0.14**	**0.05**	<0.05
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**265**	**113**	**110**	**35.8**	**143**
ø Total Cations	----	0.01	meq/L	**277**	**110**	**109**	**36.2**	**140**
ø Ionic Balance	----	0.01	%	**2.19**	**1.38**	**0.66**	**0.52**	**1.03**
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB7	MB8B	MB9A	MB9B	MB12
			Client sampling date / time	27-Oct-2020 11:30	26-Oct-2020 17:50	27-Oct-2020 15:50	27-Oct-2020 14:50	27-Oct-2020 08:40
Compound	CAS Number	LOR	Unit	EB2023609-007	EB2023609-008	EB2023609-009	EB2023609-010	EB2023609-012
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**116**	**120**	**120**	**120**	**117**
Toluene-D8	2037-26-5	2	%	**91.8**	**93.4**	**96.2**	**93.2**	**93.8**
4-Bromofluorobenzene	460-00-4	2	%	**105**	**110**	**108**	**104**	**106**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB14	IPCM GW Duplicate	IPCM GW Field Blank	IPCM Trip Blank	----
			Client sampling date / time	26-Oct-2020 16:45	27-Oct-2020 00:00	28-Oct-2020 07:00	22-Oct-2020 15:00	----
Compound	CAS Number	LOR	Unit	EB2023609-013	EB2023609-014	EB2023609-015	EB2023609-016	--------
				Result	Result	Result	Result	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.81	7.28	6.87	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	3060	24500	<1	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	1860	18600	<10	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	5	<5	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	456	472	3	----	----
Total Alkalinity as CaCO3	----	1	mg/L	456	472	3	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	114	608	<1	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	744	8630	<1	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	60	634	<1	----	----
Magnesium	7439-95-4	1	mg/L	135	649	<1	----	----
Sodium	7440-23-5	1	mg/L	425	4370	<1	----	----
Potassium	7440-09-7	1	mg/L	12	23	<1	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Arsenic	7440-38-2	0.001	mg/L	0.004	0.004	<0.001	----	----
Barium	7440-39-3	0.001	mg/L	0.063	0.322	<0.001	----	----
Molybdenum	7439-98-7	0.001	mg/L	0.001	0.004	<0.001	----	----
Rubidium	7440-17-7	0.001	mg/L	0.018	0.044	<0.001	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Strontium	7440-24-6	0.001	mg/L	1.04	55.7	0.004	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	1.04	<0.05	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.02	0.02	<0.01	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB14	IPCM GW Duplicate	IPCM GW Field Blank	IPCM Trip Blank	----
			Client sampling date / time	26-Oct-2020 16:45	27-Oct-2020 00:00	28-Oct-2020 07:00	22-Oct-2020 15:00	----
Compound	CAS Number	LOR	Unit	EB2023609-013	EB2023609-014	EB2023609-015	EB2023609-016	--------
				Result	Result	Result	Result	----
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.002**	**0.003**	<0.001	----	----
Barium	7440-39-3	0.001	mg/L	**0.069**	**0.620**	<0.001	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	**0.003**	<0.001	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Strontium	7440-24-6	0.001	mg/L	**1.10**	**49.0**	<0.001	----	----
Iron	7439-89-6	0.05	mg/L	**0.07**	**1.08**	<0.05	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	<0.1	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.05**	<0.05	**0.01**	----	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**32.5**	**266**	**0.06**	----	----
ø Total Cations	----	0.01	meq/L	**32.9**	**276**	<0.01	----	----
ø Ionic Balance	----	0.01	%	**0.65**	**1.88**	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	----
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	----	----
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	----	----
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	----
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB14	IPCM GW Duplicate	IPCM GW Field Blank	IPCM Trip Blank	----
			Client sampling date / time	26-Oct-2020 16:45	27-Oct-2020 00:00	28-Oct-2020 07:00	22-Oct-2020 15:00	----
Compound	CAS Number	LOR	Unit	EB2023609-013	EB2023609-014	EB2023609-015	EB2023609-016	--------
				Result	Result	Result	Result	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	----
Toluene	108-88-3	2	µg/L	<2	<2	**4**	<2	----
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	----
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	----
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	----
^ Sum of BTEX	----	1	µg/L	<1	<1	**4**	<1	----
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**121**	**121**	**122**	**122**	----
Toluene-D8	2037-26-5	2	%	**94.5**	**93.5**	**94.2**	**94.6**	----
4-Bromofluorobenzene	460-00-4	2	%	**108**	**108**	**110**	**104**	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

Appendix 2 – IPC Exceedance Investigation

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ISAAC PLAINS COMPLEX

Groundwater Exceedance Investigation

REPORT PREPARED FOR:

stanmore IP Coal

Date: August 2020

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Director

5/8/2020

Date

Dr Cecily Rasmussen
Director

5/8/2020

Date

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7. The report reflects both the information provided to C&R Consulting in documents made available for review and the results of observations and consultations by C&R Consulting staff.

SUMMARY OF RELEVANT INFORMATION

Project Title	Groundwater Exceedance Investigation
Property Location	Isaac Plains Complex
Property Description	Open-cut coal mine
Project Purpose	Undertake an investigation into the potential for environmental harm in accordance with EA Condition C46
Project Number	20060
Client's Details	
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Title/Position	Senior Advisor – Health, Safety, Environment and Community
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Appendix 1: April 2020 COA 24

1. INTRODUCTION

Stanmore IP Coal Pty Ltd (Stanmore) operates the Isaac Plains Complex (IPC) under environmental authority (EA) EPML00932713, dated 24 January 2018. The IPC includes both the Isaac Plains Mine (IPM) and Isaac Plains East (IPE) open-cut coal projects.

In accordance with EA Condition **C45**, IPC monitor groundwater levels and water quality on a quarterly basis from a network of eleven groundwater monitoring bores within close proximity to the mining leases. Two of the monitoring bores, Burton Coal Bore 2 and Swamp Bore 1, are assessed against groundwater contaminant triggers (GCTs) defined in EA Table 12.

During April 2020, quarterly water quality monitoring results from Burton Coal Bore 2 and Swamp Bore 1 exceeded multiple GCTs. In accordance with EA Condition **C46**, Stanmore have enlisted C&R Consulting Pty Ltd (C&R) to investigate the potential for environmental harm resulting from the exceedances.

It should be noted that since the April 2020 monitoring round was completed, IPC completed an EA amendment that included changing some groundwater contaminant limits.

1.1 SCOPE

This investigation will examine the potential for environmental harm from the April 2020 groundwater exceedances through:

- Statistical analysis of the standing water levels and water quality of Burton Coal Bore 2 and Swamp Bore 1;
- Examination of the climatic conditions influencing groundwater levels and quality; and
- Assessment of mining activities on groundwater levels and quality.

If/as required, this investigation will also make recommendations for appropriate actions to prevent further exceedances.

2. BACKGROUND

2.1 MINE DETAILS AND LOCATION

IPC is located within the Isaac Regional Council on both freehold land and state leasehold land in Central Queensland, approximately 10 km to the northeast of Moranbah and 140 km southwest of Mackay (Figure 1). The project is situated immediately north of the Peak Downs Highway between Moranbah and Coppabella, and has a rail loop off the south of the Goonyella branch rail line (Figure 1).

Historically, IPC operations have been conducted on ML70342, separated into five primary pits: N1, N2, S1, S2 and the S3 pits. The N pits are north of Smokey Creek, which bisects the mining lease area. The three S pits are south of this watercourse, with the S3 pit currently acting as the main water storage for the site. IPE operations were granted approval in 2018, involving the expansion of IPC operations into ML700016, ML700017, ML700018 and ML700019.

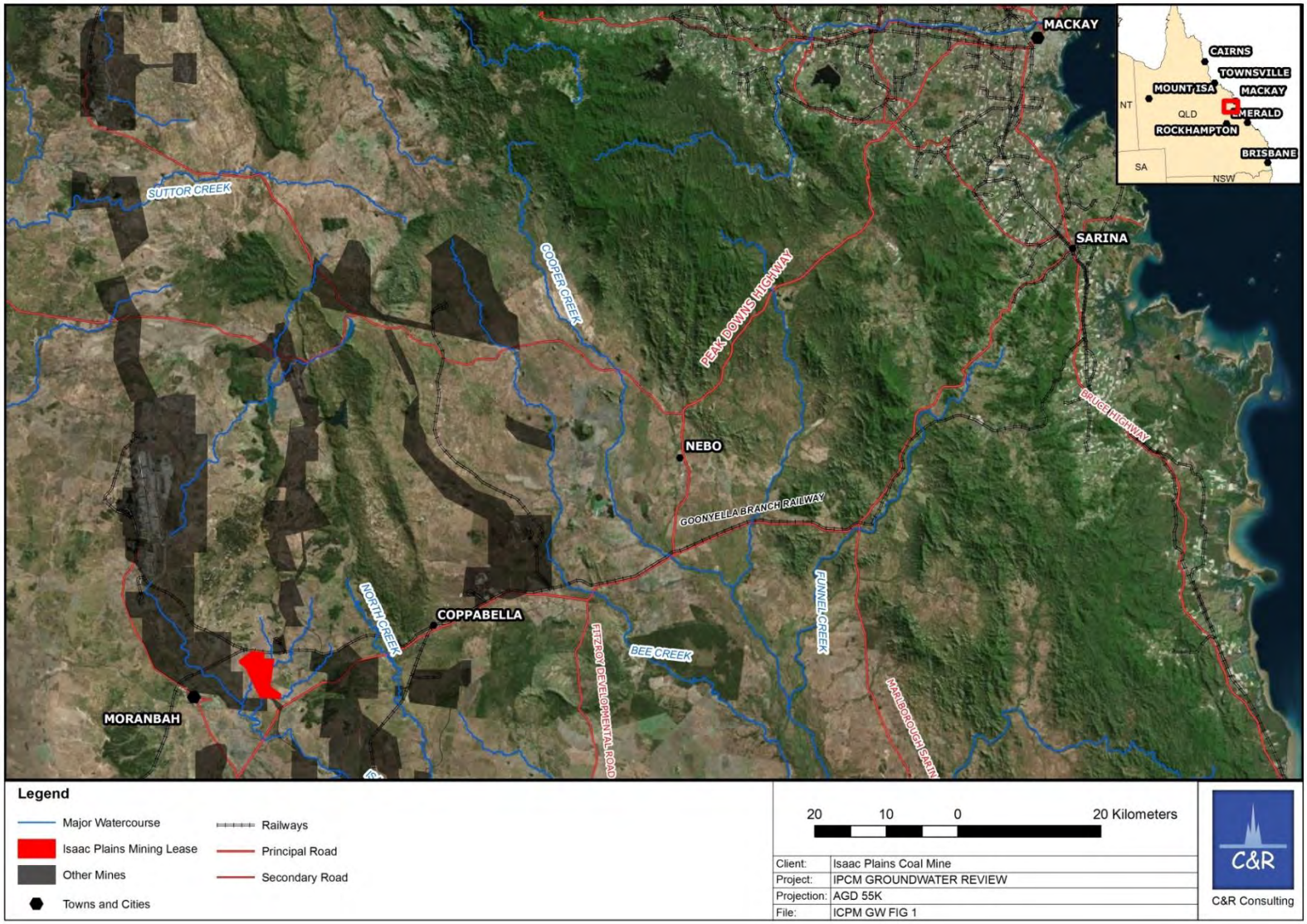

Figure 1: IPC location within Central Queensland.

2.2 RAINFALL

Rainfall in Central Queensland's seasonally arid tropics is notoriously inconsistent in its intensity, duration and location. The climate of the area is dominated by intense rainfall events throughout the summer months (wet season). These rainfall events are often highly variable in their spatial and temporal distribution, with most rain falling in distinct, spatially separated cells across the landscape.

Minimal rain falls throughout the dry season, with an occasional shower in June or July. Evaporation tends to exceed rainfall for almost all days of the year except during intense rainfall events. The extended dry season causes baking and crusting of surface soils. These processes cause greatly reduced infiltration of surface soils unless suitable pre-wetting is provided by gentle rain prior to the wet season. During the onset of the wet season, in the absence of gentle pre-wetting rains, more than 90% of rainfall can eventuate as runoff throughout catchments, reporting to waterways and altering stage-discharge relationships beyond modelled capacities. Even in the event of pre-wetting, the rainfall intensity is often high enough to exceed the infiltration capacity of the soils, generating significant runoff. This increased runoff has the potential to increase the volume of sediments delivered to waterways and result in sediment movement throughout waterways.

Rainfall data from the Bureau of Meteorology stations at the Moranbah water treatment plant (April 1972 to January 2012) and the Moranbah airport (February 2012 to present) are displayed in Figure 2. Application of a 5-year running average shows a cyclicity of wet and dry periods over the last 47 years. The cycle appears to peak every 10-15 years. The chart shows that, over the most recent 7 years (since 2012), the dry period can be characterised as both lasting longer than usual and the driest on record.

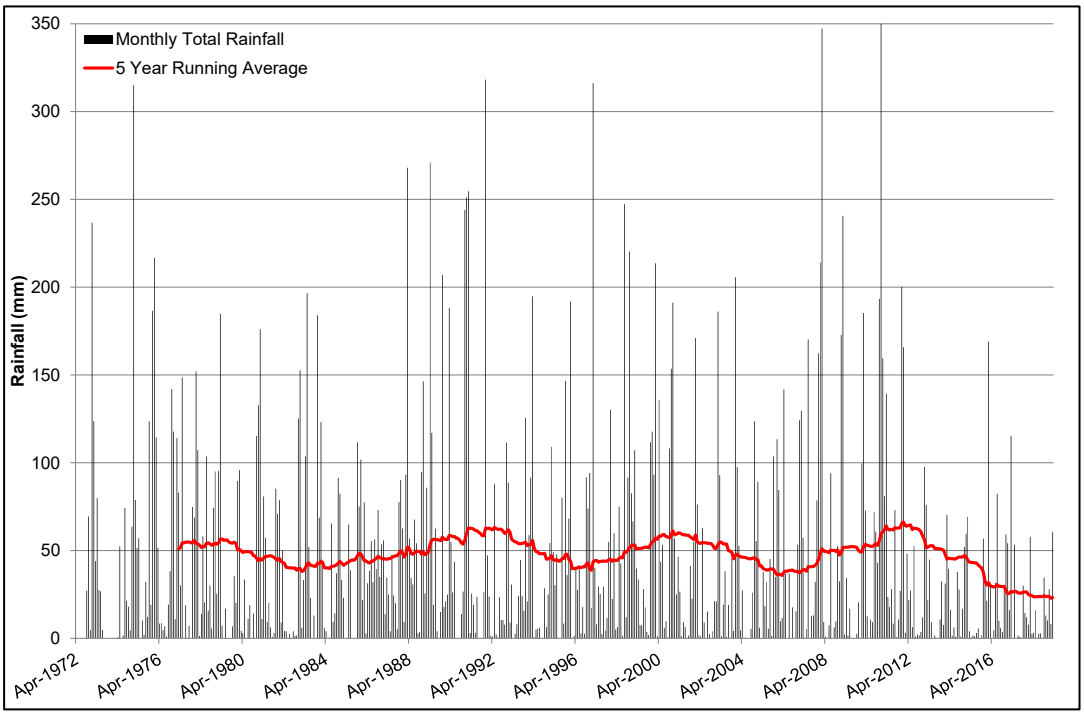

Figure 2: Monthly rainfall totals and 5-year running average.

2.3 REGIONAL HYDROGEOLOGY

There are three principal hydrostratigraphic units within the Isaac Plains tenement areas:

- Recent sediments (alluvium and colluvium);
- Cenozoic (formerly Tertiary) basalt; and
- Late Permian Rangal and Fort Cooper coal measures: sandstone, siltstone and coal (see Table 1).

The alluvium and colluvium are associated with channel deposits of Smokey Creek and the Isaac River (Table 1). Cenozoic basalt crops out to the northeast of tenement ML70342 and particular basalt flows constitute aquifers in several surrounding areas. Confinement of the Late Permian strata is variable locally, depending on pressure distribution and depth. Stratigraphic descriptions for each unit are provided in Table 1.

Surface distribution of each unit is complicated by several regional structures, including at least one syncline, and thrust faults truncating the eastward-dipping target beds. The aquifers of the Isaac Plains area are described in the subsequent sections, with reference made to aquifer characteristics, groundwater flow and groundwater quality for each unit.

Table 1: Stratigraphic units of the Isaac Plains region.

Map Sym#	Age	Group	Name/Formation	Short Description
Cza	Quaternary		Alluvium	Alluvium: mud, sand, minor gravel Colluvium and residual soil: mud, sand, gravel##
Czb	Cenozoic		Cenozoic basalt	Basalt flows
Czs*			Suttor formation*	Sandstone, mudstone, claystone
Ki*	Cretaceous		Unnamed*	Instrusives: granodiorite, diorite, gabbro
TRr	Triassic	Rewan Gp.	Rewan fm.	Green lithic sandstone, green and red sandstone and mudstone
Pwj	Permian	Blackwater Group	Rangal coal measures	Lithic sandstone, coal, siltstone, carbonaceous shale, mudstone (locally cherty), rare, pebbly sandstone
Pwt			Fort Cooper coal measures	Medium to coarse-grained, volcanolithic sandstone, conglomerate, tuff, tuffaceous mudstone, coal, shale
Pwb*			Mooranbah coal measures*	Lithic sandstone, siltstone, shale, coal, mudstone, conglomerate
Pb*		Back Creek Group*		Marine sandstone, siltstone, shale

#Map symbols as per 1:100,000 geological maps Harrybrandt (8554) and Grosvenor Downs (8553) (GSQ, 2014).

*Formation/unit is present outside the lease area and is not discussed at length in the text.

##Several generations of alluvium and colluvium exist, but only the older, more substantive one is mapped in 1:100,000 geological maps Harrybrandt (8554) and Grosvenor Downs (8553) (GSQ, 2014).

3. GROUNDWATER MONITORING NETWORK

The details of the bores included in the groundwater monitoring programme, as stipulated in the EA Condition **C43**, are summarised in Table 2, with their spatial distribution shown in Figure 3. Table 2 is adapted from EA *Table 11 – Groundwater monitoring locations and frequency*.

It should be noted that EA Table 11 currently refers to Swamp Bore 2. However, C&R has been informed that this is a clerical error and will be amended to Swamp Bore 1 when the next EA amendment is completed.

Several monitoring bores are yet to be commissioned (MB12 – MB16).

Table 2: Groundwater monitoring bores at IPC.

Monitoring Point	Aquifer Type	Easting (GDA 94)[1]	Northing (GDA 94)[1]	Surface RL[2] (mAHD)[1]
Burton Coal Bore 2	Rewan Formation	620614.14	7573946.89	240.67
Swamp Bore 1	Rewan Formation	621750.30	7569146.43	245.85
MB1	Coal measures	618792.07	7572213.34	236.54
MB2	Coal measures	619073.69	7573129.11	242.88
MB4a	Quaternary colluvium/Tertiary sediments	620355.06	7567481.37	237.00
MB4b		619625.60	7567072.68	231.44
MB8	Coal measures	618990.97	7570968.22	245.50
MB9	Coal measures	620254.18	7567865.36	238.95
MB10	Tertiary basalt	620255.02	7567872.67	238.94
MB11	Tertiary sediments/weathered Rewan Group	618717.61	7571743.16	231.77

1 - Source: Klohn Crippen Berger (KCB), 2018.

2 - RL: relative level.

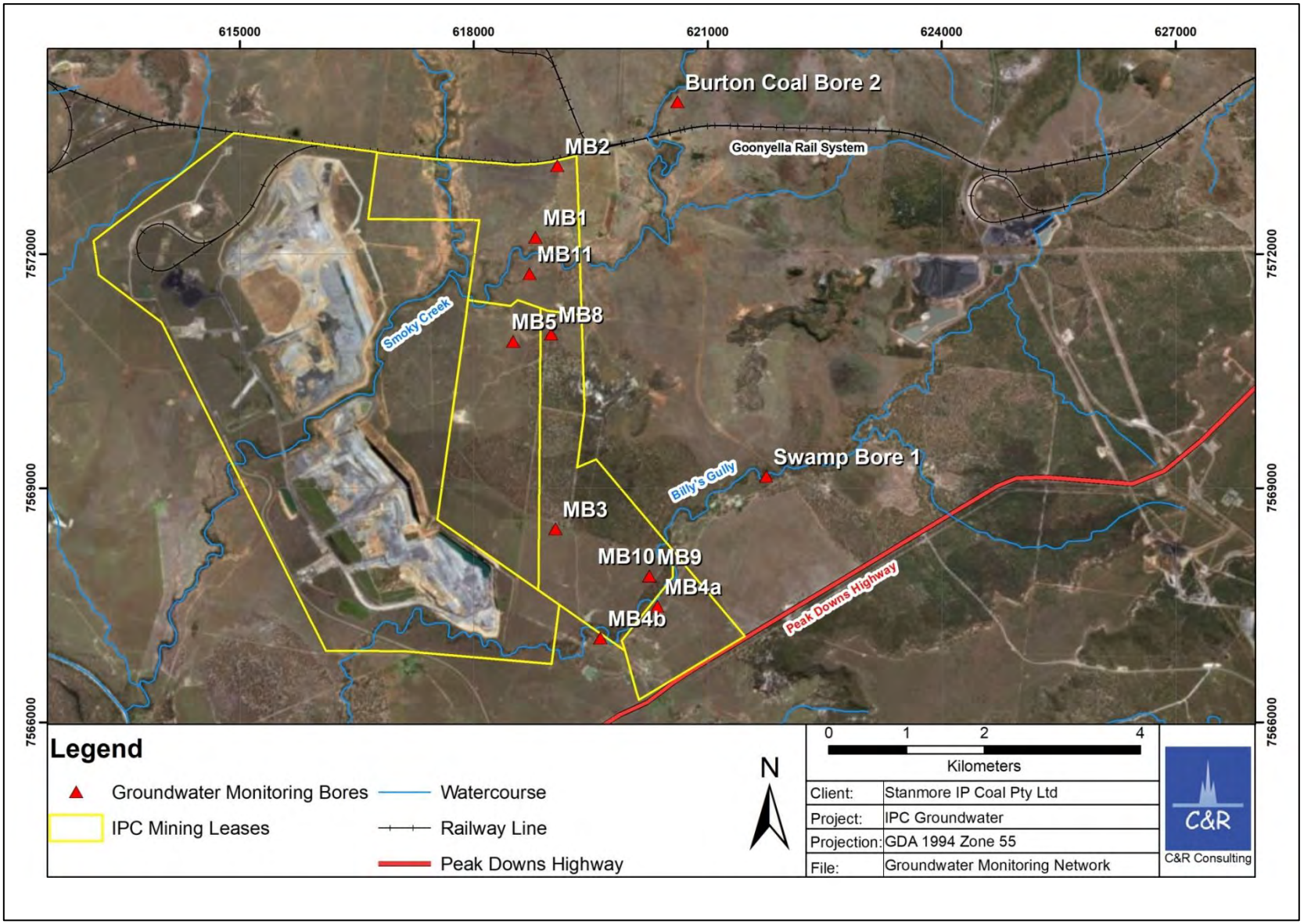

Figure 3: Groundwater monitoring network at IPC.

4. EXCEEDANCE INVESTIGATION

Data supplied to C&R for the purpose of this investigation included Microsoft Excel spreadsheets, laboratory certificates of analysis and groundwater field sheets. Time series charts were generated for each exceeding parameter to identify the potential for trending results. The IBM SPSS software package was used to undertake bivariate correlation analysis between parameters to quantify any observed relationships.

4.1 BURTON COAL BORE 2

Groundwater in the vicinity of the IPC generally follows surface topography in a southwest direction (Klohn Crippen Berger [KCB], 2016). The Burton Coal Bore 2 is positioned hydraulically up-gradient of mining at the IPC, adjacent to Smoky Creek and the Goonyella rail system.

The bore targets the Rewan Group stratigraphic unit, characterised by saline water quality associated with the low hydraulic conductivity and long residence time of the groundwater (KCB, 2016). The aquifer is recharged via rainfall infiltration in areas where the unit outcrops, as well as from seepage from the overlying stratigraphic units (KCB, 2016).

The Burton Coal Bore 2 is not currently used as a water supply (KCB, 2016).

4.1.1 EXCEEDED GROUNDWATER CONTAMINANT TRIGGERS

Multiple exceedances with Burton Coal Bore 2 were noted in the April 2020 round of groundwater monitoring (Table 3).

Table 3: Burton Coal Bore 2 (BCB2) exceedance values in April 2020.

Parameter	Unit	EA Trigger Value	BCB2 April 2020 Value
T - Aluminium	mg/L	0.01	0.07
Chloride	mg/L	1900	2310
Calcium	mg/L	170	193
Total Dissolved Solids	mg/L	3900	4770
Electrical Conductivity	µS/cm	6700	7520
Magnesium	mg/L	230	287

The groundwater contaminant limits stipulated within the EA do not specifically state whether the thresholds are applicable to dissolved or total metal concentrations. If applied against dissolved aluminium levels, there would be no exceedances, as the concentration reported in April was below the limit of reporting (<0.01 mg/L). This is also the average value for dissolved aluminium (<0.1 mg/L) in Burton Coal Bore 2 since January 2016. However, if the contaminant limit is applied to the total aluminium, then the April concentration of 0.07 mg/L would be considered an exceedance (Table 3). The April value for total aluminium is within the historic range, with an overall average concentration of 0.38 mg/L. Considering that the average value calculated since 2016 is far greater than the contaminant limit (<0.01 mg/L) that was determined from site-specific data, it is therefore believed that the contaminant limits stipulated within the EA refer to the dissolved metal concentration. Therefore, the dissolved aluminium concentration captured in April 2020 is classed as compliant.

The recent years of marginal wet seasons has had the effect of concentrating the dissolved solids in the aquifer system. This effect has been compounded by the fact that the region is currently within an extended dry cycle (identified in Section 2.2). The trend of increasing concentration of dissolved solids indicates water is being lost from the system, while salts remain.

Standing water levels in Burton Coal Bore 2 have been recorded since June 2008 (Figure 4). When the standing water levels are overlayed with local rainfall, the bore appears to be highly influenced by rain (or lack thereof), supporting the claim that the aquifer is recharged via rainfall infiltration.

Over the 2011 wet season, the standing water level rose sharply following high rainfall totals and then declined steadily in the following years alongside marginal wet seasons. The level rose again following higher rainfall totals in the 2016 and 2017 wet seasons, but has subsequently declined following dryer years thereafter (Figure 4).

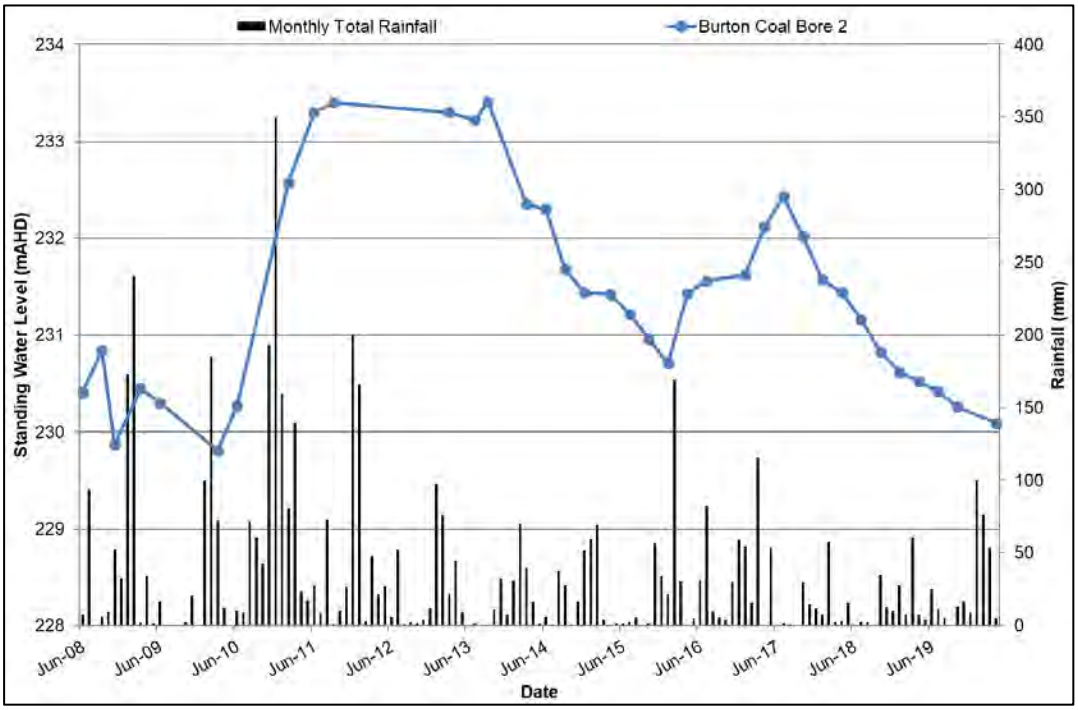

Figure 4: Local rainfall and standing water level in Burton Coal Bore 2

Total dissolved solids (TDS) recorded in Burton Coal Bore 2 since 2010 are occasionally characterised by high variability and both increasing and decreasing trends (Figure 5). The most recent trend has seen an increase in TDS to the point of exceeding the GCT (3900 mg/L) in October 2018 and again in January 2019.

Results from a Pearson correlation analysis reveal the observed trends in TDS are significantly and inversely correlated to the standing water levels ($r = -0.776$, $n = 27$, $p < 0.001$). This correlation is charted in Figure 5 and reveals a clear relationship between the two (note: standing water level has been inversed for visual purposes). Standing water levels and water quality are currently measured on a quarterly basis and have been recorded from Burton Coal Bore 2 on 37 occasions since June 2008.

The observed trends are highly indicative of evapotranspiration processes: the sum of evaporation and plant transpiration. The Burton Coal Bore 2 is located within the riparian corridor of Smoky Creek, surrounded by remnant vegetation consisting of large, deep-rooted trees. Standing water levels in the bore are known to be relatively shallow, with water levels

as shallow as 7.26 m below ground level. The combination of deep tree roots and capillary action can draw water from depths, lowering the zone of saturation and concentrating salts.

The current increasing trend in TDS is therefore inferred to be an expression of the climatic conditions in the area and not resulting from mining impacts. As the TDS and electrical conductivity (EC) are interrelated, similar observations are made for EC (Figure 6).

Three major ions (magnesium, calcium and chloride) exceeded the trigger values in Burton Coal Bore 2. Time series charts for these ions are displayed in Figure 5 through Figure 9. Each chart shows both the increasing and decreasing periods closely related to TDS trends.

While TDS in Burton Coal Bore 2 is above the ANZECC (Australian and New Zealand Environment and Conservation Council) and ARMCANZ (Agricultural and Resource Management Council of Australia and New Zealand) (2000) salinity tolerance for beef cattle (4000 mg/L), the bore is not currently used to supply livestock drinking water.

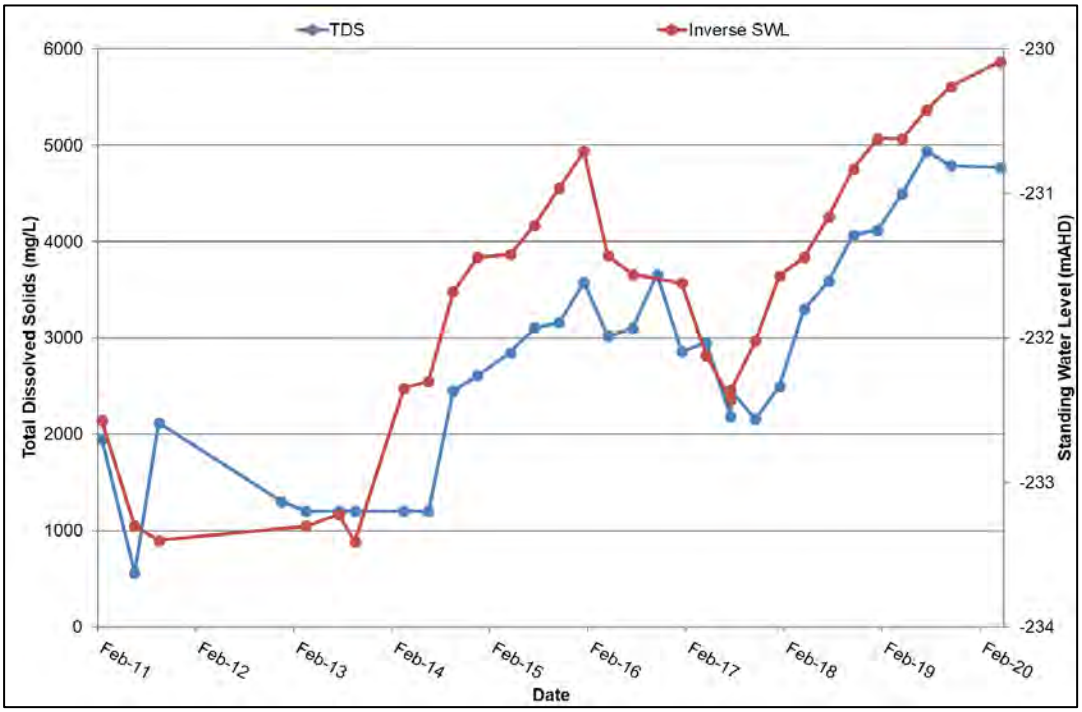

Figure 5: Total dissolved solids and inverse standing water level in Burton Coal Bore 2.

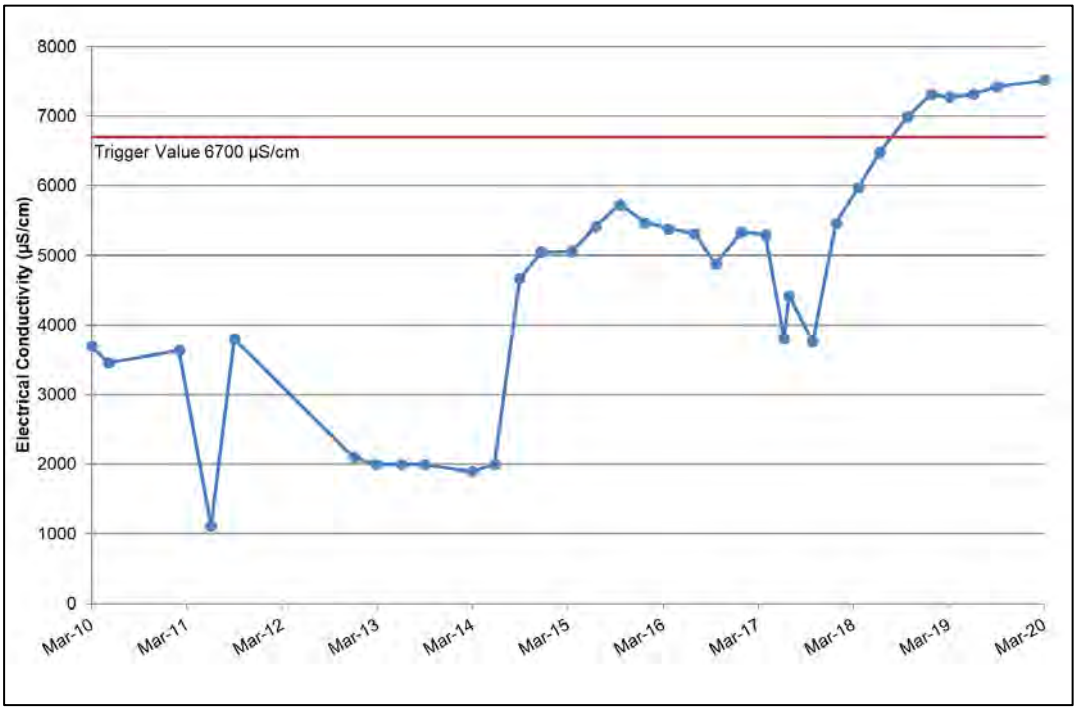

Figure 6: Electrical conductivity in Burton Coal Bore 2.

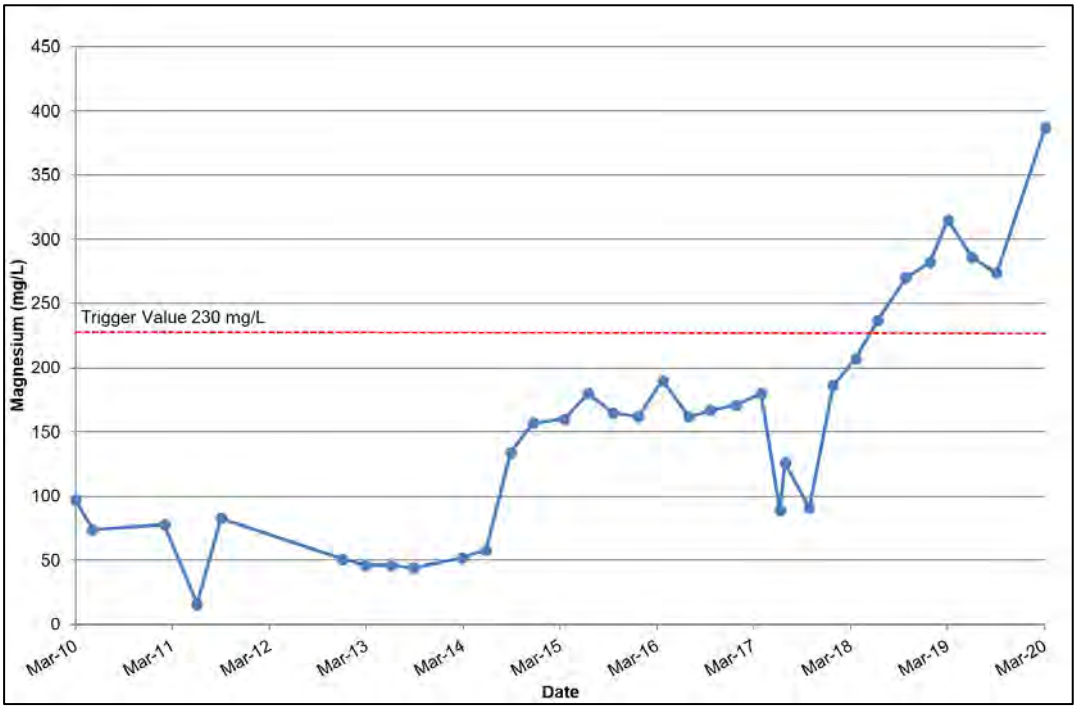

Figure 7: Magnesium in Burton Coal Bore 2.

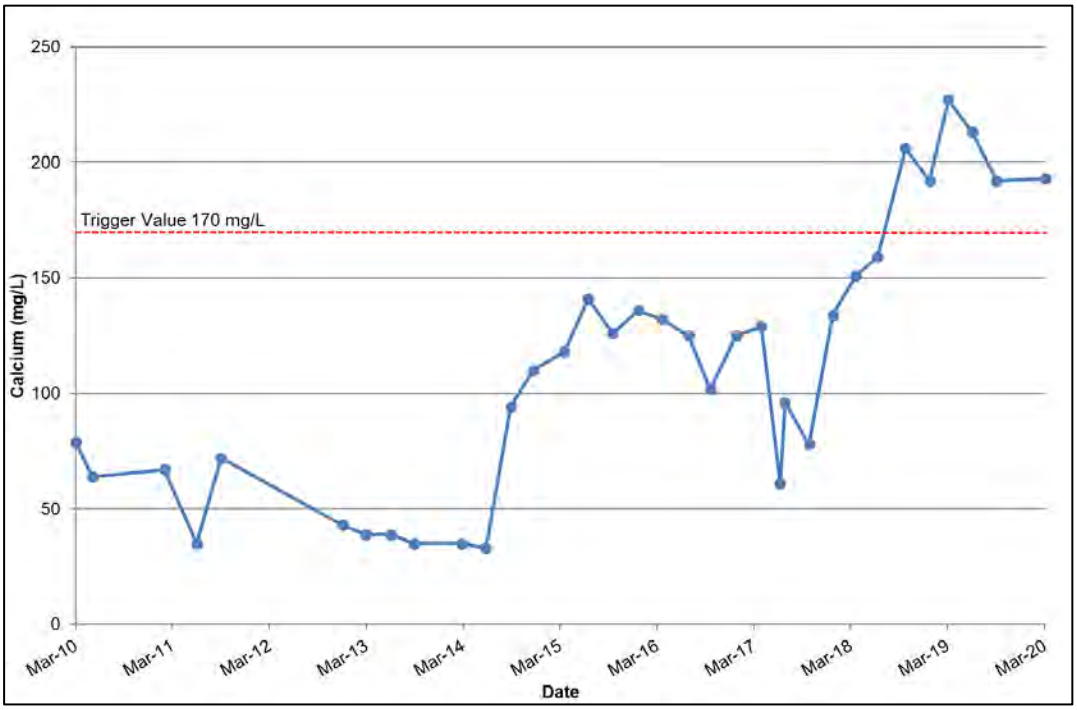

Figure 8: Calcium in Burton Coal Bore 2.

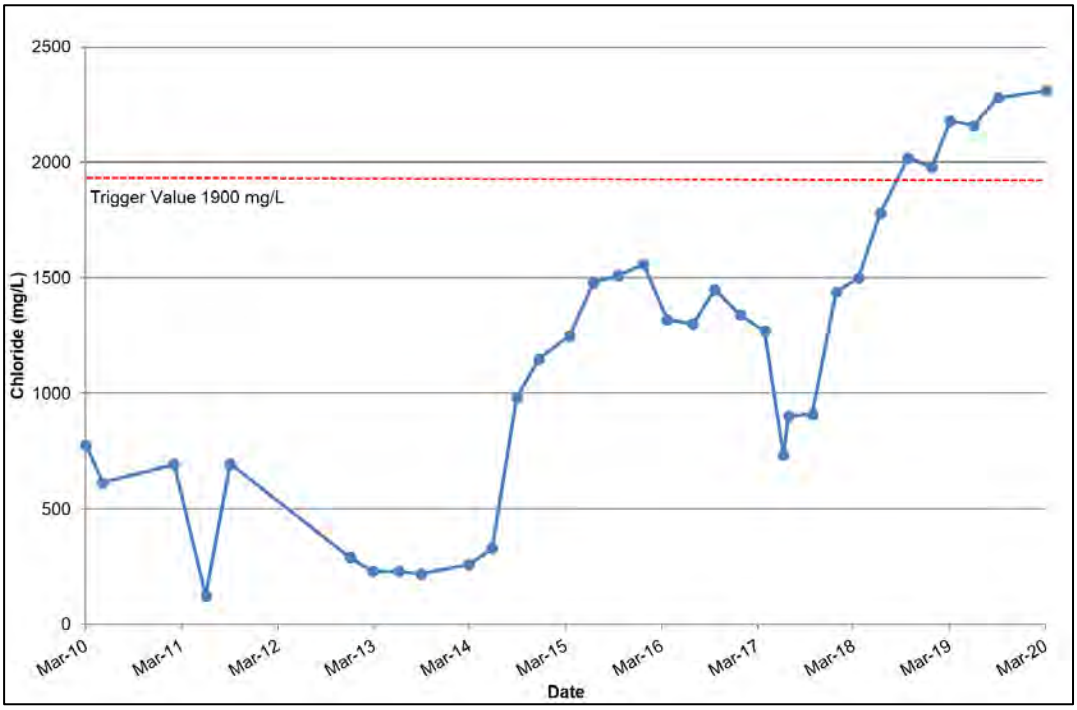

Figure 9: Chloride in Burton Coal Bore 2.

4.2 SWAMP BORE 1

Groundwater in the vicinity of the IPC generally follows surface topography in a southwest direction (KCB, 2016). The Swamp Bore 1 is positioned hydraulically up-gradient of mining at the IPC, within close proximity to Billy's Gully.

The bore targets the Rewan Group stratigraphic unit, characterised by saline water quality associated with the low hydraulic conductivity and long residence time of the groundwater (KCB, 2016). The aquifer is recharged via rainfall infiltration in areas where the unit outcrops, as well as from seepage from the overlying stratigraphic units (KCB, 2016).

The Swamp Bore 1 is not currently used as a water supply, although it is positioned directly opposite a bore that is utilised for stock water supply (KCB, 2016).

4.2.1 EXCEEDED GROUNDWATER CONTAMINANT TRIGGERS

It should be noted that the "Client Sample ID" references within the *Certificate of Analysis* refers to Swamp Bore 1 as SB1.

Three non-compliances have been detected within the Swamp Bore 1 April 2020 water quality sample. However, the same conditions as discussed for Burton Coal Bore 2 apply to Swamp Bore 1: whether the contaminant limit stipulated within the EA refers to the dissolved or total metal concentrations.

It should be noted that the initial exceedance notification completed by Stanmore on the 28 April 2020 via WaTERS stated four exceedances had occurred. However, upon further review, the exceedance regarding molybdenum was incorrect. The April 2020 concentration of molybdenum in both the dissolved and total fraction are below or equal to the contaminant limit of 0.001 mg/L. Hence, this is not classified as an exceedance.

Table 4: Swamp Bore 1 exceedance values in April 2020.

Parameter	Unit	EA Trigger Value	Swamp Bore 1 April 2020 Value
T - Aluminium	mg/L	0.01	0.15
T- Arsenic	mg/L	0.001	0.002
T - Iron	mg/L	1	1.14

Dissolved and total aluminium was recorded as <0.01 mg/L and 0.15 mg/L, respectively, in April. Historically, only one instance (October 2018) of dissolved aluminium was detected above the limit of reporting. In comparison, the total aluminium average since 2016 is 0.06 mg/L, six times the contaminant limit of 0.01 mg/L. These historic concentrations support the notion that the contaminant limits listed within the EA apply to the dissolved metals. Therefore, no exceedance for aluminium has occurred.

The groundwater contaminant limit for arsenic is equal to the limit of reporting (0.001 mg/L). In April, dissolved and total arsenic was recorded as <0.001 mg/L and 0.002 mg/L, respectively. The concentration of 0.002 mg/L for the total arsenic fraction is within the historical range for Swamp Bore 1. Although above the EA contaminant limit, 0.002 mg/L is far below the Livestock Drinking Water guideline value of 0.5 mg/L. Therefore, the April 2020 arsenic concentration is deemed to have no detrimental impact to the surrounding groundwater environmental values.

Dissolved and total iron was recorded as 0.54 mg/L and 1.14 mg/L, respectively, in April, in comparison to the contaminant limit of 1 mg/L. The historic average for dissolved iron in Swamp Bore 1 equals 0.42 mg/L, which is more than half the average for total iron (1.01 mg/L) over the same period. The April level remains within the historic range for Swamp Bore 1. Total iron concentrations display far greater variation, which is often correlated to the level of TDS found within the sample. Iron is most often found in colloidal form. Iron colloids levels can be elevated within the bore column due to pumping techniques, recent rainfall, borehole integrity or a natural reflection of the target geology.

Given the preceding discussion, the iron concentrations for Swamp Bore 1 are considered to be compliant.

5. CONCLUSIONS AND RECOMMENDATIONS

Groundwater in the vicinity of the IPC generally follows surface topography in a southwest direction (KCB, 2016). The Burton Coal Bore 2 and Swamp Bore 1 are positioned hydraulically up-gradient of mining at the IPC. The bores target the Rewan Group stratigraphic unit which is characterised by saline water quality resulting from the low hydraulic conductivity and long residence time of the groundwater (KCB, 2016). The aquifer is recharged via rainfall infiltration in areas where the unit outcrops, as well as from seepage from the overlying stratigraphic units (KCB, 2016).

Examination of local rainfall data dating back to 1972 has identified a 10-year cyclical trend of wet and dry periods. The past seven years have witnessed an extended dry period, with the 5-year average rainfall dropping to the lowest observed over the 47-year record.

The standing water level in the Burton Coal Bore 2 has been shown to be strongly influenced by local rainfall (Figure 4). Consequently, the standing water level in the bore has shown a downward trend in the recent years of marginal rainfall totals. Statistical analysis has also determined a significant and inverse correlation between the standing water level and TDS in the bore. From this observation, it is inferred that the system is losing water through processes of evapotranspiration, and not seepage or mine dewatering.

Higher TDS and EC levels are driven by the larger concentrations of the major ions contributing to water quality. Thus, the exceedances of TDS and EC are a representation of the increasing trends in the major ions associated with high evapotranspiration and low rainfall.

The current groundwater trigger levels for both water quality and standing water levels fail to account for the long-term variability in climatic systems governing groundwater conditions.

While TDS in Burton Coal Bore 2 is above the ANZECC (Australian and New Zealand Environment and Conservation Council) and ARMCANZ (Agricultural and Resource Management Council of Australia and New Zealand) (2000) salinity tolerance for beef cattle (4000 mg/L), the bore is not currently used as a water supply (KCB, 2016) and therefore has no projected impacts on groundwater users. As the observed processes are determined to be the result of natural climatic variation, exceedances, along with results for metals and hydrocarbons compliant with the GCTs, have been determined to have minimal potential to cause environmental harm.

The EA does not specifically state which metal concentration (dissolved or total) the contaminant limit applies too. Further, the particular methodology used to gain such limits remains unresolved. Three possible exceedances have occurred if the contaminant limit is applied to the total concentration of aluminium, arsenic and iron. However, as the contaminant limits are presumed to be determined using historical, site-specific groundwater bore data, C&R believe the contaminant limits are to be applied to the dissolved metals. This is supported by the concentration of dissolved aluminium remaining equal to or below the limit of reporting since 2016 in both Swamp Bore 1 and Burton Coal Bore 2. Hence, the contaminant limit is equal to the limit of reporting.

It is acknowledged that the EA groundwater contaminant limits (EA Table 12) have been modified during the most recent EA amendment, approved on 7 May 2020. However, C&R believe the following recommendations remain relevant to ensure groundwater compliance and the ability to accurately detect changes within the applicable groundwater systems.

Recommendations:

- Review and update current GCT compliance methods (if applicable) to current best practice methods that require consecutive exceedances of a defined limit (i.e. DSITI, 2017 – *Using monitoring data to assess groundwater quality and potential environmental impacts*).
- Ensure the nomenclature is consistent with the EA and laboratory analyses.
- Amend EA Table 12 to specify the applicable metal concentration (i.e. total or dissolved).

6. REFERENCES

ANZECC (Australian and New Zealand Environment and Conservation Council) and ARMCANZ (Agricultural and Resource Management Council of Australia and New Zealand) (2000). *Australian and New Zealand guidelines for fresh and marine water quality.* National Water Quality Management Strategy. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

KCB (Klohn Crippen Berger) (2016). *Isaac Plains East Project – Groundwater Report.*

KCB (Klohn Crippen Berger) (2018). *Isaac Plains Mine Groundwater Monitoring and Management Plan.*

APPENDIX 1: APRIL 2020 COA

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1909239**	Page	: 1 of 12
Client	: **STANMORE IP COAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: BELINDA PARFITT	Contact	: Anna Riddell
Address	: ALS MACKAY 78 HARBOUR ROAD MACKAY QUEENSLAND 4740	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 07 4816 7444	Telephone	: +61 7 4952 5795
Project	: IPCM	Date Samples Received	: 16-Apr-2019 08:20
Order number	: P102091	Date Analysis Commenced	: 18-Apr-2019
C-O-C number	: ----	Issue Date	: 02-May-2019 09:50
Sampler	: SCOTT AULSEBROOK		
Site	: ----		
Quote number	: TV/005/19		
No. of samples received	: 17		
No. of samples analysed	: 11		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Diana Mesa	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Santusha Pandra	Organic Chemist	Brisbane Organics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- TDS by method EA-015 may bias high due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.
- EG020-T (Total Metals by ICP-MS): Limit of reporting raised due to matrix interference.
- It is recognised that EG020T (Total Metals) is less than EG020F (Dissolved Metals) for some samples. However, the difference is within experimental variation of the methods.
- EG020-F (Dissolved Metals by ICP-MS): Limit of reporting raised due to matrix interference.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	BC2	MB7	MB1	MB2
			Client sampling date / time	15-Apr-2019 13:35	15-Apr-2019 08:40	15-Apr-2019 15:00	15-Apr-2019 10:45	15-Apr-2019 09:50
Compound	CAS Number	LOR	Unit	EB1909239-001	EB1909239-002	EB1909239-004	EB1909239-006	EB1909239-007
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.15	7.25	7.30	7.34	7.32
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	8870	7280	18400	3360	7840
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	6370	4500	12700	1840	4550
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	54	<5	30
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	58	613	201	526	776
Total Alkalinity as CaCO3	----	1	mg/L	58	613	201	526	776
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	122	104	100	38	159
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	3130	2180	6530	849	2220
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	608	227	610	97	154
Magnesium	7439-95-4	1	mg/L	137	315	232	116	198
Sodium	7440-23-5	1	mg/L	1180	1020	3190	525	1460
Potassium	7440-09-7	1	mg/L	22	5	18	3	8
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	0.02
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.006	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.001	<0.001	<0.001	0.008	0.036
Barium	7440-39-3	0.001	mg/L	0.217	0.148	0.803	0.125	0.135
Molybdenum	7439-98-7	0.001	mg/L	0.001	<0.001	0.129	0.001	0.002
Rubidium	7440-17-7	0.001	mg/L	0.032	0.010	0.039	0.003	0.012
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	8.37	5.52	47.8	2.11	4.57
Iron	7439-89-6	0.05	mg/L	0.23	<0.05	<0.05	0.05	0.43
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.06	0.03	0.70	0.02	0.65

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	BC2	MB7	MB1	MB2
			Client sampling date / time	15-Apr-2019 13:35	15-Apr-2019 08:40	15-Apr-2019 15:00	15-Apr-2019 10:45	15-Apr-2019 09:50
Compound	CAS Number	LOR	Unit	EB1909239-001	EB1909239-002	EB1909239-004	EB1909239-006	EB1909239-007
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.010	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.002	<0.001	0.001	0.007	0.034
Barium	7440-39-3	0.001	mg/L	0.227	0.135	3.59	0.114	0.141
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.162	0.002	0.003
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	8.49	5.50	51.0	2.17	4.67
Iron	7439-89-6	0.05	mg/L	0.19	0.08	3.97	0.08	1.35
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	0.1	0.1	0.4	0.4
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.01	0.01	0.03	<0.01	0.04
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	92.0	75.9	190	35.2	81.4
Total Cations	----	0.01	meq/L	93.5	81.7	189	37.3	87.7
Ionic Balance	----	0.01	%	0.82	3.70	0.41	2.83	3.70
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SB1	BC2	MB7	MB1	MB2
			Client sampling date / time	15-Apr-2019 13:35	15-Apr-2019 08:40	15-Apr-2019 15:00	15-Apr-2019 10:45	15-Apr-2019 09:50
Compound	CAS Number	LOR	Unit	EB1909239-001	EB1909239-002	EB1909239-004	EB1909239-006	EB1909239-007
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	96.7	94.3	94.3	95.0	91.8
Toluene-D8	2037-26-5	2	%	99.0	100	102	102	100
4-Bromofluorobenzene	460-00-4	2	%	99.0	95.1	97.1	98.9	97.3

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB4A	MB4B	MB8B	MB9A	MB9B
			Client sampling date / time	15-Apr-2019 08:37	15-Apr-2019 07:15	15-Apr-2019 12:20	15-Apr-2019 15:10	15-Apr-2019 16:00
Compound	CAS Number	LOR	Unit	EB1909239-009	EB1909239-010	EB1909239-013	EB1909239-014	EB1909239-015
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	6.95	7.55	7.45	7.38	7.87
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	50800	30200	12000	10800	1890
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	42400	20400	7880	7170	1110
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	1180	1290	133	<5	8
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	398	1150	183	102	566
Total Alkalinity as CaCO3	----	1	mg/L	398	1150	183	102	566
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	918	384	126	<1	91
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	19000	10500	4180	3860	255
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	622	84	374	360	47
Magnesium	7439-95-4	1	mg/L	1830	446	126	155	85
Sodium	7440-23-5	1	mg/L	9010	6400	2270	1820	306
Potassium	7440-09-7	1	mg/L	2	3	14	20	5
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.05	<0.05	<0.01	<0.01	0.02
Antimony	7440-36-0	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	<0.005	<0.005	0.005	0.002	0.002
Barium	7440-39-3	0.001	mg/L	0.204	0.173	0.637	8.38	0.171
Molybdenum	7439-98-7	0.001	mg/L	<0.005	0.007	0.005	<0.001	0.020
Rubidium	7440-17-7	0.001	mg/L	0.007	<0.005	0.026	0.032	0.008
Selenium	7782-49-2	0.01	mg/L	<0.05	<0.05	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	0.007	<0.005	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	20.5	6.62	20.5	13.6	0.752
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	0.45	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	6.02	11.9	1.79	0.14	0.27

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB4A	MB4B	MB8B	MB9A	MB9B
			Client sampling date / time	15-Apr-2019 08:37	15-Apr-2019 07:15	15-Apr-2019 12:20	15-Apr-2019 15:10	15-Apr-2019 16:00
Compound	CAS Number	LOR	Unit	EB1909239-009	EB1909239-010	EB1909239-013	EB1909239-014	EB1909239-015
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.007	0.008	0.005	0.001	0.002
Barium	7440-39-3	0.001	mg/L	0.249	0.294	0.736	9.53	0.222
Molybdenum	7439-98-7	0.001	mg/L	<0.005	0.008	0.005	<0.001	0.021
Selenium	7782-49-2	0.01	mg/L	<0.05	<0.05	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	<0.001
Strontium	7440-24-6	0.001	mg/L	22.6	7.34	20.0	13.2	0.748
Iron	7439-89-6	0.05	mg/L	9.89	26.2	1.90	0.72	0.46
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	0.3	0.6	0.2	0.1	0.3
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	0.16	0.26	0.04	0.01	0.07
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	563	327	124	111	20.4
Total Cations	----	0.01	meq/L	574	319	128	110	22.8
Ionic Balance	----	0.01	%	0.93	1.21	1.56	0.24	5.52
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB4A	MB4B	MB8B	MB9A	MB9B
			Client sampling date / time	15-Apr-2019 08:37	15-Apr-2019 07:15	15-Apr-2019 12:20	15-Apr-2019 15:10	15-Apr-2019 16:00
Compound	CAS Number	LOR	Unit	EB1909239-009	EB1909239-010	EB1909239-013	EB1909239-014	EB1909239-015
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	99.9	94.7	91.4	90.0	94.7
Toluene-D8	2037-26-5	2	%	97.4	104	104	98.1	101
4-Bromofluorobenzene	460-00-4	2	%	97.2	102	98.9	95.4	97.6

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IPCM GW Duplicate	----	----	----	----
			Client sampling date / time	15-Apr-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1909239-017	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.30**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**8890**	----	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**6100**	----	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**51**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**51**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**122**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**3120**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**608**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**133**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**1150**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**22**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.226**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.001**	----	----	----	----
Rubidium	7440-17-7	0.001	mg/L	**0.034**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	**8.85**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.30**	----	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.03**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IPCM GW Duplicate	----	----	----	----
			Client sampling date / time	15-Apr-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1909239-017	--------	--------	--------	--------
				Result	----	----	----	----
EG020T: Total Metals by ICP-MS - Continued								
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.235**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.001**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	**8.51**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.26**	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.02**	----	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**91.6**	----	----	----	----
Total Cations	----	0.01	meq/L	**91.9**	----	----	----	----
Ionic Balance	----	0.01	%	**0.16**	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	----	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IPCM GW Duplicate	----	----	----	----
			Client sampling date / time	15-Apr-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1909239-017	--------	--------	--------	--------
				Result	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	----	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	----	----	----	----
Toluene	108-88-3	2	µg/L	<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
^ Total Xylenes	----	2	µg/L	<2	----	----	----	----
^ Sum of BTEX	----	1	µg/L	<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L	<5	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	90.5	----	----	----	----
Toluene-D8	2037-26-5	2	%	103	----	----	----	----
4-Bromofluorobenzene	460-00-4	2	%	96.0	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

APPENDIX C SOIL AND LAND SUITABILITY STUDY

`

INTEGRATED ISAAC PLAINS PROJECT

EXPANSION AREA

SOIL AND LAND SUITABILITY STUDY

Prepared for

Matrix + Consulting

August 2006

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INTEGRATED ISAAC PLAINS PROJECT

EXPANSION AREA

SOIL AND LAND SUITABILITY STUDY

DOCUMENT CONTROL

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ENVIRONMENTAL EXPERTISE TO MINING AND AGRICULTURAL APPLICATIONS

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Document:	Isaac Plains South Soil Survey.doc
Title:	Soils And Land Suitability Survey Of the Intregrated Isaac Plains Project Expansion Area
Project Manager:	Graham Tuck
Author:	Graham Tuck/Peter Baker
Client:	Matrix+ Consulting
Address:	Level 4, 127 Creek St, Brisbane Qld, 4000
Client Contact:	Kate Kelleher
Client Reference:	Integrated Isaac Plains Project – Soils and Land Suitability Study
Synopsis:	Document describes the soils, stripping depths, existing land suitability and suitability in future proposed mining disturbance.

Revision Number	***Date***	***Checked by***
06	3/8/06	Draft for Client Review
07	5/09/06	Final Draft for Client review
FINAL		Final report

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Attachment 5b Post Mine Grazing Suitability

1 EXECUTIVE SUMMARY

A soil survey and land suitability assessment was undertaken for areas of future proposed disturbance from open-cut coal mining in an area referred to as the Expansion Area as part of the Integrated Isaac Plains Project located approximately 10 kilometres south-east of the Isaac River crossing of the Peak Downs Highway. The survey area comprised approximately 1,500 hectares. A soil and land suitability survey and assessment has previously been undertaken for the existing Isaac Plains Coal Mine area.

The survey procedure and land suitability assessments followed guidelines proposed by Queensland Department of Mines and Energy (QDME) (1995) that are essentially based on Gunn *et al* (1988) and the Land Resources Branch (1990). These guidelines are regarded as the established standard for soil survey in Queensland and form the basis of Local Government shire planning and agricultural assessments for a variety of purposes. In addition, the Land Resources Branch has proposed survey standards for mine planning in Queensland. This survey follows standards described by the Land Resources Branch (1990) and Gunn *et al* (1988).

The entire survey area is suited to grazing at varying stocking rates with little indication of cultivation for grain crops having been undertaken in the past. Most of the survey area had undergone pasture improvement by vegetation removal and regrowth control. The area was originally vegetated with mixed Brigalow communities, alluvial vegetation associated with Cherwell Creek in the southern end of the site, and the Isaac River, as well as Poplar Box woodlands. Soil types vary from deep uniform clays, sandy duplex to recent alluvia.

Some remnant areas of original scrub remain in alluvial areas however most other areas have been significantly cleared. At the time of the field survey, the lands within the project area were in good condition with strong pasture growth following recent rain. Clay plains had a generally thick coverage with Parthenium due to a long period of poor pasture following drought. The area was being grazed by beef cattle at the time of the field survey.

The area is typical of Brigalow communities as described by Gunn *et al* (1967) in that considerable variation in soil attributes may occur over quite small areas. Consequently soil mapping tasks often require boundaries which are not clear-cut as inter-fingering of different and varied soils occurs. In some instances a single soil mapping unit may include separate soils which occur in association but cannot be mapped separately (Land Resources Branch, 1990). Nevertheless, the scale of soil sampling conducted in this survey has, to the extent practicable, accurately identified the extent of various soil types in most instances.

Pre-mining land suitability has been assessed for grazing and cropping uses and recommendations made for retrieval of topsoil for mine rehabilitation. Projections for post mining land suitability have also been included.

2 SCOPE AND METHODOLOGY

2.1 SCOPE OF WORK

Matrix+ Consulting Pty Ltd (Matrix+) have requested that a soil and land suitability survey be conducted for the proposed Expansion Area of the existing Isaac Plains Coal Mine. Matrix+ requested the following:

- Review existing data for the study area and assess how adequately it addresses the environmental approval requirements for soil surveys over the proposed open-cut coal mine area and, if necessary, propose a revised methodology.
- Undertake a detailed soil survey of the proposed disturbance area at an appropriate scale (nominally 1:25,000). Survey methodology shall reflects the findings of the review and meets the requirements as described by Gunn *et al* (1988).
- Analyses of soil samples shall be performed by a NATA approved facility.
- Produce a soil report that includes as a minimum:
    - a description of the methodology used;
    - a description of the soils and soil profiles according to the Australian Soils and Land Survey Handbook (McDonald *et al* 1990) and Isbell (1996);
    - a map of soils at an appropriate scale (nominally 1:25,000);
    - references to the physical and chemical properties of soils which will influence erosion potential, stormwater runoff quality and rehabilitation;
    - a land suitability assessment before and after subsidence; and
    - expert comments on suitability and impacts on soils and productivity of the current land use.

2.2 DEPARTMENTAL SPECIFICATIONS

In 1995, the QDME, released Technical Guidelines for the Environmental Management of Mining as part of the Environmental Policy for Mining in Queensland (Policy). The Policy states that post mining landforms should aim to return lands of similar suitability and range of land use options which existed prior to mining, or, to an agreed alternative use(s). To achieve this, an understanding of pre-mining land resources and suitability is essential. QDME (1995) proposed that such surveys should encompass the following:

- **Review of Available Information**
  A review of available information, published or not, should be undertaken prior to the commencement of any field surveys and be considered in soils mapping and/or suitability assessments if appropriate.

- **Conduct Initial Site Mapping**
  Approximate mapping units should initially be defined using interpretation of topographic and vegetative patterns from aerial photographs. A preliminary soil legend indicating soil types should be proposed at this time and refined as detailed field surveys proceed.

- **Soil Descriptions**
  Two levels of site descriptions are nominated: detailed and non-detailed. Detailed sites describe the soil profile, major vegetation and landforms, and non-detailed confirm map unit type and boundaries. The number of site descriptions varies with mapping scale and, depending on complexity of soil types, approximately 25% should to be detailed. Gunn *et al* (1988) has nominated sampling intensities for various scale maps and for a 1: 25,000 scale map, some 8 to 16 sites per 100 hectares are recommended. Of the total number of sites, approximately 25% should be detailed soil profile descriptions. This number will vary with complexity of soils and landforms.

- **Soil Characterisation**
  Profile Descriptions - Detailed sites require descriptions for major profile and topographic attributes such that soils may be classified and major observable limiting factors are documented.
  Laboratory Analysis - QDME recommends analyses by NATA approved facilities be undertaken for key soil profile horizons deemed representative of major soil mapping units. Tests should include:
  - electrical conductivity, pH and chloride (all samples);
  - exchangeable cations, particle size, NPK (surface horizons only);
  - micronutrients, Al, Fe, Avail. N, Org C, Rep. K (surface only); and
  - heavy metals (where toxicity is suspected).

- **Document Results**
  All findings from work described above, methods used, data generated and a soils map should be contained within a discrete report.

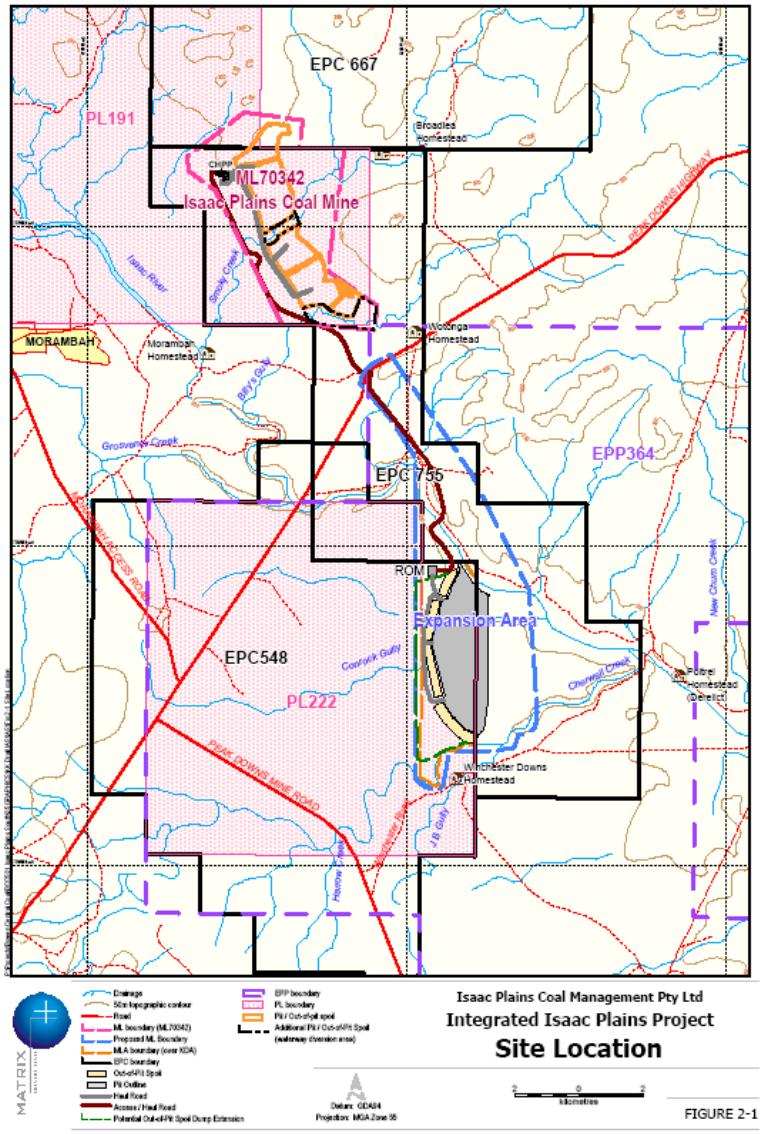
- **Land Suitability Assessment**
  Pre-mining land suitability should be assessed using established methods. The particular method employed should be stated.

3 BACKGROUND

3.1 LOCATION

The survey area comprises approximately 1,500 ha covering the proposed Expansion Area of the Integrated Isaac Plains Project on EPC755. The Expansion Area lies approximately 10 kilometres south-east of the Isaac River crossing of the Peak Downs Highway (refer Figure 2.1).

Figure 2.1 Site Location – Integrated Isaac Plains Project



3.2 LAND RESOURCE INFORMATION REVIEW

Existing land resource information specifically applicable to the survey area is limited mainly to work conducted by CSIRO in 1967 (Gunn *et al*). In the 1960s CSIRO undertook extensive soil, botanical and geomorphologic investigations throughout potential agricultural development areas in Queensland. The Expansion Area survey area is included in one such report by Gunn *et al*, (1967) *Lands of the Isaac Comet Area, Queensland.* This work still presents a major technical source of information of the area.

The Central Highlands Agricultural Land Management Manual (Bourne and Tuck, 1993) also applies to the specific area of Isaac Plains South. This manual describes agricultural management units (AMUs) which occur in the region and how they may be identified. Soil type is a major aspect of AMUs although the primary objective of the manual is to facilitate better agricultural land management. Maps which accompany the report are produced at a broad mapping scale (similar to the CSIRO work) with limited intensity of sampling which does not meet recommended standards of Gunn *et al* (1989) for mine planning purposes.

Other work which can be applied to the area includes a 1:100,000 scale soils and land suitability survey of an area some 70 kilometres to the west in the Kilcummin area (Shields and Williams, 1991). The land suitability assessment techniques used by Shields and Williams (1991) and Bourne and Tuck (1993) were used for cropping and grazing land assessments in the Expansion Area survey.

3.3 EXISTING AND POTENTIAL LAND USE

Almost the entire survey area has been cleared of original vegetation for grazing by beef cattle. The predominant land use patterns of the area remain as grazing of improved pastures with no opportunistic cropping for fodder or grain undertaken. Bourne and Tuck (1993) described existing and potential land use of AMUs occurring in the area. Soil types found in this survey have been aligned to AMUs to assist in the development of land suitability profiles for each. **Table 5.1** in **Section 5.1** describe the AMUs which apply to each soil type in the proposed mining area.

A full description of soils, land suitability and use is included in Section 5 of this report.

4 SURVEY METHODOLOGY

4.1 SOIL MAPPING AND LAND RESOURCES INVENTORY

The soils of the Expansion Area have been mapped at an approximate scale of 1:25,000 in line with methods described by Gunn *et al* (1988). This scale was selected as most appropriate for the detailed evaluation of topsoil resources for this particular area. In addition, land suitability assessments were conducted to document pre-mining conditions. Initially, available background information was examined and air photo mosaics of the area were mapped to delineate likely soil units on the basis of similar topographic and vegetative patterns.

A reference mapping phase was conducted to develop a draft soil type map legend and document the expected soil variations within the survey area. This was followed by detailed site sampling to verify soil types and define boundaries. Field sampling was straightforward as access was very good to all parts of the survey area due to recent geological drilling programs conducted along a 250 metre grid over the Expansion Area.

Free survey techniques (Gunn, 1988) were used to verify soil types and boundaries based on ground observations which are irregularly located according to the surveyor's judgement. Free survey is a commonly used method in broad scale agricultural land assessments in Queensland as it better facilitates the locations of soil boundaries. This is particularly important for mine topsoil stripping applications. The other alternative is to sample along intersection points of a fixed grid however this technique is not recommended by Gunn for broad scale agricultural assessments and better suited to very high intensity surveys. The free survey technique was particularly appropriate for this survey as topographic, vegetative and soil associations were quite uniform across most of the survey area. In addition, the availability of GPS equipment now enables rapid and very accurate determination of ground locations whilst undertaking the field surveys which facilitates mapping of units.

Field mapping involved a total of 97 site descriptions, most of which involved auger excavations of the soil profile to determine soil layers relevant to land suitability and identify which layers offer future re-use potential for rehabilitation. Detailed sites involved the exposure of the soil profile with 75 mm hand augers to depths up to 1.2 m or to hard or otherwise impenetrable layers. Where possible, soil pits or cuttings were used to better describe subsoil structure. In some areas, remnant samples from earlier exploration drilling were inspected to provide confirmation of substrate type. Non-detailed sites involved either a quick check of soil type and stripping depth with a hand auger or confirmation of changes in vegetation or topography. Mapping units were determined on the basis of similarity in morphological and topographic attributes with boundaries gradually refined from the initial air mosaic boundaries using GPS instruments. The soil scheme of Isbell (1998) was used to classify soil types.

The soil map in **Attachment 1** shows the locations of all sites described in this survey. A broad reconnaissance level of mapping was used in the area immediately to the north-east of the Isaac River which is reflected by a lack of survey sites in this area. This decision was based rainfall which occurred towards the end of the field surveys preventing access. Also, there are no plans to disturb the area as part of the IIPP. The area is cleared Brigalow lowlands with little remaining scrub. Should this area be programmed for future disturbance then more detailed soil investigations will be needed to verify strip depths.

Assessments on the basis of morphological (observable) soil attributes were made of stripping depths of useable topsoil at each detailed soil sampling site. Following interpretation of laboratory data, average strip depths for each soil type were proposed. Refer to **Attachment 2** for the List of Soil Survey Sites and details on particular sampling sites.

4.2 SOIL ANALYSIS

The selection of soils for chemical analyses was on the basis of soils at that site being most representative of the soil-mapping unit. Analyses results were used to determine limiting chemical factors and to assist in pre-mining suitability assessments for cropping and grazing. In addition, this data helped determine soil potential in future rehabilitation and stripping depths. Representative sites were sampled for detailed analyses of major horizons or assessed simply for potential problems resulting from salinity, dispersion or pH.

The following analyses were performed by a NATA registered laboratory (Phosyn Analytical):

SAMPLES	ANALYSIS
All samples	pH [H_2O], pH [$CaCl_2$], Organic Matter (%), CEC (meq/100g), EC (dS/m), NO_3-N (ppm), Phosphorus [Olsen] (ppm), Potassium (meq/100g), Calcium (meq/100g), Magnesium (meq/100g), Sulphur (ppm), Boron (ppm), Copper (ppm), Iron (ppm), Manganese (ppm), Zinc (ppm), Aluminium (meq/100g), Sodium (meq/100g), Chloride (ppm), Ca base saturation (%), K base saturation (%), Mg base saturation (%), Na base saturation (%), Ca:Mg Ratio, Aluminium (%)
Surface Horizons	AS ABOVE plus; Bicarb P and Particle Size Analysis (hydrometer)

Detailed fertility analysis. Details of laboratory analysis undertaken, results and methods are included in **Attachment 3**.

Samples were also taken from each representative site at 10 cm increments for pH and EC determinations. This was done to better demonstrate soil layering (particularly saline and sodic horizons) as a guide to topsoil stripping recommendations. This analysis was done by the authors using a *Hanna* hand-held instrument. Selected samples were also analysed by the NATA accredited laboratory to verify compatibility.

4.3 LAND SUITABILITY ASSESSMENT

Assessments were made for land suitability for grazing and cropping uses using techniques described by Land Resources Branch (1989).

A system comprising five classes has been used to assess pre-mining land suitability that is based on that developed for grazing and cropping in the Kilcummin area of Central Queensland by Shields and Williams of the Queensland Department of Primary Industries (QDPI) in 1991. This system is based on physical and chemical limiting factors which apply directly to specific uses. The five classes within the system comprise the following.

Class 1	high quality land with few or very minor limitations
Class 2	land with minor limitations
Class 3	moderate limitations to sustaining the use
Class 4	marginal land requiring major inputs to sustain the use

Class 5	unsuitable due to extreme limitations

5 SOILS

5.1 SOIL MAPPING UNITS

In this survey, a total of seven major soil types are described including one variant. A soil variant may possess attributes which are somewhat different from the mainstream soil attributes but either cannot be mapped out at this scale or does not constitute any significant deviation from the agricultural suitability or basic soil morphology. The variant in this survey consists of the shallower upper slopes of Ironbark occurring within the Poplar Box E1 (refer **Table 5.1**). **Table 5.1** also provides general details of sites described and sites sampled for analysis.

Table 5.2 describes Australian Soil Type (Isbell, 1998) for each soil unit and comparable soils described in the district by Gunn *et al* (1967) and Bourne and Tuck (1993).
Soil mapping units have been developed on the basis of similarity in morphology, laboratory data, original vegetation, soil origin and topographic position. The survey area lies predominantly between Cherwell Creek and the Isaac River. An area north of the Isaac River extending north to the Peak Downs Highway is also included which is a potential access/ haul road.

The principal soil types over the study area are non cracking sandy clay Brigalow gently undulating plains (B2) together with sandy duplex Poplar Box woodlands (E1). Deep sandy and duplex alluvia with mixed Poplar Box woodland (A1) occur in association with major alluvial lines in the area.

Table 5-1 Soil Mapping Units & Sampling Sites

Soil	Concept	General Comments	Detailed reference site
A1	Alluvial sandy duplex of mixed Poplar Box and Brigalow.	Associated with alluvia of Cherwell Creek and the Isaac River. Mostly uncleared frontage country.	4
A3	Alluvial silty clay with open Poplar box with Brigalow and Flooded Coolibah.	Possible opportunistic forage crop use but limited to relatively small area on the Isaac River.	42
A4	Alluvial plain of dark cracking clay with Brigalow.	Deep well structured clay with possible cropping use although area is not extensive.	57
E1	Poplar Box sandy duplex on undulating plains	Extensive throughout the area. Excellent pasture at time of survey with good utilization of short term rainfall in the deep sandy upper soil layer.	24
E1 variant	Relic ridgelines above E1 with shallower duplex with Silver Leaf and Narrow Leaf Ironbark with Poplar Box.	Very minor areas in upper positions of the E1 landscape.	11
B1	Uniform grey/brown clays with areas of gilgai on flat to gently undulating plains with Brigalow.	Occurs on lower lying areas above the alluvial plains in association with B2	59
B2	Sandy uniform clay or thin red/brown duplex soils overlying weathered shale / mudstone with Brigalow on undulating plains. Sandy surface which is often gravelly.	Extensive throughout the area. Buffel pastures quite dense following earlier rain. Very productive broad scale grazing land which is in good condition.	64
R1	Shallow gravely loamy sands to sandy clay loams with extensive outcropping rock	Minor occurrence to north of area. Includes rocky residual and a small area of sandy duplex soils with ironbark. Not sampled. Not programmed for disturbance.	-

Table 5-2 Relationship Between Study Area Soils & Other Surveys

Soil Type	Description	Australian Soil Type (Isbell, 1998)	AMU (Bourne & Tuck, 1993)	CSIRO (Gunn *et al*, 1967) land system / soil type
A1	Alluvial sandy duplex of mixed Poplar Box and Brigalow.	Brown Sodosol	Isaac	Connors/Luxor
A3	Alluvial silty clay with open Poplar box with Brigalow and Flooded Coolibah.	Brown Sodosol	Moramana	Connors/Springwood
A4	Alluvial plain of dark cracking clay with Brigalow.	Black Vertisol	Moramana	
E1	Poplar Box sandy duplex on undulating plains	Brown Sodosol	Lascelles	Monteagle/Luxor
E1 variant	Relic ridgelines above E1 with shallower duplex with Silver Leaf and Narrow Leaf Ironbark with Poplar Box.	Brown Sodosol	Lascelles	Monteagle/Luxor
B1	Uniform grey/brown clays with areas of gilgai on flat to gently undulating plains with Brigalow.	Vertisol	Springton	Daunia/Teviot
B2	Sandy uniform clay or thin red/brown duplex soils overlying weathered shale / mudstone with Brigalow on undulating plains. Sandy surface which is often gravelly.	Red Chromosol	Glen Idol	Daunia/Taurus
R1	Shallow gravely loamy sands to sandy clay loams with extensive outcropping rock	mixed	Highlands	No suitable group

SOIL UNIT DESCRIPTIONS

A1 ACTIVE ALLUVIAL PLAIN OF DEEPER SANDY DUPLEX SOIL

SUMMARY

This soil type occupies alluvia associated with Cherwell Creek and the Isaac River. It occurs on flat plains and is susceptible to occasional flooding. Soils are mostly sandy duplex with mixed vegetation dominated by Poplar Box, but also includes the deep alluvial loams and riverine vegetation associated with the active creek/river channels.

Nutrient levels are variable and the area supports strong buffel pasture, particularly during good seasons when moisture is not the significant limiting factor. This soil type is suitable for grazing.

The surface structure is that of a fine sandy loam with the low clay content associated with fairly rapid drainage making it susceptible to drought, although the substantial rooting depth available negates this to some extent. Trafficability will be restricted due to excessive moisture as a result of poor infiltration characteristics of the clay B horizon.

Clearing of slopes into the creek channels should be avoided where practicable. The deep surface soil is sandy, well drained and not reactive. It should not be used for water holding structures due to very high permeability characteristics. This soil will respond well to nitrogen application for pasture establishment. The top sandy layer may extend to 100 cm depth and be stripped either wet or dry. The deep clay material should be avoided completely due to saline and sodic conditions. The surface soil is better suited to less erosive situations in rehabilitation such as low gradient dumps.

REPRESENTATIVE SITE DESCRIPTION: A1

Soil Type	A1	
Concept Alluvial sandy duplex of mixed Poplar Box and Brigalow.		
AMG Reference:	623400 7554350	
Site No	4	
Australian Soil Classification	Brown Sodosol	
Landform Element	Flat	
Landform Pattern	Flat alluvial plain.	
Slope %	0	
Microrelief	none	
Surface condition	Loose sandy, no stone or rock	
Land Condition	Good condition with no erosion. Strong pasture growth	
Land Use	Being grazed by beef cattle	
Major Vegetation Form and Type	Creek channels have River Red Gum, Moreton Bay Ash, Forest Red Gum, River Sheoak and Bauhinia. Brigalow and Poplar Box on associated alluvial terraces with buffel pasture >50% cover.	
Samples for analysis	0 -20, 50-60, 90-100 cm	
Land Suitability Summary Stocking rates recommended by Bourne & Tuck (1993) for cleared pasture as hectares/adult equivalent beast (AE) for long term sustainability.		**Cropping**: Class 5 unsuitable with major limiting factor(s) moisture availability (5) workability (3). **Grazing**: Class 3 suitable with moderate limitations from moisture (3), fertility (1).

SOIL PROFILE: SITE 4

0.0m

0.1m

0.5m

0.6 m

1.0 m

Horizon	Depth cm	Description
A0	0 - 10	Organic stain. Loamy sand. 5YR3/4, Field pH 6.0, massive, no inclusions, no bleach.
A1	10 – 60	7.5YR4/4, loamy sand, Field pH 6.0, weak structure, no inclusions or gravel,
B21	60 – 90	Loamy sand. No bleach, 7.5YR5/6, Field pH 6.0, no inclusions or gravel.
B22	90 – 20+	Sandy light clay. 5YR5/6, Field pH 6.0, weak structure.
Possible Topsoil Strip Depth (this site)		80cm.
Preferred Rehabilitation Application		Flat sites only due to high erosion potential. Place > 25cm depth.

MAJOR ASPECTS OF CHEMICAL ANALYSIS: SITE 4

The 90 cm depth of the sandy surface layer facilitates good water storage which is not tied up in the clay matrix and therefore unavailable to plants. Consequently these soils can provide good cover in periods of small, frequent thunderstorm type rainfall. The deep surface horizon is loamy fine sand dominated by fine sand (72%) with a total sand fraction of 87%. Phosphorus (Bicarb P) is low/medium in the surface layer but reducing to very low once reaching 90 cm in depth.

Fertility was reasonable at the sampling site. However, it can be expected to be quite variable which is typical of active alluvial plains.

The pH and EC profile in 10 cm increments for this soil is included in **Section 5.3**. The trend indicates no limitation from salt or extreme pH.

A1 Soil - SITE 4

Site and Depth (cm)	Bicarb P (mg/kg)	Coarse sand %	Fine sand %	Silt %	Clay %
SITE 4 (0 - 20 cm)	**18**	**15**	**72**	**8**	**5**
SITE 4 (50 - 60 cm)	**10**				
SITE 4 (90 - 100 cm)	**3**				

ANALYTE	0-20CM	50-60 CM	80-90cm	Comments
pH [H_2O]	6.5	7.7	7.6	ok - neutral tending slight alkaline
pH [$CaCl_2$]	5.8	7.0	6.8	Ok
Organic Matter (%)	0.6	<0.5	0.5	very low to almost non-existent
CEC (meq/100g)	5.3	4.5	9.9	very poor becoming poor
EC (dS/m)	0.05	0.03	0.08	very low throughout
NO_3-N (ppm)	5.2	1.4	18.8	low but reasonable, increasing with depth
Phos. [Olsen] (ppm)	9	4	<1	reasonable in upper layer

ANALYTE	0-20CM	50-60 CM	80-90cm	Comments
Potassium (meq/100g)	1.10	0.88	0.55	High
Calcium (meq/100g)	2.81	2.60	6.03	above minimum plant requirements
Magnesium (meq/100g)	0.93	0.63	2.78	low at surface , good by 80cm
Sulphur (ppm)	4	2	5	Low
Boron (ppm)	0.1	<0.1	0.6	low to very low
Copper (ppm)	0.3	0.4	0.4	Medium
Iron (ppm)	28	20	30	not limiting
Manganese (ppm)	52.2	31.5	13.6	High
Zinc (ppm)	1.0	<0.1	<0.1	medium surface, very low at depth
Aluminium (meq/100g)	0.24	0.19	0.18	not limiting
Sodium (meq/100g)	0.2	0.2	0.4	very low
Chloride (ppm)	<1	<1	18	very low
Ca base saturation (%)	53.1	57.8	60.7	Ok
K base saturation (%)	20.8	19.6	5.5	Ok
Mg base saturation (%)	17.6	14.0	28.0	Ok
Na base saturation (%)	4.0	4.4	3.9	Ok
Ca:Mg Ratio	3.0	4.1	2.2	desirable throughout
Aluminium (%)	4.5	4.2	1.8	Ok

A3 ALLUVIAL SILTY CLAY OF OPEN POPLAR BOX WITH BRIGALOW AND FLOODED COOLIBAH

SUMMARY

This soil type occupies older alluvial plains associated with the Isaac River. It occurs on flat plains and is susceptible to occasional flooding. Soils are uniform silty clays and mostly cleared of vegetation which was previously dominated by Poplar Box in association with Flooded Coolibah, Brigalow, Casuarina and Blackbutt.

Nutrient levels are strong within the surface 30-40 cm layer. However, levels decrease below this depth. The area supports strong buffel pasture and is very suitable for grazing, however no cropping potential is indicated.

The surface structure is that of fine sandy clay over a silty clay profile with substantial rooting depth. The soil is not reactive, however the stratified alluvial nature of the medium is such that it should not be used for water holding structures. This soil will respond well to nitrogen application for pasture establishment and is best stripped dry. The top 30 cm may be stripped for use as topsoil with potential to take more subject to pH and EC levels. The soil will be useful on rehabilitation of level surfaces such as dump tops.

REPRESENTATIVE SITE DESCRIPTION: A3

Soil Type	A3
Concept Silty clay associated with the Isaac River alluvia with mixed Poplar Box, flooded Coolibah and Brigalow.	
AMG Reference:	6225277558353
Site No	42
Australian Soil Classification	Brown sodosol
Landform Element	Flat
Landform Pattern	alluvial plain
Slope %	0
Micro relief	None
Surface condition	sandy, no stone or rock
Land Condition	Good condition with no erosion. Strong pasture growth but extensive Parthenium.
Land Use	Being grazed by beef cattle
Major Vegetation Form and Type	Mostly cleared, originally Poplar Box with flooded Coolibah, Blackbutt, Brigalow and Casuarina.
Samples for analysis	0 -20, 40-50, 80-90 cm
Land Suitability Summary. Stocking rates recommended by Bourne & Tuck (1993) for cleared pasture as 10 hectares/adult equivalent beast (AE) for long term sustainability.	**Cropping**: Class 5 unsuitable with major limiting factor(s) moisture availability (5).salinity (4) Susceptibility to flooding (4) **Grazing**: Class 2 suitable with moderate limitations from moisture (2), fertility (1).

SOIL PROFILE: SITE 42

0.0m 0.1m 0.2m 0.3m 0.4m 0.5m 0.6m 0.7m 0.8m 0.9m 1.0m 1.2m

Horizon	Depth cm	Description
A11	0 -40	Sandy crust surface. No gravel silty clay loam, 10YR5/4, pH 6.5, no inclusions, weak structure
B21	40-120+	silty clay. pH 7.5, 10YR4/4, no inclusions
Possible Topsoil Strip Depth (this site)		30cm. (saline subsoils)
Preferred Rehabilitation Application		Flat sites preferred due to erosion potential. Place > 25cm depth

MAJOR ASPECTS OF CHEMICAL ANALYSIS: SITE 42

Surface fertility is quite good being dominated by very high nitrates and organic matter but reasonably low phosphorus. Other elements are not seriously limiting. The surface 40 cm horizon is dominated by almost 60% fine sand and silt which, with 19% clay content, tends to seal on rehabilitation thus initiating excess runoff and erosion.

The major drawback with this soil is the high salt concentration below 40 cm in depth increasing down the profile. In addition, poor structural properties are indicated below 30 cm resulting from sodic conditions and poor Ca:Mg ratio.

The pH and EC profile in 10 cm increments also indicate excess salinity below approximately 30 cm. **Refer Section 5.3.**

Site and Depth (cm)	Bicarb P (mg/kg)	Coarse sand %	Fine sand %	Silt %	Clay %
SITE 42 (0 - 20 cm)	**10**	**23**	**38**	**21**	**19**
SITE 42 (40 – 50 cm)	**3**				
SITE 42 (80 – 90 cm)	**<LOQ**				

SITE 42

ANALYTE	0-20CM	40-50 CM	80-90cm	Comments
pH [H_2O]	5.7	7.1	8.2	OK - neutral tending alkaline
pH [$CaCl_2$]	5.3	6.7	7.5	OK
Organic Matter (%)	1.7	2.4	1.2	Low
CEC (meq/100g)	10.0	24.5	30.0	Poor becoming moderate with depth
EC (dS/m)	0.26	0.50	0.71	Low on surface but moderate by 40cm and saline at 80cm
NO_3-N (ppm)	91.4	24.5	5.9	Very high surface decreasing with depth
Phos. [Olsen] (ppm)	3	<1	<1	Low to reasonable in upper layer decreasing down profile
Potassium (meq/100g)	0.49	0.55	0.62	High
Calcium (meq/100g)	6.07	9.54	10.53	Above minimum plant requirements
Magnesium (meq/100g)	2.48	11.18	14.81	Above minimum plant requirements
Sulphur (ppm)	13	22	113	Not limiting
Boron (ppm)	0.3	2.0	6.2	Low but increasing with depth to high
Copper (ppm)	1.2	1.3	1.1	Medium
Iron (ppm)	51	28	22	Not limiting
Manganese (ppm)	39.9	19.6	41.2	Medium to high
Zinc (ppm)	<0.1	<0.1	<0.1	Very low
Aluminium (meq/100g)	0.31	0.07	0.08	Not limiting
Sodium (meq/100g)	0.6	3.2	4.0	Very low
Chloride (ppm)	65	428	602	Very low at surface increasing to high below 30 cm.
Ca base saturation (%)	60.9	38.9	35.1	OK
K base saturation (%)	4.9	2.2	2.1	OK
Mg base saturation (%)	24.9	45.6	49.4	OK
Na base saturation (%)	6.2	12.9	13.2	Sodic below surface layer
Ca:Mg Ratio	2.5	0.9	0.7	Desirable in surface but suggestions of poor structural properties below 30 cm
Aluminium (%)	3.1	0.3	0.3	OK

A4 ALLUVIAL PLAIN OF DARK CRACKING CLAY WITH BRIGALOW

SUMMARY

This soil type occurs in association with soil type A3 along older alluvial plains associated with the Isaac River. As with soil type A3, it occurs on flat plains and is susceptible to occasional flooding. The soils are uniform dark cracking clays which were originally thick Brigalow, which differ from the silty non-cracking clays with Poplar Box of the A3.

A4 soils have been completely cleared of vegetation, although, Brigalow regrowth is quite evident. These soils offer some potential for opportunistic cropping. However, the extent of A4 is not large and is currently being used for high value grazing. Nutrient levels are reasonable and the area supports strong buffel pasture once initial establishment has been satisfactorily achieved. At the time of the survey, parthenium weed was quite dense in the area.

The surface structure is that of a granular cracking vertisol with medium clay over well structured medium heavy clay which extends to depths exceeding 100 cm. The soil is not reactive, but the shrink/swell nature of the clay medium is such that it should not be used for water holding structures. This soil will respond well to nitrogen application for pasture establishment. The soil is best stripped dry. The top 30 cm may be stripped for topsoil with potential to take soils from deeper than 30 cm subject to pH and EC levels. The soil will be useful on rehabilitation of level surfaces such as dump tops. However, problems with the initial establishment of fine seeded pasture species can be expected.

REPRESENTATIVE SITE DESCRIPTION: A4

Soil Type	A4
Concept Alluvial plains associated with the Isaac River of dark cracking clay originally with thick Brigalow scrub.	
AMG Reference:	621364 7558755
Site No	57
Australian Soil Classification	Vertisol
Landform Element	Flat
Landform Pattern	alluvial plain
Slope %	0
Microrelief	None
Surface condition	cracking granular with no stone
Land Condition	Good condition with no erosion. Reasonable pasture growth but extensive Parthenium
Land Use	Being grazed by beef cattle
Major Vegetation Form and Type	Mostly cleared. originally Brigalow.
Samples for analysis	0-20, 30-40, 70-80 cm
Land Suitability Summary Stocking rates recommended by Bourne & Tuck (1993) for cleared pasture as 8 hectares/adult equivalent beast (AE) for long term sustainability.	**Cropping**:Class 4 suitable with major limiting factor(s) moisture availability (3), susceptibility to flooding (3). **Grazing**: Class 2 suitable with moderate limitations from moisture (2), fertility (1).

SOIL PROFILE: SITE 57

0.0m
0.1m
0.2m
0.3m
0.4m
0.5m
0.6m
0.7m
0.8m
0.9 m
1.0m

Horizon	Depth cm	Description
A11	0-45	Cracking and self mulching surface. No gravel, medium clay, 10YR3/3, Field pH 9.0, carbonate nodules.
B21	45-100+	uniform medium heavy clay. Field pH 9.0, 10YR4/2, carbonate nodules throughout, lenticular structure.
Possible Topsoil Strip Depth (this site)		30 cm (saline below 40 cm)
Preferred Rehabilitation Application		Flat sites preferred due to erosion potential combined with difficulty in establishment of initial pasture cover. Place 25 cm depth

.

MAJOR ASPECTS OF CHEMICAL ANALYSIS: SITE 57

The salinity profile of soil type A4 is virtually identical to the adjoining A3 so each soil may be treated the same in terms of rehabilitation suitability and basic land suitability.

Surface fertility is reasonable but with low concentrations of nitrates and phosphorus. Organic matter levels are good and most other elements are not seriously limiting. The surface 40 cm horizon has a desirable particle size distribution tending for high moisture storage with 65% clay. High clays such as these may be problematic in terms of establishment of a pasture cover on rehabilitation. Refer **Section 5.3**.

The major drawback with this soil is high salt below 40 cm depth and increasing in depth down the profile. The subsoil material is non-sodic and well structured.

The pH and EC profile in 10 cm increments also indicate excess salinity below about 30 cm. Refer **Section 5.3**.

Site and Depth (cm)	Bicarb P (mg/kg)	Coarse sand %	Fine sand %	Silt %	Clay %
SITE 57 (0 - 20 cm)	**4**	***5***	**17**	**15**	**65**
SITE 57 (30 - 40 cm)	**5**				
SITE 57 (70 - 80 cm)	**2**				

Site 57

ANALYTE	0-20CM	30-40 CM	70-80cm	Comments
pH [H_2O]	8.5	8.4	8.3	alkaline
pH [$CaCl_2$]	8.0	7.9	7.9	ok
Organic Matter (%)	2.1	2.4	2.1	moderate
CEC (meq/100g)	52.5	56.6	52.1	high
EC (dS/m)	0.14	0.50	1.21	low on surface but moderate by 40 cm and highly saline at 80 cm
NO_3-N (ppm)	1.1	42.9	2.7	Very high at 40 cm but low elsewhere including surface
Phos. [Olsen] (ppm)	<1	<1	<1	very low
Potassium (meq/100g)	1.29	1.20	1.13	High
Calcium (meq/100g)	34.15	33.60	26.64	above minimum plant requirements
Magnesium (meq/100g)	14.91	17.77	19.61	above minimum plant requirements
Sulphur (ppm)	5	13	129	not limiting
Boron (ppm)	1.3	2.6	9.6	not limiting
Copper (ppm)	1.6	1.6	1.3	Medium
Iron (ppm)	38	38	33	not limiting
Manganese (ppm)	38.1	43.1	51.5	medium
Zinc (ppm)	<0.1	<0.1	<0.1	very low
Aluminium (meq/100g)	0.10	0.07	0.08	not limiting
Sodium (meq/100g)	2.0	4.0	4.6	very low
Chloride (ppm)	6	260	630	very low at surface increasing to high below 30 cm
Ca base saturation (%)	65.1	59.4	51.2	Ok
K base saturation (%)	2.5	2.1	2.2	Ok
Mg base saturation (%)	28.4	31.4	37.7	Ok
Na base saturation (%)	3.9	7.0	8.8	non sodic
Ca:Mg Ratio	2.3	1.9	1.4	desirable in surface but suggestions of poor structural properties deep in profile
Aluminium (%)	0.2	0.1	0.2	Ok

E1 & E1 VARIANT - POPLAR BOX WOODLANDS ON SANDY DUPLEX SOILS

SUMMARY

These two soil types occupy a major portion of the survey area, i.e. it is a significant component. It is generally quite uniform in characteristics with open Poplar Box on a 50 cm thick (average) surface layer of loamy sand over mottled yellow clay. It occurs on undulating 0 - 2% slopes, is susceptible to erosion, and supports buffel pasture which was quite abundant at the time of the survey. The soil unit has been subject to extensive thinning and clearing.

A localised soil variant which occurs on upper ridge areas involves a thinner sandy surface horizon with both Narrow and Silver Leaf Ironbark.

Nutrient levels are low, the area supports reasonable buffel pasture. Plants may better utilise soil moisture from sandy soils following short rainfall events than is possible from clays which

tend to tie up such moisture in the dry clay matrix. This soil type is suitable for grazing at fairly broad scale stocking rates.

The surface structure is that of a sandy loam to loamy sand overlying very hard, mottled clay subsoils. Restricted drainage is indicated by the presence of bleached A2 horizons at some sites.

REPRESENTATIVE SITE DESCRIPTION: E1

Soil Type	E1	
Concept Gently undulating plains with sandy duplex soil and Poplar Box.		
AMG Reference:	621107 7555444	
Site No	24	
Australian Soil Classification	Brown Sodosol	
Landform Element	midslope	
Landform Pattern	Gently undulating plain	
Slope %	1.0	
Microrelief	occasional termite mounds	
Surface Condition		sandy, loose
Land Condition		Good condition
Land Use		Being grazed by beef cattle
Major Vegetation Form and Type		Poplar Box open woodland. Buffel pasture 50-60% cover
Samples for Analysis		0-20, 70-80 cm
Land Suitability Summar Stocking rates recommended by Bourne & Tuck (1993) for cleared pasture as 12 hectares/adult equivalent beast (AE) for long term sustainability.		**Cropping**: Class 5 unsuitable with major limiting factor(s) moisture availability (5), physical (5). **Grazing**: Class 3 suitable with moderate limitations from moisture availability (3), physical problems (3), fertility (2).

SOIL PROFILE: SITE 24

0.0m 0.2m 0.3m 0.4m 0.5m 0.6m 0.7m 0.8m 0.9m 1.0m 1.1m 1.2m

Horizon	Depth cm	Description
A11	0-60	Loamy sand, Field pH 6.0, no bleach, massive structure, no inclusions, 7.5YR4/4,
B21	60 – 120+	Sandy clay, weak angular blocky, Field pH 8.0, no inclusions or gravel, extensive red/ grey mottles, moderate consistency & restricted drainage. 10YR5/6
Recommended Topsoil Strip Depth		50 cm
Preferred Rehabilitation Application		Flat sites only due to high erosion potential. Place to 25 cm depth

MAJOR ASPECTS OF CHEMICAL ANALYSIS: SITE 24

The 50-60 cm depth of the sandy surface has very low fertility but high coarse sand fraction which facilitates good infiltration and erosion resistance. The clay subsoil below 50 cm is

non-saline or sodic but exhibits a very coarse structure, mottling and tends to form a dense cloddy medium, again, not particularly suitable for rehabilitation.

The pH and EC profile in 10 cm increments for this soil is included in **Section 5.3**.

Site 24

Site and Depth (cm)	Bicarb P (mg/kg)	Coarse sand %	Fine sand %	Silt %	Clay %
SITE 24 (0 - 20 cm)	**2**	**43**	**45**	**5**	**5**
SITE 24 (70 - 80 cm)	**<LOQ**				

ANALYTE	0-20CM	70-80 CM	Comments
pH [H_2O]	6.2	7.4	neutral
pH [$CaCl_2$]	5.5	7.0	ok
Organic Matter (%)	0.6	1.3	very low to low
CEC (meq/100g)	2.7	11.8	very poor
EC (dS/m)	0.02	0.08	very low on surface extending to at least 80cm
NO_3-N (ppm)	1.7	<1.0	Very low including surface.
Phos. [Olsen] (ppm)	2	<1	very low
Potassium (meq/100g)	0.43	0.76	high
Calcium (meq/100g)	1.61	5.33	below minimum plant requirements on surface
Magnesium (meq/100g)	0.42	4.52	below minimum plant requirements on surface
Sulphur (ppm)	3	4	not limiting
Boron (ppm)	<0.1	1.7	below minimum plant requirements on surface
Copper (ppm)	0.3	0.3	low
Iron (ppm)	26	23	not limiting
Manganese (ppm)	26.0	9.7	medium
Zinc (ppm)	<0.1	<0.1	very low
Aluminium (meq/100g)	0.08	0.18	not limiting
Sodium (meq/100g)	0.1	1.1	very low – non sodic
Chloride (ppm)	9	78	very low at surface increasing slightly below 30cm.
Ca base saturation (%)	60.1	45.0	ok
K base saturation (%)	16.0	6.4	ok
Mg base saturation (%)	15.7	38.2	ok
Na base saturation (%)	5.2	8.9	non sodic
Ca:Mg Ratio	3.8	1.2	desirable in surface but suggestions of poor structural properties deep in profile.
Aluminium (%)	3.0	1.5	ok

REPRESENTATIVE SITE DESCRIPTION: E1 variant

Soil Type	E1 Variant	
Concept Ridges along undulating plains with sandy duplex soil and Ironbark with Poplar Box.		
AMG Reference:	621430 7554212	
Site No	11	
Australian Soil Classification	Brown Sodosol	
Landform Element	ridge	
Landform Pattern	Gently undulating plain.	
Slope %	0.5	
Microrelief	occasional termite mounds	
Surface Condition		sandy, loose
Land Condition		Good condition
Land Use		Being grazed by beef cattle
Major Vegetation Form and Type		Narrow and Silver leaf ironbark with Poplar Box open woodland. Buffel pasture 50% cover.
Samples for Analysis		0-20, 40-50 cm
Land Suitability Summary. Stocking rates recommended by Bourne & Tuck (1993) for cleared pasture as 14 hectares / adult equivalent beast (AE) for long term sustainability.		**Cropping**: class 5 unsuitable with major limiting factor(s) moisture availability (5), physical (5). **Grazing**: Class 3 suitable with moderate limitations from moisture availability(4), physical problems (3), fertility (2).

SOIL PROFILE: SITE 11

0.0m
0.1m
0.2m
0.3m
0.4m
0.5m
0.6m
0.7m
0.8m
0.9m
1.0m
1.1m
1.2m

Horizon	cm	
A11	0-30	Fine sandy loam, Field pH 6.0, no bleach, massive structure, no inclusions, 7.5YR3/4,
A12	30-45	as above but 7.5YR4/4
B21	45 – 120+	Light sandy clay, weak angular blocky, Field pH 8.0, no inclusions or gravel, some grey mottles, moderate consistency & restricted drainage. 10YR5/6
Recommended Topsoil Strip Depth		30 cm
Preferred Rehabilitation Application		Flat sites only due to high erosion potential. Place to 25cm depth

MAJOR ASPECTS OF CHEMICAL ANALYSIS: SITE 11

The 30 cm depth of the sandy surface has very low fertility. The clay content in the surface is significantly less in this ironbark ridge variant which is replaced by much higher silt fraction. This feature will cause soils on rehabilitation to set hard and seal which somewhat restricts its use. Subsoil is non-saline or sodic but exhibits very coarse structure, mottling and tends to form a dense cloddy medium, again, not particularly helpful for rehabilitation.

The pH and EC profile in 10 cm increments for this soil is included in **Section 5.3**.

Site and Depth (cm)	Bicarb P (mg/kg)	Coarse sand %	Fine sand %	Silt %	Clay %
SITE 11 (0 - 20 cm)	**3**	**38**	**48**	**5**	**8**
SITE 11 (40 - 50 cm)	**2**				

SITE 11

ANALYTE	0-20CM	40-50 CM	Comments
pH [H_2O]	5.9	6.2	slightly acidic to neutral
pH [$CaCl_2$]	5.1	5.8	Ok
Organic Matter (%)	0.7	1.4	very low to low
CEC (meq/100g)	3.7	11.3	very poor
EC (dS/m)	0.01	0.05	very low on surface extending to at least 50cm
NO_3-N (ppm)	<1.0	2.9	Very low including surface.
Phos. [Olsen] (ppm)	2	<1	very low
Potassium (meq/100g)	0.55	0.79	High
Calcium (meq/100g)	1.79	5.43	below minimum plant requirements on surface
Magnesium (meq/100g)	0.96	4.20	below minimum plant requirements on surface
Sulphur (ppm)	3	6	not limiting
Boron (ppm)	0.1	0.8	below minimum plant requirements on surface
Copper (ppm)	0.4	0.5	Moderate
Iron (ppm)	32	27	not limiting
Manganese (ppm)	30.5	5.8	medium
Zinc (ppm)	<0.1	<0.1	very low
Aluminium (meq/100g)	0.13	0.11	not limiting
Sodium (meq/100g)	0.2	0.8	very low – non sodic
Chloride (ppm)	4	28	very low at surface increasing slightly below 30cm.
Ca base saturation (%)	48.9	48.1	Ok
K base saturation (%)	15.0	7.0	Ok
Mg base saturation (%)	26.2	37.2	Ok
Na base saturation (%)	6.3	6.6	non sodic
Ca:Mg Ratio	1.9	1.3	desirable in surface but suggestions of poor structural properties deep in profile.
Aluminium (%)	3.6	1.0	Ok

B1 BROWN & GREY UNIFORM NON-CRACKING CLAYS

SUMMARY

Productive grazing soils with desirable all round qualities on very low slopes with reduced degradation potential from erosion following dry times. The soils are brown to grey, moderately well structured, generally non-cracking clays which support abundant Buffel pasture.

Nutrient levels are quite good on the surface layers. However, saline and sodic conditions prevail immediately below 20 cm depth. It is recommended that prior to stripping of topsoil layers on this soil type, more EC tests should be undertaken to more fully evaluate the potentially high salinity concentrations.

Some of the area may include shallow (up to 15 cm deep) gilgai of brown sandy clay interspersed with grey clay depressions. The surface structure is sandy and firm with areas of ironstone gravel. In most instances drainage is not impeded to 40 cm.

A high cation exchange capacity will facilitate favourable responses to fertiliser application for pasture improvement. Preferably, the soil should be stripped when dry to minimise compaction and structural decline. The top 20 cm may be stripped for topsoil with little potential to go deeper (at the location of site 59). The soil will be useful on rehabilitation in a variety of situations.

REPRESENTATIVE SITE DESCRIPTION: B1

Soil Type	B1	
Concept Uniform grey/brown clays with areas of gilgai on flat to gently undulating plains with Brigalow.		
AMG Reference:	6204387558921	
Site No	59	
Australian Soil Classification	Vertisol	
Landform Element	midslope	
Landform Pattern	undulating plain.	
Slope %	1.5%	
Microrelief	nil	
Surface condition		Few surface stone/rock (<2%), minor ironstone pebbles, firm sandy surface no crust.
Land Condition		Good condition
Land Use		Being grazed by beef cattle
Major Vegetation Form and Type		Mostly cleared Brigalow. Good buffel >60% cover but some Brigalow regrowth
Samples for analysis		0-20, 30-40, 70-80 cm
Land Suitability Summary Stocking rates recommended by Bourne & Tuck (1993) for cleared pasture as 8 hectares/adult equivalent beast (AE) for long term sustainability.		**Cropping** Class 5 unsuitable with major limiting factor(s) moisture availability (4), erosion susceptibility (4). **Grazing**: Class 2 suitable with limitations from moisture (2), effective root depth (2), fertility (2), erosion (2).

The photograph to left shows heavy Parthenium infestation above a small gully into B1 soil. Depth of topsoil approx 30 cm.

SOIL PROFILE: SITE 59

0.0m 0.1m 0.2m 0.3m 0.4m 0.5m 0.6m 0.7m 0.8m 0.9m 1.0m 1.1m 1.2m

Horizon	Depth cm	Description
A1	0-30	Field pH 6.5, 10YR3/4, no carbonate nodules, angular blocky, no mottles, sandy clay.
B21	30-65	Field pH 6.5, 10YR4/3, no carbonate nodules, hard sub angular blocky, no mottles, reasonably drained, medium clay.
B22	65-100+	Field pH 6.5, 10YR5/4, no mottles, medium clay.
Recommended Topsoil Strip Depth		20-30cm
Preferred Rehabilitation Application		Preferably flatter sites due to erosion potential. Place to 25 cm depth

MAJOR ASPECTS OF CHEMICAL ANALYSIS: SITE 59

Good surface fertility with high nitrogen, cation exchange and non-limiting elements however saline and sodic conditions occur from 20 cm depth. The particle size distribution in the surface layer is desirable for pasture production in this area however saline subsoils will restrict root development and increase susceptibility to droughting in prolonged dry weather.

The pH and EC profile in 10 cm increments for this soil is included in **Section 5.3**.

Site 59

Site and Depth (cm)	Bicarb P (mg/kg)	Coarse sand %	Fine sand %	Silt %	Clay %
SITE 59 (0 - 20 cm)	**17**	**21**	**20**	**15**	**47**
SITE 59 (30 - 40 cm)	**7**				
SITE 59 (70 - 80 cm)	**<LOQ**				

ANALYTE	0-20CM	30-40 CM	70-80cm	Comments
pH [H_2O]	7.7	8.1	7.7	Slightly alkaline
pH [$CaCl_2$]	7.1	7.5	7.0	Ok
Organic Matter (%)	3.5	2.8	1.4	high
CEC (meq/100g)	35.5	33.0	26.5	Good
EC (dS/m)	0.56	0.48	0.91	Almost into saline range in surface horizon and continuing throughout.
NO_3-N (ppm)	42.1	10.5	4.7	Very high insurface.
Phos. [Olsen] (ppm)	9	2	<1	reasonable in surface then very low
Potassium (meq/100g)	1.30	0.99	0.77	above minimum plant requirements
Calcium (meq/100g)	22.61	15.82	8.88	above minimum plant requirements
Magnesium (meq/100g)	9.60	12.65	12.48	above minimum plant requirements
Sulphur (ppm)	63	18	4	not limiting
Boron (ppm)	1.8	2.8	2.4	above minimum plant requirements
Copper (ppm)	1.7	2.0	1.6	Moderate
Iron (ppm)	40	32	28	not limiting
Manganese (ppm)	16.0	8.5	14.4	medium
Zinc (ppm)	<0.1	0.3	<0.1	very low

ANALYTE	0-20CM	30-40 CM	70-80cm	Comments
Aluminium (meq/100g)	0.08	0.07	0.06	not limiting
Sodium (meq/100g)	1.9	3.5	4.3	very low surface but high with depth
Chloride (ppm)	272	324	1119	low at surface increasing below 20cm.
Ca base saturation (%)	63.7	47.9	33.5	Ok
K base saturation (%)	3.7	3.0	2.9	Ok
Mg base saturation (%)	27.1	38.3	47.1	Ok
Na base saturation (%)	5.3	10.6	16.3	non sodic surface , sodic below 20cm.
Ca:Mg Ratio	2.4	1.3	0.7	desirable in surface but suggestions of poor structural properties deep in profile.
Aluminium (%)	0.2	0.2	0.2	Ok

B2 REDDISH BROWN SANDY CLAY

SUMMARY

This soil occupies mid to upper slope positions within the undulating Brigalow lands. The surface structure is firm and sandy with ironstone gravel common. A significant and productive grazing soil but lighter texture and reduced soil depth would reduce moisture storage and increase drying rates with onset of dry times. These soils have fairly hard structured light clay subsoils over weathered material but appear to be well drained to at least 40 cm in most instances. The soil has a sandy surface and supports strong Buffel pasture.

General fertility is not high although reasonable for grazing lands. There are problems apparent from subsoil sodicity and salinity below 30 cm depth which is not assisted by its coarse structure.

The soil is well suited to grazing and pasture improvement with favourable responses to fertiliser addition expected. The soil should preferably be stripped when dry to minimise action and structural decline. The top 20 cm may be stripped for topsoil only. The soil will be useful on rehabilitation in a variety of situations.

REPRESENTATIVE SITE DESCRIPTION: B2

Soil Type	B2	
Concept Sandy uniform clay or thin red/brown duplex soils overlying weathered shale/mudstone with Brigalow on undulating plains. Sandy surface which is often gravelly.		
AMG Reference:	621981 7555820	
Site No	64	
Australian Soil Classification	Red Chromosol	
Landform Element	midslope	
Landform Pattern	Gently undulating plain.	
Slope %	0.5%	
Microrelief	None	
Surface condition		Sandy firm surface, 10% ironstone gravel, cleared and minor evidence of loss of topsoil.
Land Condition		Good condition
Land Use		Being grazed by beef cattle
Major Vegetation Form and Type		Mostly cleared mixed Brigalow. Buffel 50% cover. Currently bush.
Samples for analysis		0-20, 40-50, 70-80 cm
Land Suitability Summary. Stocking rates recommended by Bourne & Tuck (1993) for cleared pasture as 8 hectares/adult equivalent beast (AE) for long term sustainability.		**Cropping**: Class 5 unsuitable with major limiting factor(s) moisture availability (5), erosion susceptibility (4). **Grazing**: Class 2 suitable with limitations from moisture (2), fertility (2), erosion (2).

SOIL PROFILE: SITE 64

Depth	Horizon	Depth cm	Description
0.0m – 0.1 m	A1	0-20	Light sandy clay, field pH 6.0, 7.5YR4/4, weak structure, no bleach
0.1 m – 0.6m	B21	20-65	Medium clay, hard and dense massive structure, field pH 8.0, Carbonate nodules increasing, 7.5YR3/3, no mottles or bleach,
0.6m – 0.8m	B21	65-100	Medium clay, hard and dense massive, increasing grey and red mottles. structure, field pH 8.0, Carbonate nodules increasing, 7.5YR5/4,
0.8m – 0.9m	Recommended Topsoil Strip Depth		20 cm
0.9m – 1.1m	Preferred Rehabilitation Application		Preferably flatter sites due to erosion potential. Place to 25 cm depth

MAJOR ASPECTS OF CHEMICAL ANALYSIS: SITE 64

The surface fertility is reasonable but with increasing salinity and sodium below 30 cm depth. Reasonably low phosphorus in the surface but with good particle size distribution for pasture production. The pH and EC profile in 10 cm increments for this soil is included in **Section 5.3**.

Site and Depth (cm)	Bicarb P (mg/kg)	Coarse sand %	Fine sand %	Silt %	Clay %
SITE 64 (0 - 20 cm)	**10**	**13**	**33**	**22**	**36**
SITE 64 (40 - 50 cm)	**2**				
SITE 64 (70 - 80 cm)	**<LOQ**				

ANALYTE	0-20CM	40-50 CM	70-80cm	Comments
pH [H_2O]	6.6	8.3	8.4	neutral tending alkaline
pH [$CaCl_2$]	6.1	7.9	7.9	Ok
Organic Matter (%)	4.4	2.7	1.5	very high
CEC (meq/100g)	22.7	40.6	60.0	medium/good
EC (dS/m)	0.06	0.42	1.54	Saline below 40 cm depth
NO_3-N (ppm)	5.0	<1.0	<1.0	reasonable in surface then very low.
Phos. [Olsen] (ppm)	3	<1	<1	low in surface then very low
Potassium (meq/100g)	0.83	0.91	0.73	above minimum plant requirements
Calcium (meq/100g)	18.04	21.78	39.45	well above minimum plant requirements
Magnesium (meq/100g)	3.15	13.92	15.29	above minimum plant requirements
Sulphur (ppm)	8	12	162	not limiting
Boron (ppm)	0.8	1.5	5.3	above minimum plant requirements
Copper (ppm)	2.5	2.9	1.2	Moderate
Iron (ppm)	45	43	20	not limiting
Manganese (ppm)	41.8	29.4	14.1	medium
Zinc (ppm)	0.4	<0.1	<0.1	very low
Aluminium (meq/100g)	0.15	0.06	0.06	not limiting
Sodium (meq/100g)	0.6	4.0	4.4	very low surface but high with depth
Chloride (ppm)	16	333	1093	low at surface increasing below 30 cm

ANALYTE	0-20CM	40-50 CM	70-80cm	Comments
Ca base saturation (%)	79.3	53.6	65.8	Ok
K base saturation (%)	3.6	2.2	1.2	Ok
Mg base saturation (%)	13.9	34.3	25.5	Ok
Na base saturation (%)	2.5	9.7	7.4	non sodic surface , sodic below 30 cm.
Ca:Mg Ratio	5.7	1.6	2.6	desirable – no suggestions of poor structural properties.
Aluminium (%)	0.7	0.1	0.1	Ok

R1 RESIDUAL MESA AND ASSOCIATED UPLAND SOIL

A very minor unit to the extreme north of the survey area. The only potential disturbance planned for the area is an access road and a water pipeline which is located about 1000 m to the west of the mesa. The area includes a mesa and with outcropping sandstone, silcrete rock with shallow skeletal soil. Also included in the area is an area of gravely duplex soils with Narrow and Silver leaf ironbark.

Variable soil profiles occur in this area but most surfaces are very hard and gravelly. The ironbark ridge soils are shallow pale brown sandy loam over mottled clay with poor structure.

The inaccessible nature of the mesa terrain coupled with the rockiness makes the area poorly suited to grazing or any other agricultural purpose. The restricted soil depth and extreme rockiness would basically prevent any significant recovery for rehabilitation purposes.

REPRESENTATIVE SITE DESCRIPTION R1

SURFACE FEATURES: SITE 73

Soil Type	R1	
Concept	Relic surface of mesa, scree slopes and associated ironbark ridge.	
AMG Reference:	619500mE 7565200 mN	
Site No	73	
Australian Soil Classification	Variable. Mainly shallow Sodosol or Dermosol	
Landform Element	Upper slope / top of mesa.	
Landform Pattern	Jump-up – low hill - ridgeline	
Slope %	0 mesa top, 7 scree slope, 2% ridgeline	
Microrelief	None	
Surface condition		Sandy hard setting with extensive rock and gravel.
Land Condition		Quite bare.
Land Use		grazed by beef cattle – very low intensity
Major Vegetation Form and Type		A variety of vegetation (not described) on mesa tops. Margins are Brigalow and Leichardt Bean regrowth. Mixed grasses cover < 20%
Samples for analysis		Minor unit - not sampled
Land Suitability Summary. Stocking rates recommended by Bourne & Tuck (1993) for cleared pasture as >30 hectares/adult equivalent beast (AE) for long term sustainability.		**Cropping**: Class 5 not suitable cropping, significant moisture, workability, nutrients, and erosion potential. **Grazing**: Class 4 - Broadacre grazing if under sound management

Soil Profile: Site 73 Ironbark Ridgeline

	0-10 cm Very hard, Reddish Brown 5YR5/3 , sandy loam, no mottles, few coarse fragments, poor structure. Field pH 6.0, clear to;
	10-80cm Reddish to Yellowish Brown 7.5YR5/6, sandy clay, field pH 6.0, extensive gravels and rock. Refusal highly variable
	Vegetation : Narrow and Silver Leaf Ironbark, Poplar Box Topsoil Strip depth: nil . Area offers potential gravel resource. Preferred Rehabilitation

	Application: Unsuitable media – outside future mining area

6 TOPSOIL STRIPPING PROGRAMS

The areas of the survey area programmed for disturbance as a result of open-cut mining are mostly contained within the E1, B1, B2, A3 and A4 soils. Where such disturbance occurs, stripping of topsoil for reuse in rehabilitation programs will be required. The following comments are relevant for stripping of topsoil in these soil units.

The basic principle in determining useable depths of topsoil for rehabilitation is its quality in comparison to the spoil requiring rehabilitation. As a rule of thumb, the quality of the topsoil must exceed that of the spoil. While this may seem obvious, there are situations where additional problems have been created with the inappropriate use of topsoil. In addition, spoil can be expected to improve with years of exposure, leaching and plant colonisation and in some cases may provide better coverage than topsoil after an appropriate time-span.

Often, Brigalow soils associated with Tertiary sediments in Central Queensland (Bourne and Tuck, 1993) are sodic and saline at depth. The depth to the salt accumulation layer (or salt bulge) may be quite variable but greater than 40 cm in most cases. Most Brigalow subsoil which has accumulations of salt is not recommended for reuse in rehabilitation, not solely due to the salt but also the associated sodic conditions predisposing coarse handsetting behaviour.

This survey specifically evaluated subsoil conditions in this regard and found evidence of inhibitive salinity in certain soil types. The following table shows the pH and EC profile in 10 cm depth increments for each soil type. Basically the pH and EC profiles indicate that potential saline and sodic conditions may occur in brigalow clay soils in particular A3, A4, B1 and B2.

Table 6-1 Electrical Conductivity & pH Profiles for Major Soil Types

Depth (cm)	A1 (site4)		A3 (site42)		A4 (site57)		B1 (site 59)		B2 (site64)		E1 (site 24)	
	pH	EC (us/cm)	pH	EC (us/cm)	pH	EC (us/cm)	pH	EC (us/cm)	pH	EC (us/cm)	pH	EC (us/cm)
10	6.1	0.01	5.5	0.09	8.5	0.05	6.8	*0.10*	*6.2*	0.01	6.1	0.01
20	6.3 *(6.5)*	0.02 *(0.05)*	5.5 *(5.7)*	0.25 *(0.26)*	8.5 *(8.5)*	0.07 *(0.14)*	7.5 *(7.7)*	**0.43** ***(0.56)***	6.5 *(6.6)*	0.03 *(0.06)*	6.1 *(6.2)*	0.03 *(0.02)*
30	6.4	0.04	5.6	0.22	8.5	0.26	7.9	**0.54**	6.2	0.03	6.0	
40	6.5	0.01	6.8	**0.43**	8.6 *(8.4)*	**0.44** ***(0.50)***	8.0 *(8.1)*	**0.49** ***(0.48)***	7.7	0.29	6.5	0.01
50	7.1	0.04	7.0 *(7.1)*	**0.58** ***(0.50)***	8.5	**0.62**	8.0	**0.51**	8.0 *(8.3)*	0.38 *(0.42)*	6.5	0.05
60	7.5 *(7.7)*	0.02 *(0.03)*	7.4	**0.65**	8.4	**0.78**	8.1	**0.66**	8.1	**0.58**	6.8	0.01
70	7.5	0.04	7.9	**0.77**	8.4	**0.87**	8.0	**0.78**	8.2	**0.79**	6.7	0.04
80	7.5	0.04	8.0	**0.68**	8.4 *(8.3)*	***0.98*** ***(1.21)***	8.0 *(7.7)*	**0.86** ***(0.91)***	8.5 *(8.4)*	**1.22** ***(1.54)***	6.9 *(7.4)*	0.05 *(0.08)*
90	7.5 *(7.6)*	0.05 *(0.08)*	8.0 *(8.2)*	**0.74** ***(0.71)***	8.5	**1.05**	8.1	**0.88**	8.3	**1.19**	7.1	0.04

- pH and EC values determined by the author using a hand held Hanna instrument
- values in *(italics)* are those from NATA laboratory
- **Bold** highlight indicates salinity above levels which may affect pasture species

Overall, the area includes considerable reserves of topsoil that may be used in mine rehabilitation programs. The following comments are included to assist management decisions for topsoil. As a guide, all soils used in rehabilitation should be applied to no less than 250 mm. This provides sufficient depth for re ripping, should follow-up maintenance

work be required. Soils placed to 150 mm or less can be significantly contaminated by spoil when a single pass of deep ripping occurs.

Alluvial Soils A1, A3 and A4

The alluvial nature contributes to these soils being generally higher fertility (Bourne and Tuck, 2001). Alluvial soils included in this survey vary from deep well structured cracking clay (A4), deep light silty clay (A3) and deep uniform sandy or sandy duplex (A1). In addition, they may further vary within each group. More detailed auger inspections and pH/EC profiles will be needed to more precisely characterise maximum useable soil depth in each alluvial area.

All soils are well suited to rehabilitation and the recommended strip depth will vary accordingly. In summary, the average recommended strip depth nominated (for planning purposes, setting of works contracts etc) for each soil is;

A1	50 cm or within 10cm of subsoil clay layer
A3	30 cm
A4	30 cm

It is important to avoid inclusion of the harder, denser structured subsoils. Laboratory data (refer previous section) indicates that salinity below about 30 cm depth is an area of possible concern for soils A3 and A4. General fertility is acceptable in all soils. The sandy type soils of A1 will more readily germinate and support both grasses and native trees.

Brigalow B1 and B2 Soils

These soils are excellent quality topsoil due to well-balanced fertility, lighter, sandy clay texture and other attributes which will assist rapid establishment of small pasture or tree seed. The overall recommended strip depth is 20 cm (up to a maximum of 30 cm) as the soil below this depth is quite hard and coarse structured with increasing probability of salinity. The soils are suitable for application in all areas of rehabilitation, however should be preferentially used on sloping sites due to higher erosion resistance compared to sandy alluvial soils.

Poplar Box E1 Soils

Most of the undulating sandy poplar box country has at least 50 cm of sandy loam overlying the yellow/brown clay. As a general rule all of the sandy material may be retrieved for reuse on rehabilitation. It is important to ensure that no subsoil clay material is included as its presence will significantly decrease the value of the topsoil for rehabilitation by promoting conditions of surface sealing and erosion. A 50 cm strip depth is nominated.

On the upper ironbark ridge country with ironbarks, the depth of the sandy upper horizon is generally less than 40 cm.

R1 Soils

This unit includes minor mesa soils which are inaccessible and of a skeletal hard setting nature, with no application for rehabilitation. Sandy, gravelly ironbark soils along adjacent ridgelines may be stripped to within 10 cm of the subsoil clay layer which constitutes about 20 cm maximum possible soil suitable for stripping.

7 AGRICULTURAL LAND SUITABILITY

The relative suitability for beef cattle grazing as well as dryland cropping has been determined. Grazing of native and improved pastures by beef cattle has remained the dominant land use since agricultural development of the district. Cropping has not been practiced generally due to significant moisture, workability and fertility limitations.

The methodology used to identify agricultural suitability in this survey follows guidelines established by Land Resources Branch (1990), which is the basis for DME (1995), in addition to the work of Shields and Williams (1991) in the Kilcummin area. Other QDPI internet resources were utilised as considered necessary.

The land suitability classification identifies the types and severity of limiting factors for each land use on the different soil types present. Details of limiting factors and their assessment follow. Basically, suitability class is determined by the most severe limitation, or a combination of varying limitations.

Limiting factors

The following limitations are considered relevant to the suitability for rainfed cropping and grazing in the area of the mining leases. These were (using the DPI nomenclature in brackets):

- plant available water capacity (m);
- nutrient deficiency (n);
- soil physical factors (p);
- soil workability (k);
- salinity (s);
- rockiness (r);
- microrelief (g-gilgai);
- wetness (w);
- water erosion (e);
- flooding (f); and
- topography (t).

Land suitability class is determined by the highest ranking limiting factor or a combination of a number of factors. Normally, only the most severe two or three limiting factors would determine suitability and the remainder become irrelevant. For this reason, only the major limiting factors determining suitability are presented. In this survey, the main limiting factors which determined crop and grazing suitability class were plant available moisture (m), nutrient deficiency (n), soil physical factors (p), erosion (e) workability (k) and susceptibility to flooding (f).

Land suitability classification is based on specific land uses assessed using the following classes (based on Shields and Williams, 1991 and DME, 1995):

Class 1	Suitable land with negligible limitations and is highly productive requiring only simple management practices;
Class 2	Suitable land with minor limitations which either reduce production or require more than simple management practices to sustain the use;
Class 3	Suitable land with moderate limitations – Land which is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use;
Class 4	Marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long term; and
Class 5	Unsuitable land with extreme limitations that precludes its use.

7.1 PRE MINING LAND SUITABILITY

7.1.1 INTRODUCTION

Existing landuse and soils within the lease area have been described earlier. In summary, the soils suite includes:

Soil Type	Description
A1	Alluvial sandy duplex of mixed Poplar Box and Brigalow.
A3	Alluvial silty clay with open Poplar box with Brigalow and Flooded Coolibah.
A4	Alluvial plain of dark cracking clay with Brigalow.
E1	Poplar Box sandy duplex on undulating plains
E1 variant	Relic ridgelines above E1 with shallower duplex with Silver Leaf and Narrow Leaf Ironbark with Poplar Box.
B1	Uniform grey/brown clays with areas of gilgai on flat to gently undulating plains with Brigalow.
B2	Sandy uniform clay or thin red/brown duplex soils overlying weathered shale / mudstone with Brigalow on undulating plains. Sandy surface which is often gravelly.
R1	Shallow gravely loamy sands to sandy clay loams with extensive outcropping rock

All of the soils have been used for beef cattle grazing for many years. Only the better fine textured Brigalow scrub soils (*Picardy* AMU – Bourne and Tuck 1993) are known to have cropping potential in the district. None of *Picardy* type soils were in evidence in the survey area.

7.1.2 RAINFED CROPPING SUITABILITY

This classification evaluates the broad acre potential for growing non-irrigated cash crops, mainly sorghum and wheat.

Plant Available Water Capacity (m)

Plant available water capacity (PAWC) is a significant soil property in this locality as cropping is based on fallow storage of moisture in the soil profile. PAWC is the moisture stored in the soil profile that is available to the plant and is classically defined as the moisture present between field capacity and permanent wilting point by 15 bar measurement technique (Baker, D.E. and Eldershaw, V.J. 1993). **Table 7.1** shows the criteria which Shields and Williams (1991) proposed for assessment of the moisture availability limitation for crops in this region.

Table 7-1 PAWC Criteria for Assessing Cropping Limitations (Shields & Williams (1991)

Limitation Level	PAWC (mm)	Depth Of Black Cracking Clay (Effective Rooting Depth)	Predicted Cropping Success
2	>130	900 mm	70-75%
3	100-130	600 mm	40-70%
4	75-100	400 mm	<40%
5	<75	<400mm	<<40%

In this survey, PAWC for soil groups was assessed from site specific chemistry and effective rooting depth estimations developed in accordance with guidelines of Bourne and Tuck (1991) and DME (1995). Effective rooting depth and PAWC estimations were further refined from observed field morphology which facilitated the alignment and comparison of PAWC profiles determined in Shaw and Yule (1978) and Shields and Williams (1991). Field morphology observations and chemical data used included soil texture, barriers to root growth such as high sodium, gravel, poor soil structure, high electrical conductivity and chloride.

Conclusions for soils in this survey area are shown in **Table 7.2** which indicates that the Brigalow clays of B1 hold significant water that can be effectively used for pastures. At the other end of the scale are the sandy duplex (E1) which typically have less than 80mm PAWC.

Shields considered crops on land whose only major limitation was moisture (m4) would only succeed in 4 of every 10 years in this district.

Table 7-2 Estimated PAWC & Limitation Levels for Isaac Plains

Soil Type	Effective Rooting Depth (Cm)	PAWC (mm)	Available Plant Moisture Limitation (M) – Refer Table 1.	
			Dryland cropping	Beef cattle grazing
A1	40-100	70-100	5	3
A3 A4	40 – 50	70-80	5	2
E1	50 - 60	60-80	5	3
B1	30-80	80-120	5	2
B2	30 -50	80-100	5	2
R1	10- 200	20- 40	5	4

On a field morphology basis, the only potential for dryland cropping is on the alluvial A4 cracking clay scrub soils which have been assessed as moisture limitation m4 which Shields considers would only succeed in less than 40% of years. Saline subsoils were found in analysis of all Brigalow soils (A3, A4, B1, B2) suggesting variable salinity profiles in all Brigalow clay soils including the A4. In addition, the spatial extent of the soil is not large and isolated from any other areas of soils with cropping potential, and would probably render the area unsuitable for crops due to management restrictions (access by machinery). It is likely that the inputs required to achieve and maintain an reasonable level of production would outweigh the benefits so, given these factors, A4 is not considered suitable cropping land by the authors.

Susceptibility to Water erosion (e)

The risk of soil loss from water erosion magnifies with increased water velocity when land is devoid of vegetation for cropping. In the undulating Brigalow soil unit of B2, this risk has been assessed as low to moderate, with limitation levels of 2 -3 applied. During this survey, some evidence of erosion was observed under a grazing use but it was not considered severe. Erosive effects would increase under cropping.

Nutrient deficiency (n)

Shields states that soil nutrient deficiency has not been recognised as a major problem for crop production on traditionally cultivated soils in the Central Highlands. Although most soils described in this survey are not the 'traditional cultivated soil' to which Shields refers (G. Tuck pers com), the levels of nutrient deficiency found are not severe. The major soil types have levels of limitation between 2 and 3.

Salinity (s)

This refers to the reduction in dry matter yield as a result of soluble salt in the soil profile. It also contributes to reduced water availability limitation. Increasing salinity in the soil profile (below 40cm) was evidenced across all Brigalow soil types (A3, A4, B1 and B2). In this survey, no specific limitation level has been assigned with the effect of salinity incorporated into moisture availability estimations which directly affects PAWC and hence suitability.

Soil Physical Factors (p)

This limitation deals with conditions which determine sufficient seed contact with moist soil to prevent desiccation prior to germination and establishment. One such condition applies to clay soils which have a narrow moisture content suitable for cultivation as they are susceptible to compaction and smearing when wetter than the plastic limit. Trafficability is also limited by high clay content and moisture retention on the clay soils.

The brown clay soils in the survey area have potential to compact with resulting structure decline under the lowest limitation assigned for soil physical factors was a p2 limitation for the A4 soils while the maximum limitation was p3 for the sandy duplex E1.

Rockiness (r)

Rockiness refers to the amount of rock out crop and coarse fragments greater than 6 cm in diameter. Plough zones 30 cm depth with 10% or less rock was considered to be r1, r2 was 10-20%, r3 was 20-30%, r4 30-40% and r5 50% or greater. Apart from R1, no soils were identified with significant rock.

Flooding (f)

Flooding may limit cropping opportunities due to the high risk of erosion of cultivated soil as well as loss of access in critical times. The highest erosion risk occurs in summer with the majority of rainfall coming in intense storms. Flooding risk also increases the risk of crop and pasture improvement failure due to water logging, particularly during establishment. Flooding limitation is a real issue for A3 and A4 but is generally considered minor in comparison to the limitations discussed above.

Topography (t)

Topography is assessed in terms of slope and micro-relief. Slope may limit the effective and safe use of machinery and contribute to erosion hazard. While (t) is a factor in this survey, it is not a major determining factor.

7.1.3 SUITABILITY FOR BEEF CATTLE GRAZING

The assessment process adopted in his report follows that used by Shields and Williams (1991). Apart from the addition of vegetation regrowth (v) as a limiting factor, the same limitations assessed for cropping were also used to access suitability for grazing of improved buffel grass pastures.

Class 1 to 3 lands are considered suitable for significant pasture improvement; class 4 offers marginal potential for pasture improvement, and class 5 is not suitable for improvement and restricted to grazing of native pastures with low productivity. Major limiting factors are assigned a severity rating (1-5) with the most severe being the overall suitability class for that soil type.

All soil units are suited to a beef cattle grazing with potential for improved buffel pastures. Basically, most soils do not have significant limitations to a grazing use with the incorporation of sound management practices and have potential for pasture improvement. For these reasons, most of the survey area has long since been cleared.

Plant Available Water Capacity (m)

Pasture production occurs in a shallower root zone than cropping systems and 60 cm of rooting depth in clay soils is considered to be adequate for pastures to achieve maximum production (Shields and Williams, 1991). Limitation levels for grazing are shown in **Table 7-3**

Table 7-3 Land Suitability For Cattle Grazing – PAWC (Shields & Williams)

LAND SUITABILITY CLASS					
	1	2	3	4	5
Moisture (M)	PAWC>125mm	PAWC 100-125mm	PAWC 75-100mm	PAWC 50-75mm	PAWC<50mm

Nutrient deficiency (n)

These were rated from soil analysis data of surface horizons using DME 1995. Shields and Williams (1991) state that a major limiting factor to pasture production in northern Australia is reduced pasture quality as a result of deficiencies in nitrogen and phosphorus. Other elements which also play key roles are potassium and calcium. The clay Brigalow soils (A3,

A4, B1, B2) were generally adequate however the sandy duplex Poplar Box dominated soils (E1) were low fertility.

Salinity (s)

This refers to the reduction in dry matter yield as a result of soluble salt in the soil profile. It also contributes to reduced water availability limitation. Increasing salinity in the soil profile (below 40cm) was evidenced across all Brigalow soil types B1, B2, A3 and A4. In this survey, no specific limitation level has been assigned with the effect of salinity incorporated into effective rooting depth estimations which directly affects PAWC and hence suitability.

Soil Physical Factors (p)

Physical factors refer to restrictions in the establishment and vigour of pastures as a result of soil surface condition and are typically related to the size of surface aggregates which affects tendencies to seal and hardset.

Shields (1991) considers the establishment and spread of most pasture species is restricted on hard setting surface soils such as sandy loam to clay loam textures which are extensive in this survey area.

In cracking clays such as the A4 alluvia, variable levels of moisture alters the soil to seed relationships for small seeded species such as buffel and Rhodes grass which increases establishment problems. When such soils are dry, seeds may be lost down large cracks, desiccate in airspaces or rapidly dry out after germination in the porous soil.

Susceptibility to Water Erosion (e)

Some evidence of water erosion was noticed in the survey area with the major areas of concern confined to B2 soils. Most of the survey area has slope gradients < 1% which constitute only minor limitation level. Table 7-4 shows slope limits for erosion limitation of DME 1995.

Table 7-4 Land Suitability For Cattle Grazing Land Effects Of Slopes

Limitation rating					
	1	2	3	4	5
Cracking clays	<3% slope	Slopes 3-6%	Slopes 6-9%	Slopes 9-15%	>15%
Sodic rigid soils	<1% slope	Slopes 1-3%	Slopes 3-6%	Slopes 6-12%	>12%

Rockiness (r), Microrelief (g), Wetness (w) Flooding (f) Vegetation regrowth (v)

These limitations in the grazing context were considered minor and would not contribute any significant weighting in the classification of grazing land suitability in the survey area. Other limiting factors discussed above were all more significant. Only a limited number of improved species persist in areas which are subject to frequent or extended inundation and was also considered to be a low level limitation only in some stream channel areas.

No regrowth limitations were assigned for any of the soil types, with A4 being the most prominent Brigalow regrowth.

7.1.4 SUMMARY OF PRE-MINE LAND SUITABILITY

The land suitability of the proposed Project area is summarised in Table 7-5.

Table 7-5 Land Suitability Classes – Pre-Mining

Soil Unit	Description	Cropping		Grazing		Preferred use
		Major Limitations and Severity	class	Major Limitations and Severity	class	
A1	Alluvial sandy duplex of mixed Poplar Box and Brigalow.	moisture – m5 workability – k3 soil physical factors – p2 nutrients – n2 flooding – f2	5	moisture – m3 nutrients – n3 soil physical factors – p2	3	Grazing native pastures. Deep sandy A horizon improves short term water availability (e.g. storm rain is immediately available) but limits long term storage.
A3	Alluvial silty clay with open Poplar box with Brigalow and Flooded Coolibah.	moisture – m5 workability – k4 soil physical factors – p3 nutrients – n2	5	moisture – m2 nutrients – n1 soil physical factors – p2	2	Grazing native pastures. Deep silty clay assists moisture availability and root exploitation
A4	Alluvial plain of dark cracking clay with Brigalow.	moisture – m4 workability – k3 soil physical factors – p3 salinity – s3	4	erosion susceptibility e2 moisture – m2 nutrients – n2	2	Grazing of improved pastures, Productive grazing lands with possibility of opportunist forage in good years.
E1	Poplar Box sandy duplex on undulating plains	moisture – m5 erosion susceptibility e4 workability – k4 soil physical factors – p4 nutrients – n3	5	erosion susceptibility e2 moisture – m3 nutrients – n2 soil physical factors – p2	3	Grazing of improved pastures. Deep sandy A horizon improves water retention and use of small rainfall events e.g. thunderstorms for pastures
B1	Uniform grey/brown clays with areas of gilgai on flat to gently undulating plains with Brigalow.	moisture – m5 workability – k4 soil physical factors – p3 nutrients – n3 salinity– s3	5	moisture – m2 nutrients – n2 wetness – w3 physical factors – p3	2	Salinity observed below 20cm in representative site. Brigalow regrowth a problem.
B2	Sandy uniform clay or thin red/brown duplex soils overlying weathered shale / mudstone with Brigalow on undulating plains. Sandy surface which is often gravelly.	moisture – m5 nutrients – n2 soil physical factors – p4 salinity – s3	5	moisture – m2 nutrients – n2	2	Hard subsoil structure and sealing sandy surface restricts moisture. Also, saline subsoils.
R1	Shallow gravely loamy sands to sandy clay loams with extensive outcropping rock	moisture – m5 workability – k4 erosion – e4 nutrients – n4 soil physical factors – p4	5	moisture – m4 erosion – e3 nutrients – n2 soil physical factors – p2	4	Broad scale grazing can be sustained if well managed.

7.1.5 EXISTING LAND CONDITION

Observations were made at each sampling site of estimated pasture cover % and general state of the land in terms of erosion, vegetation condition and degradation generally. At the time of the survey, the area had endured extended periods of extremely dry weather with all soil profiles completely dry to the depth of sampling. In terms of viewing evidence of land degradation from past grazing practices, there was no better time.

Overall, the survey area is in quite good condition and appeared to have been used in accordance with land suitability. Comments follow for specific aspects.

Erosion

The original soils in units B2 would probably have been a texture contrast soil with a thin sandy surface layer over the clay B horizon. In most cases, the thin surface had been either wholly or partially removed by sheet wash. This is a common occurrence for such soils and has not significantly impacted suitability.

Some soils have dispersive subsoils and apart from localized areas of A1, most subsoils have not been exposed. In the main, the land was not severely depleted from erosion.

Structural decline

No evidence of compaction as a result of overgrazing was in evidence apart from localized areas such as water points and holding yards. No cultivation has been conducted.

Stocking rates

No specific data was obtained of historical rates. However, the condition of pastures did not indicate overgrazing was occurring.

Vegetation Vigor

Pasture cover varied from 40 – 70% with most sites in the 60% area. This cover was quite good in view of seasonal experiences. Most of the original vegetation has been removed and regrowth in most areas is well controlled. Most remnant vegetation remaining was along creek lines and the Isaac River.

There was a significant cover of Parthenium in the clay A4, B2 and B1 following good earlier rain. No significant occurrences of other noxious species were observed.

Fertility

Fertility levels for each soil type have been described previously. Overall, fertility levels recorded were quite good with some results quite surprising in terms of surface fertility. There is no evidence to suggest that fertility has been degraded as a result of grazing use.

Property Management

Farm infrastructure was well maintained and the property appears to be very well managed.

7.2 POST-MINE LAND USE SUITABILITY

Factors influencing changes in land suitability following mining include changed physical, chemical and biological properties of soil, changes in slope and slope length and changes in soil depth. The suitability of the waste rock dumps for cropping and grazing is constrained by slope angle, the nature of soil cover, and altered moisture profile. These constraints would increase the risk of erosion significantly if cropping or grazing were undertaken.

The plateaus of the final waste dump landforms are not considered suitable for rainfed cropping as it would require the replacement of a black cracking clay profile of approximately 900 mm depth and the installation of suitable soil conservation works, and that is not practical. The erosional stability of the waste dump plateau may also be compromised by grazing. It is also isolated from other pastures and suitable watering points and so was not considered suitable for sustained grazing.

It is anticipated that a significant net reduction in land suitability rating will result from mining and subsequent rehabilitation.

Rainfed Cropping

No areas considered suitable for rainfed cropping were identified in the survey area and from knowledge and experience by the authors in the Bowen basin coal industry, none are envisaged in post-mine lands.
Table 7-6 shows the changes in land suitability for cropping use. The changes will result in no loss of significant cropping capacity of affected land.

Table 7-6 Cropping Pre & Post Mine Capability Change

Class	Description	Pre-Mining Area (Ha)	Estimated Post- Mining Area (Ha)
1	Suitable land with negligible limitations and is highly productive requiring only simple management practices.	0	0
2	Suitable land with minor limitations which either reduce production or require more than simple management practices to sustain the use.	0	0
3	Suitable land with moderate limitations – Land which is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use.	0	0
4	Marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long term.	461.4	403.9
5	Unsuitable land with extreme limitations that precludes its use.	2691.2	2748.7
TOTALS		***3152.6***	***3152.6***

Attachments 4a and 5a outline Pre-Mine and Post-Mine Cropping Suitabilities.

Cattle Grazing

The pre- and post-mining areas of land suitable for cattle grazing are shown in **Table 7.7**.
Much remains to be demonstrated that grazing is a sustainable land use on mine rehabilitation areas and no definitive standards exist. Nevertheless, the authors have proposed a grazing use scenario below.

Limitations for beef cattle grazing are similar to those for rainfed cropping, with the addition of vegetation regrowth (v) (Shields and Williams, 1991). In grazing trials conducted at BMA Blackwater and Norwich Park Mines, results have led to proposals for limitation levels for grazing which are fundamentally based on slope gradient. (G.Tuck, P. Baker pers experience). These levels basically define slopes < 11% as constituting class 3/4 grazing lands with erosion susceptibility being the major limiting factor governing the class. Slope gradient from 11 – 17% are also being trialled for grazing but are highly prone to degradation from erosion if not managed appropriately.

Consequently, only lands <11% are considered as realistic grazing lands in this report. Mine rehabilitation areas which exceed this gradient include various waste rock dump areas including their margins, ramps and final voids which are unlikely to sustain this use unless considerable regrading effort is undertaken.

Table 7-7 Grazing Pre & Post Mine Land Suitability Change

Class	Description	Pre-Mining Area (Ha)	Post Mining Area (Ha)
1	Suitable land with negligible limitations and is highly productive requiring only simple management practices;	0	0
2	Suitable land with minor limitations which either reduce production or require more than simple management practices to sustain the use;	1626.9	1135.3
3	Suitable land with moderate limitations – Land which is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use;	1525.7	1351.7
4	Marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long term; and	0	0
5	Unsuitable land with extreme limitations that precludes its use.	0	665.6
TOTALS		***3152.6***	***3152.6***

Attachments 4b and 5b outline the projected grazing suitability of the site for pre- and post-mining phases.

Bushland Use

Many opencut mines in the Bowen Basin have a stated aim of native bushland use/suitability at completion of rehabilitation after mining has ceased. This is a fundamentally conservative enduse which, given the climatic limitations in the region, is the preferred use of the site. A higher use such as grazing is feasible, but will require the implementation of a very conservative landform design involving the formation of slopes generally less than 11%, and or rock lining of batters of dumps as well as a probable ongoing higher maintenance costs compared to surrounding lands.

7.3 GOOD QUALITY AGRICULTURAL LAND (GQAL)

The Planning Guidelines: The Identification of Good Quality Agricultural Land (DLGP and DPI, 1993) establishes four Classes of agricultural land for Queensland. Class A Land in all areas is considered to be good quality agricultural land. In some areas Class B land (where agricultural land is scarce) and better quality Class C land (where pastoral industries predominate) may also be considered to be good quality agricultural land. The description of the classes is as follows.

Class A Crop Land – land suitable for current and potential crops with limitations to production which range from non to moderate levels.

Class B Limited Crop Land – land that is marginal for current and potential crops due to severe limitations; and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping.

Class C Pasture Land – land suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production. Some areas may tolerate a short period of ground disturbance for pasture establishment. C1 designates suitability for improved pastures. C2 designated land is suitable for native pasture.

Class D Non-agricultural Land – land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop or poor drainage.

In Belyando Shire, QDPI have identified the presence of crop land (Class A), marginal crop land (Class B) and land suitable for improved pastures (Class C1). About 60% of the project area has been categorised as C1 - land suitable for improved pastures. The GQAL area designated on the DPI GQAL map sourced from Emerald DRNM&E is shown as Figure 3.

Thus on his basis, much of the proposed mining area forms part of GQAL (as would much of central Queensland for that matter as the region is well suited to pasture improvement). The following extract from the GQAL map provided by DRNM&E Emerald office shows that most of the site falls within C1 land suitability classification.

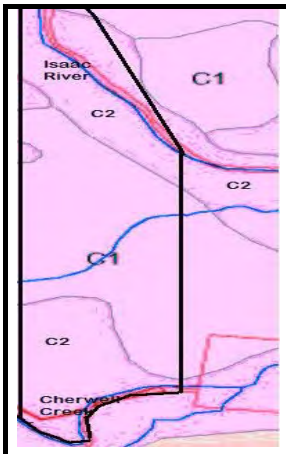


Figure 3 GQAL – Isaac Plains Project

The plan shows that there is no GQAL cropping in the area. However the C1 land which makes up most of the mine lease area is considered to be suited for grazing under improved pasture.

However, this soil survey indicates that much of the C2 land is also suitable for improved pasture. Buffel grass has been either sown into or pioneered much of the study area and grass cover is generally quite good, except for minor areas of relict mesa/ridge and for dark vertisols (Alluvial plain of dark cracking clay with Brigalow) which occurs in lower lying areas, close to on major drainage lines.

SPP 1/92 provides a framework for development to be assessed that considers the value of GQAL. The policy acknowledges that there will be developments that can legitimately alienate GQAL because they represent an overriding benefit to the community.

The Project is considered to provide the following overriding community benefits in that it:

- Allows the utilisation of the coal resources of the State;
- Provide substantial employment within Belyando Shire and elsewhere in Queensland;
- Allows the continuation and expansion of a locally significant industry that provides substantial export income to the State;

- There is no alternative location on land of lesser agricultural quality. The Project location is dictated by the position of the coal reserves; and
- The land is typical of medium quality grazing land in the region.

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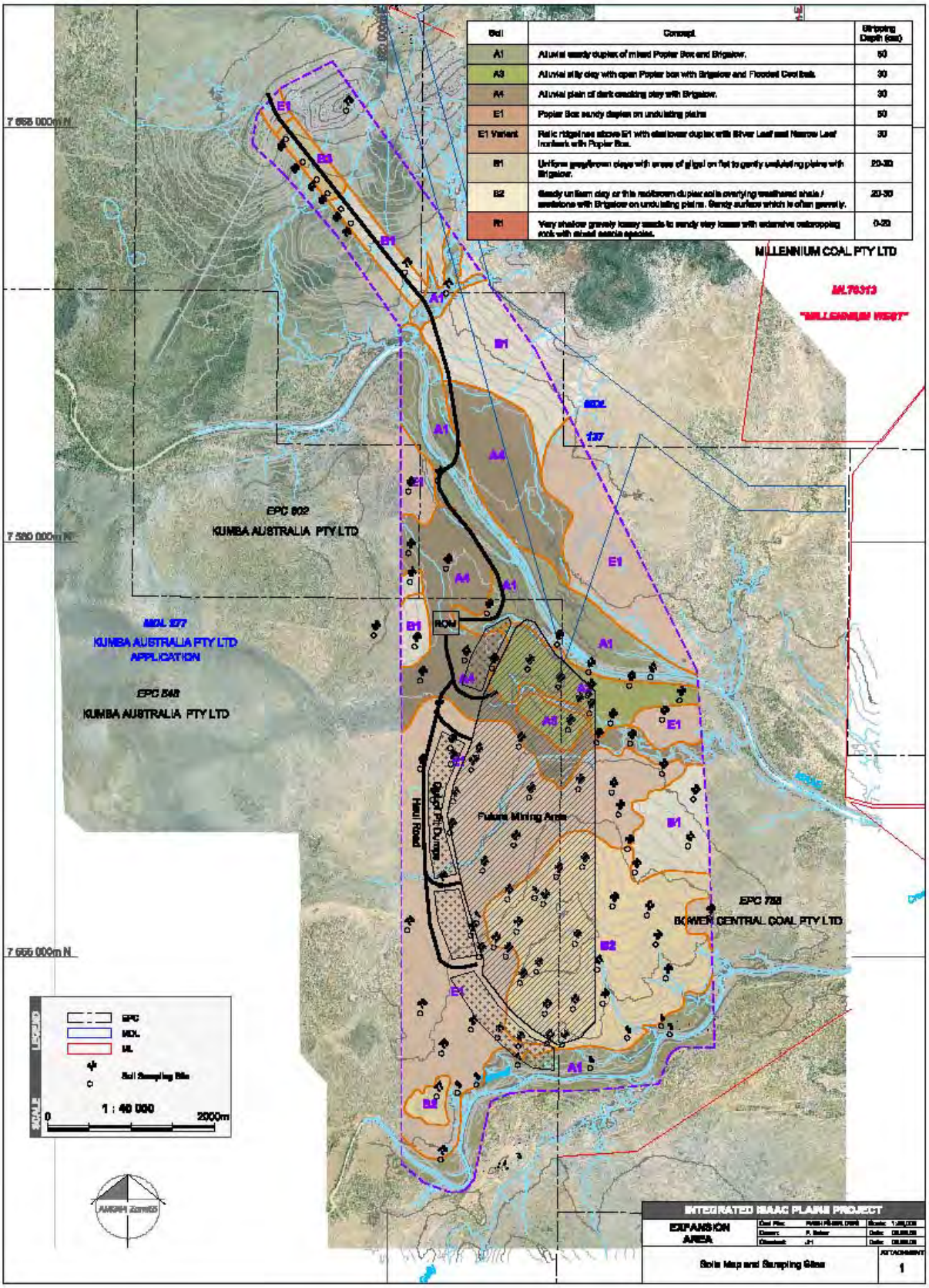
ATTACHMENTS


Soil | Concept | Stripping Depth (cm)
A1 | Alluvial sandy duplex of mixed Poplar Box and Brigalow. | 50
A3 | Alluvial silty clay with open Poplar box with Brigalow and Flooded Gum flats. | 30
A4 | Alluvial plain of dark cracking clay with Brigalow. | 30
E1 | Poplar Box sandy duplex on undulating plains | 50
E1 Variant | Relic ridges rise above E1 with deep lower duplex with Silver Leaf and Narrow Leaf Ironbark with Poplar Box. | 30
B1 | Uniform grey/brown clays with areas of gilgai on flat to gently undulating plains with Brigalow. | 20-30
B2 | Sandy uniform clay or thin red/brown duplex soils overlying weathered shale / sediments with Brigalow on undulating plains. Sandy surface which is often gravelly. | 20-30
R1 | Very shallow gravelly loamy sands to sandy clay loams with extensive outcropping rock with mixed acacia species. | 0-20
MILLENNIUM COAL PTY LTD
ML70313
"MILLENNIUM WEST"
EPC 602
KUMBA AUSTRALIA PTY LTD
MDL 277
KUMBA AUSTRALIA PTY LTD
APPLICATION
EPC 548
KUMBA AUSTRALIA PTY LTD
EPC 752
BOWEN CENTRAL COAL PTY LTD
Future Mining Area
Haul Road
Dump
ROM
7 555 000m N
LEGEND
EPC
MDL
ML
Soil Sampling Site
SCALE
1 : 40 000
0
2000m
AMG84 Zone55
INTEGRATED NIAAC PLAINS PROJECT
EXPANSION AREA
Soils Map and Sampling Sites
ATTACHMENT
1

ATTACHMENT 2 - SITE DESCRIPTIONS

SITE	SOIL	EASTING	NORTHING	LANDFORM / COMMENTS	SOIL PROFILE	SAMPLES
1	B2	621180	7555594	Brigalow regrowth with Blackbutt	0-15 cm pH 6.5, sandy clay, 5YR4/4, no incl's. 15-55 cm pH 6.0, med clay, 2.5YR4/6, no bleach or incls. 55-100 cm pH 6.0, Medium clay, 75YR5/5, some grey mottles 100-120+ BC	
2	B2	621878	7555895	Slight ridge, rocky, hard sandy surface	uniform brown clay	
3	A1	623500	7554250	Deep alluvial sand of River red Gum, Moreton Bay Ash. Thick Buffel with no tree /shrub regrowth. Level and loose sandy surface	0-20 cm Organic stain. Loamy coarse sand, 7.5YR34, pH 5.5, massive. 20-110+ cm LCS 7.5YR5/6, pH 6.5, massive.	
4	**A1**	623400	7554350	Alluvial plain, firm sandy surface, no rocks. Poplar Box, (RE11.3.2)	0-10 cm pH 6.0, loamy sand, 5.0YR3/4. 10-60 cm pH 6.0, 7.5YR4/4, loamy sand. 60-90 cm pH 6.0, 7.5YR5/6, loamy sand, no mottle 90-150+ cm pH 6.0, 5.0YR5/6, sandy light clay,	0-20 50-60 90-100
5	B2	622991	7554207	Undulating sandy Brigalow. Cleared. 1.5% slope.	Reddish brown sandy surface. Gravelly. 0-15 cm SC, pH 6.0, 5YR4/6 15-85 cm MC, pH 6.5, hard angular, 5YR5/6 85+ cm BC	
6	A1	622547	7553846	Creek alluvia mainly Poplar Box with Brigalow. very good Buffel	Sandy duplex. 0-25 cm sandy loam, 10YR4/4, pH 6.0, weak structure, no coarse fragments or inclusions, 25-30 cm conspicuous bleach pH 6.0 30-80+ cm very hard weakly structured and dense yellow clay. 10YR5/8. pH 7.0.	
7	E1v	621676	7553883	Low ridge with Silver leaf ironbark, bloodwood and Mountain Coolibah.	Sandy surface with termite mounds. 0 – 35 cm sandy loam 7.5yR4/4. pH 6.0. 35cm gravel over clay.	
8	E1v	621177	7553646	*E crebra, E populnea* ridge.	Red sandy. 0-40 cm 5YR 4/4, sandy loam over yellowish brown clay, mottled.	
9	B2	620952	7553548	Gravelly ridge Brigalow and box.	Uniform brown clay. sandy hard set surface.	
10	E1	621680	7554107	Tall open box duplex	Loose sandy surface no gravel. 0-45 cm coarse sand, 7.5YR5/4, pH 6.0, 45-50 cm gravelly layer above clay. 50 – 100+ cm lcmight sandy clay. pH 7.0, some mottles and no inclusions.	
11	**E1v**	621430	7554212	Low ridge line of E crebra, E populnea, Bloodwood. termite mounds.	Yellow duplex. Surface firm and sandy. few gravels. 0-30 cm sandy loam, 7.5YR3/4, pH 6.0, no bleach. 30-45 cm sandy loam, 7.5YR 4/4, 45-120+ cm light clay, no mottles, pH 6.0, 10YR5/6.	0-20 40-50
12	B2	622029	7554138	Gently undulating plain. 1% slope. Brigalow and cassia brewerstrii. Gravelly in places	0-5 cm sandy clay loam ,pH 7.0, 5YR4/6 5-10 cm SCL, pH 6.5, 75YR4/4, v hard, 10- 55 cm SC, pH 8.5, 7.5YR5/4, v hard, carb nodules. 55-65 cm GSA weathered sandstone	
13	B2	622000	7554500	Same as 12	0-15 cm Sandy clay, pH 6.5, 7YR4/3, weak structure	

SITE	SOIL	EASTING	NORTHING	LANDFORM / COMMENTS	SOIL PROFILE	SAMPLES
					15-45 cm Med clay, hard, pH 7.0, 7.5YR4/4, moderate gravel / stone, 45-100+ cm, pH 8.0, Med clay, hard 7.5YR5/4, grey / yellow mottles	
14	B2/E1	622207	7554129	Boundary site		
15	B2	622334	7554557	Midslope of gently undulating plain 1% slope. Minor Brigalow regrowth <1M with mainly open Buffel pasture	Non cracking sandy clay no gravel. 0-20 cm pH 6.0, SC, 5.5YR4/4, moderate structure SB. 20 - 60+ cm ironstone gravels incorporated with pale and very hard Medium clay.	
16	B2	622695	7554625	Crest of low ridge. Brigalow Blackbutt.	Sandy surface with 10% gravel. 0-35 cm light sandy clay. 7.5YR 5/4, pH 7.0, 35-90 cm sandy clay, 10YR4/4, pH 8.0, some carb nodules, hard.	
17	B2	622627	7555028	Same as 16 but only 0.5% slope. no gravel. hardset sandy surface.		
18	B2	622363	7555343	Ridge top in gently undulating plain 1-2% slope. Cleared pasture 70% cover. Small regrowth Brigalow with Currant Bush. Odd small gilgai.	Scattered surface gravel. Non-cracking sandy hardsetting. 0-20 cm Light clay fine sandy texture, weak granular structure, pH 7.0, 5YR4/6. 20-60 cm Whole coloured 7.5YR4/6. pH 7.5, moderate SB structure. medium clay, no inclusions. 60-100+ cm as for B21 horizon with gravels and weathered PM increasing.	
19	B2	621899	7555003	Blackbutt, Bauhinia, Currant Bush, ,Brigalow. 0.5% slope. hard sandy surface.	0-15 cm SL, pH 6.5,10YR4/3, weak structure 15-45 cm Med clay, hard, 7.0, 7.5YR4/4, moderate gravel / stone, 45-100+ cm pH 8.0, Med clay hard 7.5YR4/4, grey / yellow mottles	
20	B2	621705	75544870	Brigalow	uniform clay. Hard setting sandy surface. Few gravel. 0-40 cm SCL, 7.5YR4/4, pH 6.0, no bleach 10 - 60+ cm Very hard yellowish brown clay. Some mottles. pH 7.0.	
21	E1	621112	7554309	Sandy poplar box	deep duplex	
22	E1	621533	7555187	Midslope, poplar box. sandy. good pasture.	0-40 cm sandy clay loam, pH 6.0, 7.5YR5/4, no mottles. 40 – 70+ cm medium yellowish brown clay with some mottling,	
23	E1	621210	7555182	Box duplex slightly shallower A horizon depth	0-25 cm sandy loam, 7.5 YR5/4, no bleach 25 – 30 cm gravelly layer over yellow clay	
24	**E1**	621107	7555444	Box duplex. gently undulating plain. sandy surface with no gravel. strong pasture cover.	0-60 cm loamy sand, 7.5YR4/4, pH 6.6, no inclusions or bleach. 60-120+ cm sandy clay, heavily mottled (red & grey). pH 7.0, 7.5YR 5/6.	0-20 70-80
25	E1/B2	621389	7555300	boundary site		
26	B2	621656	7555489	Midslope of Brigalow undulating plain.	Sandy UF 0-40 cm pH 6.0. 7.5YR4/4 moderate structure, Sandy clay, no bleach. 40-110 cm pH 6.5 7.5YR4/4 hard angular blocky, med clay no mottles or inclusions. 110 – 180 cm pH 7.0 grey mottles and PM.	
27	B2	621550	7555879	Flat plain Brigalow, no gravel	uniform clay	
28	B2	622453	7556269	Ridge top of red/brown non	Red hard setting UF.	

SITE	SOIL	EASTING	NORTHING	LANDFORM / COMMENTS	SOIL PROFILE	SAMPLES
				cracking clay slope 2% on long gently undulating plain. Regrowth of occasional stunted Brigalow. Surface is sandy, hard and no gravel	0-20 cm 2.5YR4/4, pH 5.5, SC, hard and sandy over, 20- 60+ cm red MC with extensive laterite gravel up to 20cm diameter. pH 6.0	
29	B2	622140	7556150	Same as 27		
30	E1	622993	7556487	Poplar box duplex		
31	B1	623080	7556200	Shrubby Brigalow regrowth & Currant Bush. Buffel 60%, slope 2%, surface sandy and 20% ironstone.	0 - 35 cm Dark yellowish brown 10YR4/4. Sandy clay. Field pH 7.5, some surface carbonate nodules, no gravel, no bleach or mottles, clear to; 35 – 100+ cm Brown 10YR5/4 , Medium heavy clay, few yellow mottles, little gravel, Very hard sub angular blocky. Field pH 7.0,	
32	B2	623229	7555687	Midslope of 3% slope.	Sandy B2 soil with some surface gravel.	
33	E1	623970	7555650	Poplar box duplex		
34	B2	623331	7555333	Scattered Brigalow regrowth <1M with mainly open Buffel pasture and odd Blackbutt. Topsoil strip 20cm. Crest of undulating plain slope < 0.5%.	Non cracking sandy clay 0-20 cm pH 6.0, SC, 5.5YR4/4, moderate structure SB. 20 - 60+ cm Lots of ironstone gravels incorporated with pale and very hard MC.	
35	B2	623452	7554926	Undulating plain. Slope 0.5%. Regrowth of Brigalow 60% Buffel cover.	Gravelly surface with red brown sandy clay loam over MC. Thin duplex. 0-3 cm sandy clay loam. pH 5.5, no structure. 5YR5/4 3-10 cm coarse sandy clay. Very hard. Poor structure. No gravel. pH 6.5. 5YR4/4 10-30+ cm very gravelly with over 60% of material lateritic gravels up to 30mm diameter. Red 2.5YR3/4.	
36	E1	622882	7556900	Box duplex. rise in gently undulating plain.	0-50 cm loamy coarse sand, 7.5YR4/6, pH 6.0, no bleach. 50-90+ cm sandy clay, mottled (red & grey). pH 7.0, 7.5YR 5/6.	
37	E1	622803	7557164	same as 36		
38	E1	622401	7557209	Box duplex. Midslope	0-45 cm loamy sand, 7.5YR4/4, pH 6.5, 45-100+ cm sandy clay, 7.5YR 5/4.	
39	A1	622620	7557768	Brigalow bauhinia alluvia	0-35 cm medium clay, pH 7.5, 10YR4/6 35-100 cm med clay pH 8.5 10YR5/4, slight mottle	
40	A1	622532	7558117	Mixed poplar box Brigalow alluvia	Uniform sandy clay	
41	A1	622516	7558328	Flat sandy mixed veg alluvia		
42	**A3**	622527	7558353	Alluvia. Cleared flat plain of previous Poplar box and possibly Brigalow.	Sandy crust surface. No gravel. 0-40 cm silty clay, 10YR5/4, pH 6.5, no inclusions, weak structure. 40-120+ cm. silty clay. pH 7.5, 10YR4/4, no inclusions	0-20 40-50 80-90
43	A3	623012	7558450	Open poplar box	same as 42	
44	A1	622526	7558611	Isaac river channel. Very sandy surface, no rocks. Poplar Box, River red gum, Casuarina, Bauhinia, Moreton Bay Ash and Brigalow	0-30 cm pH 7.5, Sandy clay,10YR44 30-90+ cm pH 7.5 10YR54, Medium clay, no mottle	
45	A1	622146	7558946	Same as 44		
46	A1	621686	7557718	Flat, Blackbutt bauhinia	0-30 cm sandy clay, pH 6.5, 10YR4/6	

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				alluvia	30-90 cm med clay pH 7.5 10YR5/6,	
47	E1	621185	7557583	Poplar box	Sandy duplex. 0-45 cm sandy loam, weak structure, pH 6.0, 7.5YR5/4, no bleach. 45-70+ cm sandy clay, pH 6.5, whole coloured, very dry and hard, weak S/B structure, 7.5YR 4/4.	
48	E1	620870	7557507	Same as 47	0 – 35 cm 7.5YR4/3, sandy loam, no mottles, loose and massive. pH 6.0, 35 - 75+ Brown 7.5YR4/3, medium clay (sandy), mottled, no inclusions, field pH 7.0, very hard angular blocky	
49	E1	620501	7557450	Same as 48		
50	E1	620863	7557699	Same as 48		
51	E1	620900	7557058	Dead cleared poplar box	Surface sets hard and sandy. No surface gravel. 0-55 cm sandy loam, weak structure, pH 6.0, 7.5YR5/4, no bleach. 55-100+ cm sandy clay, pH 6.5, whole coloured, very dry and hard , weak S/B structure, 7.5YR 4/4.	
52	E1	620650	7557080	As 51		
53	E1	620861	7556677	As 51. very thick pasture		
54	E1	621116	7557437	Midslope. Poplar box duplex	Sandy A horizon 50 cm over clay	
55	A3	622161	7558437	Open country with odd Blackbutt	uniform silty clay to 70+ cm	
56	A4	621364	7558662	Flooded coolibah	Uniform black clay	
57	**A4**	621035	7558755	Cleared Brigalow black cracking clay flat alluvia. Thick Parthenium.	Minor surface crust, sandy. 0-45 cm medium clay, 10YR3/3, pH 9.0, carb. nodules, sub angular blocky. 45-100+ cm medium heavy clay, 10YR4/2, pH 9.0, carb nodules, lenticular structure.	0-20 30-40 70-80
58	A4	620505	7558511	Same as 57	Uniform dark clay to at least 60 cm as 57.	
59	**B1**	620438	7558921	Midslope above A4 alluvia. Slope 2%. Brigalow regrowth	Surface sandy, firm no stone. 0-30 cm sandy clay, pH 6.5, no inclusions, weak S/B structure, 10YR3/4. 30-65 cm medium clay sandy, 10YR4/3, pH 6.5, no bleach or inclusions, 65-100+ cm medium clay, 10YR5/4, pH 6.5	0-20 30-40 79-80
60	E1	619945	7559060	Mid-upper slope 1%, poplar box. sandy. good pasture.	0-45 cm sandy clay loam, pH 6.0, 7.5YR5/4, no mottles. 45 – 100+ cm medium yellowish brown clay with red/grey mottling, pH 6.5	
61	E1	620380	7559701	Same as 60	Sandy A horizon is 50 cm to clay	
62	A3	622788	7558000	Old poplar box and possibly Brigalow prior to clearing	Sandy surface. No gravel. 0-40 cm silty clay, 10YR4/4,pH 6.5, no inclusions, 40-100+ cm. silty clay. pH 7.5, 10YR5/4, no inclusions	
63	E1	623412	7558040	Undulating 1% slope, poplar box. sandy.	0-40 cm sandy clay loam, pH 5.5, 7.5YR4/4, no mottles. 40 – 80+ cm medium yellowish brown clay with some mottling, pH 6.0	
64	**B2**	621981	7555820	Gently undulating plain. Slope 0.5%. Brigalow carissa regrowth. 50% buffel cover.	Sandy hardsetting surface with 15% ironstone gravel strew. Non cracking. 0-20 cm sandy clay, 7.5YR4/4,	0-20 40-50 70-80

SITE	SOIL	EASTING	NORTHING	LANDFORM / COMMENTS	SOIL PROFILE	SAMPLES
				Land in good condition not eroded.	moderate sub-angular structure, pH 7.0, no bleach or inclusions. 20-65 cm 7.5YR3/3, hard with some carbonate nodules, pH 8.0, no bleach. 65-100+ cm yellow clay 7.5YR5/4, hard with restricted drainage, pH 8.0.	
65	R1	618547	7564385	Very minor area of sandy duplex with *E crebra* and associated species including Poplar Box.	0-25 cm loamy sand, pale coloured, pH 5.5. 25-65+ cm gravelly clay, pH 6.0,	no samples taken
66	B2	618665	7564339	Upper slope off the ironbark ridge. Brigalow / Poplar Box regrowth 3-4% slope.	Very gravelly with stone up to 20 cm diameter. Thin duplex over hard clay	
67	B2	618934	7564213	Base of slope. 50% cobble on surface which is sandy. Brigalow regrowth.	0-25 cm grey medium clay, 7.5YR3/6, pH 8.0, hard. 25-35 cm zone of carbonate accumulation. clay. 35-60 cm weathered parent material increasing (about 50%) 60+ cm weathered shale / mudstone.	
68	B2	619102	7564094	Same as 67. Flatter 1% slope. Brigalow	Sandy N/C clay. A horizon is 40cm over pale clay.	
69	B1	619377	7563946	Lower slope position. Gravelly Better soil starts here. Strip 3cm	UF brown. 0-40 cm Sandy clay. pH 7.5, 10YR3/4, no gravel or inclusions. 40-90+ cm medium clay, 7.0, 10YR4/2, some mottles, moderate SB structure.	
70	B1	619557	7563845	Crest 0% slope. 10% cobble. Lots Parthenium	Grey Brigalow clay. Non cracking with firm sandy crusting surface. 0-30 cm pH 6.5. 10YR4/3 SB structure, SC, no bleach. 30-100+ cm pH 6.5 10YR5/4 hard angular blocky, no mottles.	
71	A1	620701	7563000	Alluvia of mixed Brigalow/ bauhinia/ poplar box.	This sandy duplex over sandy clay.	
72	B1	620207	7563251	Grey Brigalow clay. Slope 1%.	Non cracking with firm sandy crusting surface. 0-40 cm pH 6.0. 10YR4/4 moderate SM structure, SC, no bleach. 40-100+ cm pH 6.5 10YR5/6 hard angular blocky, no mottles,	
73	R1	619500	7565200	Mesa – mixed acacias.	Shallow rocky skeletal soils with extensive outcropping rock.	
74	E1	620350	7555506	Gently undulating 1% slope, poplar box. sandy.	0-45 cm sandy clay loam, pH 5.5, 7.5YR4/4, no mottles. 45 – 90+ cm medium yellowish brown clay, pH 6.0	
75	E1	620751	7556043	Same as 74	A horizon 35 cm	
76	E1	620502	7554508	Same as 74	A horizon 50 cm	
77	B2	620702	7553502	Upper slope position. 2% gradient. Brigalow regrowth	Sandy N/C clay 0-40 cm pH 6.0. 7.5YR4/4 moderate SM structure, SC, no bleach. 40-110 cm pH 6.5 7.5YR4/4 hard angular blocky, no mottles increasing gravels.	
78	A1	620749	7552741	Poplar Box with Brigalow and mixed species.	Sandy duplex. 0-30 cm sandy loam, 10YR4/4, pH 6.0, weak structure, no coarse fragments or inclusions, 30-80+ cm very hard weakly structured and dense yellow clay. 10YR5/8. pH 7.0.	
79	E1	620761	7554022	Poplar box undulating plain	Surface sets hard and sandy. No surface gravel. 0-45 cm sandy loam, weak structure,	

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					pH 6.0, 7.5YR5/4, no bleach. 45-100+ cm sandy clay, pH 6.5, whole coloured, very dry and hard , weak S/B structure, 7.5YR 4/4.	
80	B2	622811	7555792	Brigalow. Reddish brown hardsetting surface. Slope 1-2%.	Hard sandy surface with 10% gravel strew. 0-10cm Light sandy clay, weak structure, pH 5.5, no inclusions. 7.5YR4/4. 10-35 cm 50% laterite gravels 35-60 cm Brown light clay under gravel layer. 10YR5/4, mod SB structure, well drained, pH 7.0	
81	B1	623720	7556520	Lower slope position. Gravelly H/S surface, Brigalow, Bauhinia regrowth. Small area Poplar Box nearby. Strip 40cm	UF brown. 0-40 cm sandy clay. 7.5, 10YR4/4, no gravel or inclusions. 40-90+ cm medium clay, pH 8.0, 10YR5/2, some mottles, moderate SB structure.	
82	B1	623783	7557084	Surface is hardsetting, sandy and quite gravelly. Grey/brown generally non cracking	0-30 cm Sandy clay, pH 6.5, weak sub angular blocky, 7.5YR5/4, no bleach. 30-90 cm Medium clay, pH 7.0, coarse angular blocky, hard, 7.5YR4/4, 90+ cm medium clay, pH 7.0, increasing gravels and PM	
83	E1	623404	7557393	Poplar box undulating plain	A horizon is 45 cm over clay	
84	A3	623615	7558272	Alluvia. Cleared flat plain.	Sandy surface. No gravel. 0-45 cm silty clay, 10YR5/4, pH 6.5, no inclusions, weak structure. 45-120+ cm. silty clay. pH 7.5, 10YR4/4, no inclusions	
85	A3	622280	7557921	same as 84		
86	A4	623025	7557752	Cleared Brigalow black cracking clay flat alluvia.	deep cracking dark clay	
87	A1	623272	7558554		Thin duplex. Hardsetting sandy surface. Few gravel. 0-10 SCL, 7.5YR4/4, 6.0, no bleach 10+ lots gravel in hard pale yellowish brown clay. Some mottles. pH 7.0.	
88	A3	621795	7558651	Same as 84		
89	A1	621306	7559322	Deep alluvial sand of River red Gum, Moreton Bay Ash. Thick buffel with no tree /shrub regrowth. Level and loose sandy surface	0-20 cm Organic stain. Loamy coarse sand, 7.5YR34, pH 5.5, massive. 20-110+ cm LCS 7.5YR5/6, pH 6.5, massive.	
90	A4	620811	7559862	Same as 86		
91	A1	620710	7560921	60% buffel cover, flat alluvial plain, some no surface gravel.	Non cracking clay, hardsetting quite bare surface 0-50 cm Sandy clay. Very hard and coarse structure. No inclusions, pH 6.5, 5YR4/4. 50-90+ cm medium clay,. pH 7.0, 7.5YR5/4.	
92	E1	620364	7560794	Poplar box undulating plain	Sandy duplex	
93	A4	620362	7560048	Cleared Brigalow black cracking clay flat alluvia. Thick Parthenium.	0-40 cm medium clay, 10YR3/2, pH 8.0, carb. nodules, 40-90+ cm medium clay, 10YR4/2, pH 9.0, carb nodules,	
94	E1	620704	7558135	Poplar box undulating plain	Sandy duplex	
95	E1	621810	7557106	Poplar box undulating plain	Sandy duplex – A horizon 45 cm	
96	E1	621625	7556532	Poplar box undulating plain	Sandy duplex	
97	E1	621255	7556223	Poplar box undulating plain	Sandy duplex – A horizon 50 cm	

ATTACHMENT 3 - ANALYTICAL DATA AND LABORATORY DETAILS

Analysis Results (SOIL)
Date Printed : 21 Jul 2006
Additional Comments
You should consult your local agronomist and/or Phosyn representative before deciding upon any course of action based on this report.
Calcium (Ca): 1 meq/100g equals 200ppm
Magnesium (Mg): 1 meq/100g equals 120ppm
Sodium (Na): 1 meq/100g equals 230 ppm
Potassium (K): 1 meq/100g equals 390 ppm
Aluminium (Al): 1 meq/100g equals 90 ppm

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SITE 4 0-20 19/07/06 B022771-01 / SG0516	**SITE 4 50-60 19/07/06** B022771-02 / SG0517	**SITE4 90-100 19/07/06** B022771-03 / SG0518
pH [H_2O] 6.5 pH [$CaCl_2$] 5.8 Organic Matter (%) 0.6 CEC (meq/100g) 5.3 EC (dS/m) 0.05 NO_3-N (ppm) 5.2 Phosphorus [Olsen] (ppm) 9 Potassium (meq/100g) 1.10 Calcium (meq/100g) 2.81 Magnesium (meq/100g) 0.93 Sulphur (ppm) 4 Boron (ppm) 0.1 Copper (ppm) 0.3 Iron (ppm) 28 Manganese (ppm) 52.2 Zinc (ppm) 1.0 Aluminium (meq/100g) 0.24 Sodium (meq/100g) 0.2 Chloride (ppm) <1 Ca base saturation (%) 53.1 K base saturation (%) 20.8 Mg base saturation (%) 17.6 Na base saturation (%) 4.0 Ca:Mg Ratio 3.0 Aluminium (%) 4.5	pH [H_2O] 7.7 pH [$CaCl_2$] 7.0 Organic Matter (%) <0.5 CEC (meq/100g) 4.5 EC (dS/m) 0.03 NO_3-N (ppm) 1.4 Phosphorus [Olsen] (ppm) 4 Potassium (meq/100g) 0.88 Calcium (meq/100g) 2.60 Magnesium (meq/100g) 0.63 Sulphur (ppm) 2 Boron (ppm) <0.1 Copper (ppm) 0.4 Iron (ppm) 20 Manganese (ppm) 31.5 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.19 Sodium (meq/100g) 0.2 Chloride (ppm) <1 Ca base saturation (%) 57.8 K base saturation (%) 19.6 Mg base saturation (%) 14.0 Na base saturation (%) 4.4 Ca:Mg Ratio 4.1 Aluminium (%) 4.2	pH [H_2O] 7.6 pH [$CaCl_2$] 6.8 Organic Matter (%) 0.5 CEC (meq/100g) 9.9 EC (dS/m) 0.08 NO_3-N (ppm) 18.8 Phosphorus [Olsen] (ppm) <1 Potassium (meq/100g) 0.55 Calcium (meq/100g) 6.03 Magnesium (meq/100g) 2.78 Sulphur (ppm) 5 Boron (ppm) 0.6 Copper (ppm) 0.4 Iron (ppm) 30 Manganese (ppm) 13.6 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.18 Sodium (meq/100g) 0.4 Chloride (ppm) 18 Ca base saturation (%) 60.7 K base saturation (%) 5.5 Mg base saturation (%) 28.0 Na base saturation (%) 3.9 Ca:Mg Ratio 2.2 Aluminium (%) 1.8

SITE11 0-20 19/07/06 B022771-04 / SG0519	**SITE 11 40-50 19/07/06** B022771-05 / SG0520
pH [H_2O] 5.9 pH [$CaCl_2$] 5.1 Organic Matter (%) 0.7 CEC (meq/100g) 3.7 EC (dS/m) 0.01 NO_3-N (ppm) <1.0 Phosphorus [Olsen] (ppm) 2 Potassium (meq/100g) 0.55 Calcium (meq/100g) 1.79 Magnesium (meq/100g) 0.96 Sulphur (ppm) 3 Boron (ppm) 0.1 Copper (ppm) 0.4 Iron (ppm) 32 Manganese (ppm) 30.5 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.13 Sodium (meq/100g) 0.2 Chloride (ppm) 4 Ca base saturation (%) 48.9 K base saturation (%) 15.0 Mg base saturation (%) 26.2 Na base saturation (%) 6.3 Ca:Mg Ratio 1.9 Aluminium (%) 3.6	pH [H_2O] 6.2 pH [$CaCl_2$] 5.8 Organic Matter (%) 1.4 CEC (meq/100g) 11.3 EC (dS/m) 0.05 NO_3-N (ppm) 2.9 Phosphorus [Olsen] (ppm) <1 Potassium (meq/100g) 0.79 Calcium (meq/100g) 5.43 Magnesium (meq/100g) 4.20 Sulphur (ppm) 6 Boron (ppm) 0.8 Copper (ppm) 0.5 Iron (ppm) 27 Manganese (ppm) 5.8 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.11 Sodium (meq/100g) 0.8 Chloride (ppm) 28 Ca base saturation (%) 48.1 K base saturation (%) 7.0 Mg base saturation (%) 37.2 Na base saturation (%) 6.6 Ca:Mg Ratio 1.3 Aluminium (%) 1.0

SITE 24 0-20 19/07/06 B022771-06 / SG0521	**SITE 24 70-80 19/07/06** B022771-07 / SG0522
pH [H_2O] 6.2 pH [$CaCl_2$] 5.5 Organic Matter (%) 0.6 CEC (meq/100g) 2.7 EC (dS/m) 0.02 NO_3-N (ppm) 1.7 Phosphorus [Olsen] (ppm) 2 Potassium (meq/100g) 0.43 Calcium (meq/100g) 1.61 Magnesium (meq/100g) 0.42 Sulphur (ppm) 3 Boron (ppm) <0.1 Copper (ppm) 0.3 Iron (ppm) 26 Manganese (ppm) 26.0 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.08 Sodium (meq/100g) 0.1 Chloride (ppm) 9 Ca base saturation (%) 60.1 K base saturation (%) 16.0 Mg base saturation (%) 15.7 Na base saturation (%) 5.2 Ca:Mg Ratio 3.8 Aluminium (%) 3.0	pH [H_2O] 7.4 pH [$CaCl_2$] 7.0 Organic Matter (%) 1.3 CEC (meq/100g) 11.8 EC (dS/m) 0.08 NO_3-N (ppm) <1.0 Phosphorus [Olsen] (ppm) <1 Potassium (meq/100g) 0.76 Calcium (meq/100g) 5.33 Magnesium (meq/100g) 4.52 Sulphur (ppm) 4 Boron (ppm) 1.7 Copper (ppm) 0.3 Iron (ppm) 23 Manganese (ppm) 9.7 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.18 Sodium (meq/100g) 1.1 Chloride (ppm) 78 Ca base saturation (%) 45.0 K base saturation (%) 6.4 Mg base saturation (%) 38.2 Na base saturation (%) 8.9 Ca:Mg Ratio 1.2 Aluminium (%) 1.5

SITE 42 0-20 19/07/06 B022771-08 / SG0523	**SITE 42 40-50 19/07/06** B022771-09 / SG0524	**SITE 42 80-90 19/07/06** B022771-10 / SG0525
pH [H_2O] 5.7 pH [$CaCl_2$] 5.3 Organic Matter (%) 1.7 CEC (meq/100g) 10.0 EC (dS/m) 0.26 NO_3-N (ppm) 91.4 Phosphorus [Olsen] (ppm) 3 Potassium (meq/100g) 0.49 Calcium (meq/100g) 6.07 Magnesium (meq/100g) 2.48 Sulphur (ppm) 13 Boron (ppm) 0.3 Copper (ppm) 1.2 Iron (ppm) 51 Manganese (ppm) 39.9 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.31 Sodium (meq/100g) 0.6 Chloride (ppm) 65 Ca base saturation (%) 60.9 K base saturation (%) 4.9 Mg base saturation (%) 24.9 Na base saturation (%) 6.2 Ca:Mg Ratio 2.5 Aluminium (%) 3.1	pH [H_2O] 7.1 pH [$CaCl_2$] 6.7 Organic Matter (%) 2.4 CEC (meq/100g) 24.5 EC (dS/m) 0.50 NO_3-N (ppm) 24.5 Phosphorus [Olsen] (ppm) <1 Potassium (meq/100g) 0.55 Calcium (meq/100g) 9.54 Magnesium (meq/100g) 11.18 Sulphur (ppm) 22 Boron (ppm) 2.0 Copper (ppm) 1.3 Iron (ppm) 28 Manganese (ppm) 19.6 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.07 Sodium (meq/100g) 3.2 Chloride (ppm) 428 Ca base saturation (%) 38.9 K base saturation (%) 2.2 Mg base saturation (%) 45.6 Na base saturation (%) 12.9 Ca:Mg Ratio 0.9 Aluminium (%) 0.3	pH [H_2O] 8.2 pH [$CaCl_2$] 7.5 Organic Matter (%) 1.2 CEC (meq/100g) 30.0 EC (dS/m) 0.71 NO_3-N (ppm) 5.9 Phosphorus [Olsen] (ppm) <1 Potassium (meq/100g) 0.62 Calcium (meq/100g) 10.53 Magnesium (meq/100g) 14.81 Sulphur (ppm) 113 Boron (ppm) 6.2 Copper (ppm) 1.1 Iron (ppm) 22 Manganese (ppm) 41.2 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.08 Sodium (meq/100g) 4.0 Chloride (ppm) 602 Ca base saturation (%) 35.1 K base saturation (%) 2.1 Mg base saturation (%) 49.4 Na base saturation (%) 13.2 Ca:Mg Ratio 0.7 Aluminium (%) 0.3

SITE 57 0-20 19/07/06 B022771-11 / SG0526	**SITE 57 30-40 19/07/06** B022771-12 / SG0527	**SITE 57 70-80 19/07/06** B022771-13 / SG0528
pH [H_2O] 8.5 pH [$CaCl_2$] 8.0 Organic Matter (%) 2.1 CEC (meq/100g) 52.5 EC (dS/m) 0.14 NO_3-N (ppm) 1.1 Phosphorus [Olsen] (ppm) <1 Potassium (meq/100g) 1.29 Calcium (meq/100g) 34.15 Magnesium (meq/100g) 14.91 Sulphur (ppm) 5 Boron (ppm) 1.3 Copper (ppm) 1.6 Iron (ppm) 38 Manganese (ppm) 38.1 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.10 Sodium (meq/100g) 2.0 Chloride (ppm) 6 Ca base saturation (%) 65.1 K base saturation (%) 2.5 Mg base saturation (%) 28.4 Na base saturation (%) 3.9 Ca:Mg Ratio 2.3 Aluminium (%) 0.2	pH [H_2O] 8.4 pH [$CaCl_2$] 7.9 Organic Matter (%) 2.4 CEC (meq/100g) 56.6 EC (dS/m) 0.50 NO_3-N (ppm) 42.9 Phosphorus [Olsen] (ppm) <1 Potassium (meq/100g) 1.20 Calcium (meq/100g) 33.60 Magnesium (meq/100g) 17.77 Sulphur (ppm) 13 Boron (ppm) 2.6 Copper (ppm) 1.6 Iron (ppm) 38 Manganese (ppm) 43.1 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.07 Sodium (meq/100g) 4.0 Chloride (ppm) 260 Ca base saturation (%) 59.4 K base saturation (%) 2.1 Mg base saturation (%) 31.4 Na base saturation (%) 7.0 Ca:Mg Ratio 1.9 Aluminium (%) 0.1	pH [H_2O] 8.3 pH [$CaCl_2$] 7.9 Organic Matter (%) 2.1 CEC (meq/100g) 52.1 EC (dS/m) 1.21 NO_3-N (ppm) 2.7 Phosphorus [Olsen] (ppm) <1 Potassium (meq/100g) 1.13 Calcium (meq/100g) 26.64 Magnesium (meq/100g) 19.61 Sulphur (ppm) 129 Boron (ppm) 9.6 Copper (ppm) 1.3 Iron (ppm) 33 Manganese (ppm) 51.5 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.08 Sodium (meq/100g) 4.6 Chloride (ppm) 630 Ca base saturation (%) 51.2 K base saturation (%) 2.2 Mg base saturation (%) 37.7 Na base saturation (%) 8.8 Ca:Mg Ratio 1.4 Aluminium (%) 0.2

SITE 59 0-20 19/07/06 B022771-14 / SG0529	**SITE 59 30-40 19/07/06** B022771-15 / SG0530	**SITE 59 70-80 19/07/06** B022771-16 / SG0531
pH [H_2O] 7.7 pH [$CaCl_2$] 7.1 Organic Matter (%) 3.5 CEC (meq/100g) 35.5 EC (dS/m) 0.56 NO_3-N (ppm) 42.1 Phosphorus [Olsen] (ppm) 9 Potassium (meq/100g) 1.30 Calcium (meq/100g) 22.61 Magnesium (meq/100g) 9.60 Sulphur (ppm) 63 Boron (ppm) 1.8 Copper (ppm) 1.7 Iron (ppm) 40 Manganese (ppm) 16.0 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.08 Sodium (meq/100g) 1.9 Chloride (ppm) 272 Ca base saturation (%) 63.7 K base saturation (%) 3.7 Mg base saturation (%) 27.1 Na base saturation (%) 5.3 Ca:Mg Ratio 2.4 Aluminium (%) 0.2	pH [H_2O] 8.1 pH [$CaCl_2$] 7.5 Organic Matter (%) 2.8 CEC (meq/100g) 33.0 EC (dS/m) 0.48 NO_3-N (ppm) 10.5 Phosphorus [Olsen] (ppm) 2 Potassium (meq/100g) 0.99 Calcium (meq/100g) 15.82 Magnesium (meq/100g) 12.65 Sulphur (ppm) 18 Boron (ppm) 2.8 Copper (ppm) 2.0 Iron (ppm) 32 Manganese (ppm) 8.5 Zinc (ppm) 0.3 Aluminium (meq/100g) 0.07 Sodium (meq/100g) 3.5 Chloride (ppm) 324 Ca base saturation (%) 47.9 K base saturation (%) 3.0 Mg base saturation (%) 38.3 Na base saturation (%) 10.6 Ca:Mg Ratio 1.3 Aluminium (%) 0.2	pH [H_2O] 7.7 pH [$CaCl_2$] 7.0 Organic Matter (%) 1.4 CEC (meq/100g) 26.5 EC (dS/m) 0.91 NO_3-N (ppm) 4.7 Phosphorus [Olsen] (ppm) <1 Potassium (meq/100g) 0.77 Calcium (meq/100g) 8.88 Magnesium (meq/100g) 12.48 Sulphur (ppm) 4 Boron (ppm) 2.4 Copper (ppm) 1.6 Iron (ppm) 28 Manganese (ppm) 14.4 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.06 Sodium (meq/100g) 4.3 Chloride (ppm) 1119 Ca base saturation (%) 33.5 K base saturation (%) 2.9 Mg base saturation (%) 47.1 Na base saturation (%) 16.3 Ca:Mg Ratio 0.7 Aluminium (%) 0.2

SITE 64 0-20 19/07/06 B022771-17 / SG0532	**SITE 64 40-50 19/07/06** B022771-18 / SG0533	**SITE 64 70-80 19/07/06** B022771-19 / SG0534
pH [H_2O] 6.6 pH [$CaCl_2$] 6.1 Organic Matter (%) 4.4 CEC (meq/100g) 22.7 EC (dS/m) 0.06 NO_3-N (ppm) 5.0 Phosphorus [Olsen] (ppm) 3 Potassium (meq/100g) 0.83 Calcium (meq/100g) 18.04 Magnesium (meq/100g) 3.15 Sulphur (ppm) 8 Boron (ppm) 0.8 Copper (ppm) 2.5 Iron (ppm) 45 Manganese (ppm) 41.8 Zinc (ppm) 0.4 Aluminium (meq/100g) 0.15 Sodium (meq/100g) 0.6 Chloride (ppm) 16 Ca base saturation (%) 79.3 K base saturation (%) 3.6 Mg base saturation (%) 13.9 Na base saturation (%) 2.5 Ca:Mg Ratio 5.7 Aluminium (%) 0.7	pH [H_2O] 8.3 pH [$CaCl_2$] 7.9 Organic Matter (%) 2.7 CEC (meq/100g) 40.6 EC (dS/m) 0.42 NO_3-N (ppm) <1.0 Phosphorus [Olsen] (ppm) <1 Potassium (meq/100g) 0.91 Calcium (meq/100g) 21.78 Magnesium (meq/100g) 13.92 Sulphur (ppm) 12 Boron (ppm) 1.5 Copper (ppm) 2.9 Iron (ppm) 43 Manganese (ppm) 29.4 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.06 Sodium (meq/100g) 4.0 Chloride (ppm) 333 Ca base saturation (%) 53.6 K base saturation (%) 2.2 Mg base saturation (%) 34.3 Na base saturation (%) 9.7 Ca:Mg Ratio 1.6 Aluminium (%) 0.1	pH [H_2O] 8.4 pH [$CaCl_2$] 7.9 Organic Matter (%) 1.5 CEC (meq/100g) 60.0 EC (dS/m) 1.54 NO_3-N (ppm) <1.0 Phosphorus [Olsen] (ppm) <1 Potassium (meq/100g) 0.73 Calcium (meq/100g) 39.45 Magnesium (meq/100g) 15.29 Sulphur (ppm) 162 Boron (ppm) 5.3 Copper (ppm) 1.2 Iron (ppm) 20 Manganese (ppm) 14.1 Zinc (ppm) <0.1 Aluminium (meq/100g) 0.06 Sodium (meq/100g) 4.4 Chloride (ppm) 1093 Ca base saturation (%) 65.8 K base saturation (%) 1.2 Mg base saturation (%) 25.5 Na base saturation (%) 7.4 Ca:Mg Ratio 2.6 Aluminium (%) 0.1

PARTICLE SIZE FRACTIONS AND BICARB P

ESSA ENVIRONMENTAL

5 Dunphy St

Sunnybank Hills Q 4343

Reference Number: **06-09386-01**

Sample Status: **as received**

Date Received: **24-7-2006**

Date Completed: **31-7-2006**

Printed: **31-7-2006**

NA denotes "not applicable"

IS denotes "insufficient sample"

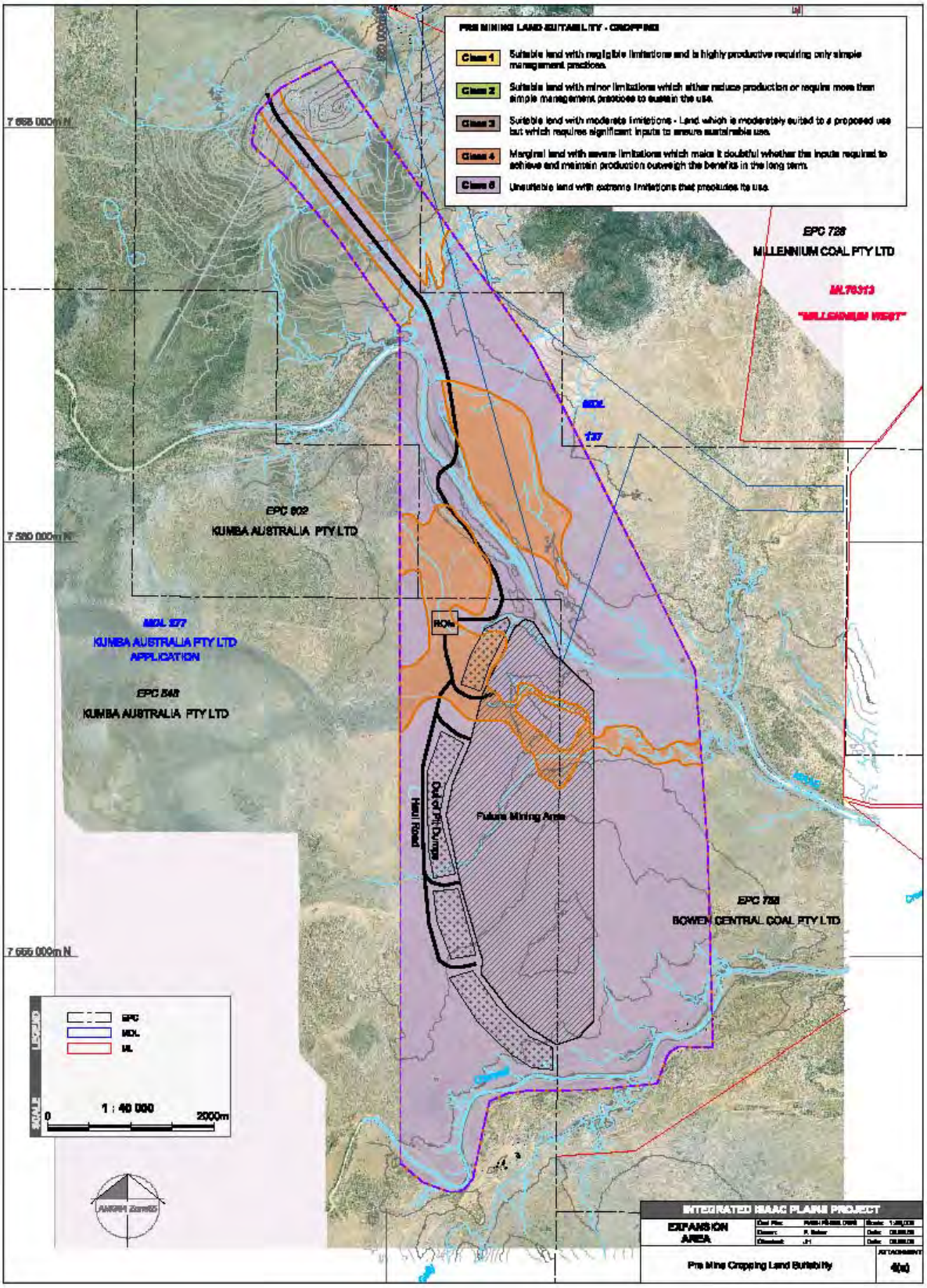
MS denotes "missing sample"

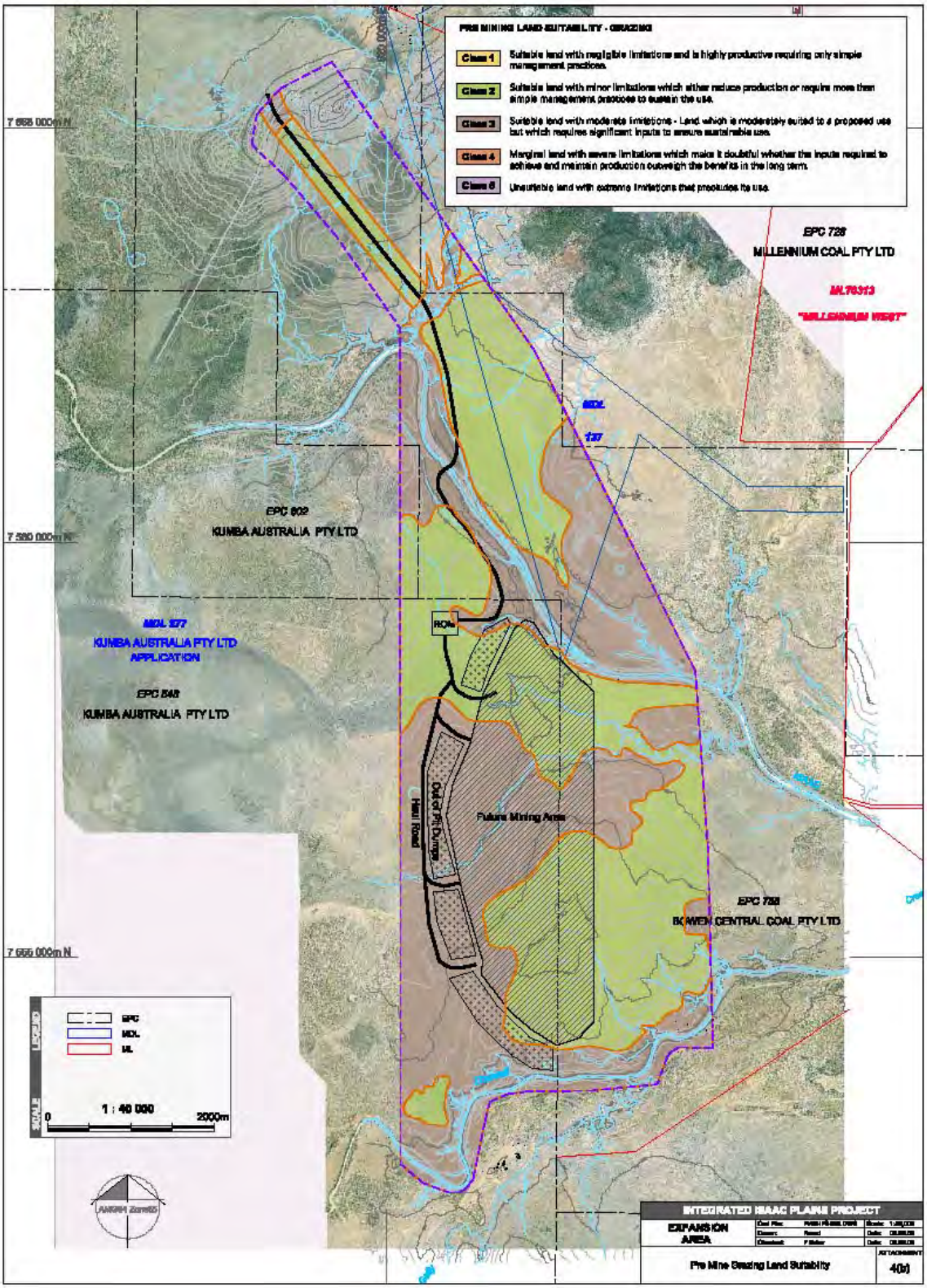
<LOQ denotes "below limit of quantitation"

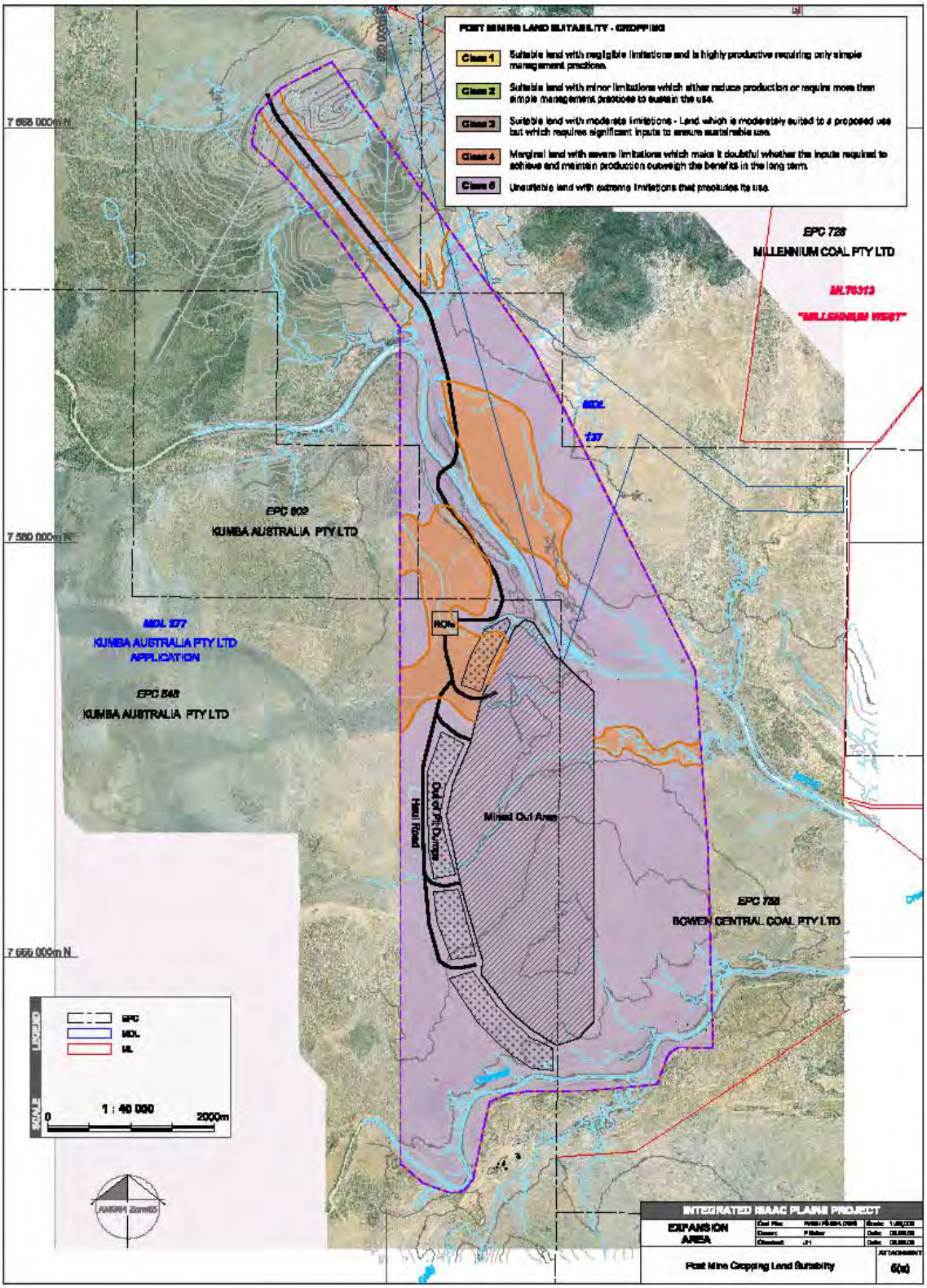
Sample ID	Lab No.		Bicarb. P (mg/kg)	CS (%)	FS (%)	SILT (%)	CLAY (%)
SITE 4 (0 - 20 cm)	06/09386		**18**	**15**	**72**	**8**	**5**
SITE 4 (50 - 60 cm)	06/09387		**10**				
SITE 4 (90 - 100 cm)	06/09388		**3**				
SITE 11 (0 - 20 cm)	06/09389		**3**	**38**	**48**	**5**	**8**
SITE 11 (40 - 50 cm)	06/09390		**2**				
SITE 24 (0 - 20 cm)	06/09391		**2**	**43**	**45**	**5**	**5**
SITE 24 (70 - 80 cm)	06/09392		**<LOQ**				
SITE 42 (0 - 20 cm)	06/09393		**10**	**23**	**38**	**21**	**19**
SITE 42 (40 - 50 cm)	06/09394		**3**				
SITE 42 (80 - 90 cm)	06/09395		**<LOQ**				
SITE 57 (0 - 20 cm)	06/09396		**4**	***5***	**17**	**15**	**65**
SITE 57 (30 - 40 cm)	06/09397		**5**				
SITE 57 (70 - 80 cm)	06/09398		**2**				
SITE 59 (0 - 20 cm)	06/09399		**17**	**21**	**20**	**15**	**47**
SITE 59 (30 - 40 cm)	06/09400		**7**				
SITE 59 (70 - 80 cm)	06/09401		**<LOQ**				
SITE 64 (0 - 20 cm)	06/09402		**10**	**13**	**33**	**22**	**36**
SITE 64 (40 - 50 cm)	06/09403		**2**				
SITE 64 (70 - 80 cm)	06/09404		**<LOQ**				

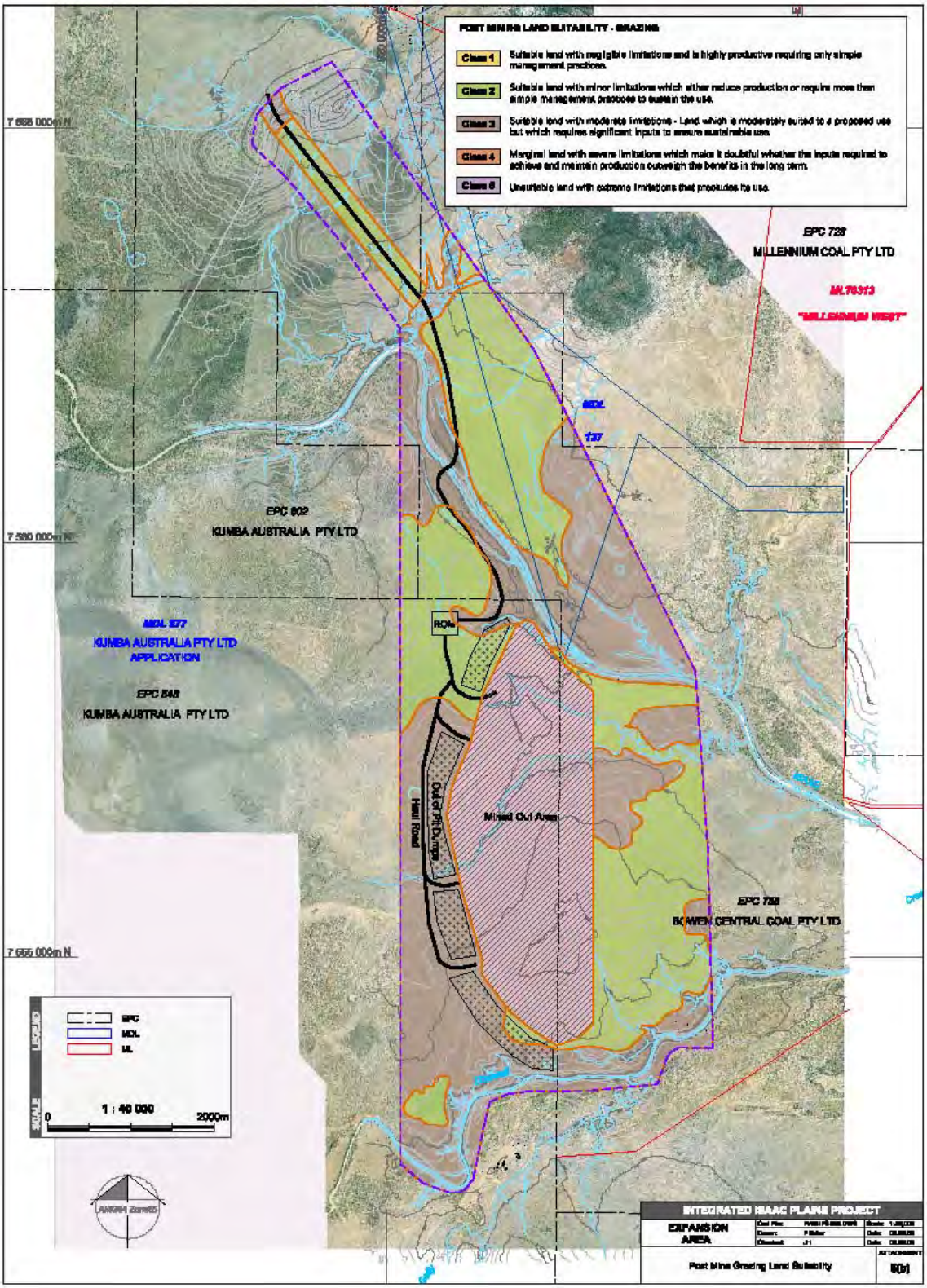
ATTACHMENT 4 – 5

PRE- AND POST-MINING LAND SUITABILITY MAPS


PRE MINING LAND SUITABILITY - CROPPING
Class 1
Suitable land with negligible limitations and is highly productive requiring only simple management practices.
Class 2
Suitable land with minor limitations which either reduce production or require more than simple management practices to sustain the use.
Class 3
Suitable land with moderate limitations - Land which is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use.
Class 4
Marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long term.
Class 5
Unsuitable land with extreme limitations that precludes its use.
EPC 728
MILLENNIUM COAL PTY LTD
ML70313
"MILLENNIUM WEST"
MDL 137
EPC 602
KUMBA AUSTRALIA PTY LTD
MDL 277
KUMBA AUSTRALIA PTY LTD
APPLICATION
EPC 548
KUMBA AUSTRALIA PTY LTD
ROM
Haul Road
Out of Pit Dumps
Future Mining Area
EPC 758
BOWEN CENTRAL COAL PTY LTD
7 555 000m N
7 550 000m N
7 545 000m N
LEGEND
EPC
MDL
ML
SCALE
1 : 40 000
0
2000m
INTEGRATED ISAAC PLAINS PROJECT
EXPANSION AREA
Pre Mine Cropping Land Suitability
ATTACHMENT
4(a)


PRE MINING LAND SUITABILITY - GRAZING
Class 1
Suitable land with negligible limitations and is highly productive requiring only simple management practices.
Class 2
Suitable land with minor limitations which either reduce production or require more than simple management practices to sustain the use.
Class 3
Suitable land with moderate limitations - Land which is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use.
Class 4
Marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long term.
Class 5
Unsuitable land with extreme limitations that precludes its use.
7 665 000m N
7 660 000m N
7 655 000m N
EPC 728
MILLENNIUM COAL PTY LTD
ML70313
"MILLENNIUM WEST"
137
EPC 802
KUMBA AUSTRALIA PTY LTD
MDL 377
KUMBA AUSTRALIA PTY LTD
APPLICATION
EPC 548
KUMBA AUSTRALIA PTY LTD
ROM
Hill Road
Out of Pit Dumps
Future Mining Area
EPC 728
BOWEN CENTRAL COAL PTY LTD
LEGEND
EPC
MDL
ML
SCALE
0
1 : 40 000
2000m
INTEGRATED ISAAC PLAINS PROJECT
EXPANSION AREA
Pre Mine Grazing Land Suitability
ATTACHMENT
40(b)


POST MINING LAND SUITABILITY - CROPPING
Class 1
Suitable land with negligible limitations and is highly productive requiring only simple management practices.
Class 2
Suitable land with minor limitations which either reduce production or require more than simple management practices to sustain the use.
Class 3
Suitable land with moderate limitations - Land which is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use.
Class 4
Marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long term.
Class 5
Unsuitable land with extreme limitations that precludes its use.
7 665 000m N
7 660 000m N
7 655 000m N
EPC 728
MILLENNIUM COAL PTY LTD
ML70313
"MILLENNIUM WEST"
137
EPC 802
KUMBA AUSTRALIA PTY LTD
MDL 377
KUMBA AUSTRALIA PTY LTD
APPLICATION
EPC 848
KUMBA AUSTRALIA PTY LTD
ROM
Hall Road
Out of Pit Dumps
Mined Out Area
EPC 728
BOWEN CENTRAL COAL PTY LTD
LEGEND
EPC
MDL
ML
SCALE
0
1 : 40 000
2000m
INTEGRATED ISAAC PLAINS PROJECT
EXPANSION AREA
Post Mine Cropping Land Suitability
ATTACHMENT
6(a)


POST MINING LAND SUITABILITY - GRAZING
Class 1
Suitable land with negligible limitations and is highly productive requiring only simple management practices.
Class 2
Suitable land with minor limitations which either reduce production or require more than simple management practices to sustain the use.
Class 3
Suitable land with moderate limitations - Land which is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use.
Class 4
Marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long term.
Class 5
Unsuitable land with extreme limitations that precludes its use.
7 665 000m N
7 660 000m N
7 655 000m N
EPC 728
MILLENNIUM COAL PTY LTD
ML70313
"MILLENNIUM WEST"
137
EPC 802
KUMBA AUSTRALIA PTY LTD
MDL 377
KUMBA AUSTRALIA PTY LTD
APPLICATION
EPC 548
KUMBA AUSTRALIA PTY LTD
ROM
Haul Road
Out of Pit Dumps
Mined Out Area
EPC 728
BOWEN CENTRAL COAL PTY LTD
LEGEND
EPC
MDL
ML
SCALE
0
1 : 40 000
2000m
INTEGRATED ISAAC PLAINS PROJECT
EXPANSION AREA
Post Mine Grazing Land Suitability
ATTACHMENT
6(b)

APPENDIX D SURFACE WATER IMPACT ASSESSMENT (IPEE)

Isaac Plains East Extension

EA Amendment
Surface Water Impact Assessment

Stanmore IP Coal Pty Ltd

0476-32-B4, 2 September 2019

Report Title	Isaac Plains East Extension EA Amendment Surface Water Impact Assessment
Client	Stanmore IP Coal Pty Ltd
Report Number	0476-32-B4

Revision Number	Report Date	Report Author	Reviewer
B4 (FINAL)	2 September 2019	DM/MGB	DN

For and on behalf of
WRM Water & Environment Pty Ltd
Level 9, 135 Wickham Tce, Spring Hill
PO Box 10703 Brisbane Adelaide St Qld 4000
Tel 07 3225 0200

Matthew Briody
Principal Engineer

NOTE: This report has been prepared on the assumption that all information, data and reports provided to us by our client, on behalf of our client, or by third parties (e.g. government agencies) is complete and accurate and on the basis that such other assumptions we have identified (whether or not those assumptions have been identified in this advice) are correct. You must inform us if any of the assumptions are not complete or accurate. We retain ownership of all copyright in this report. Except where you obtain our prior written consent, this report may only be used by our client for the purpose for which it has been provided by us.

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Glossary

Term	Definition
AEP	Annual Exceedance Probability (%) - the chance of a given rainfall total which is accumulated over a given time period will be exceeded in any one year
AGD 84	Australian Geodetic Datum 1984
ALS	Aerial Laser Scanning
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Guidelines
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AR&R	Australian Rainfall and Runoff - a national guideline used for design flood estimation in Australia. Considered a key source of technical information for designing infrastructure to withstand the impact of extreme rainfall, flooding and storm surge.
AS/NZS	Australian Standard/New Zealand Standard
AWBM	Australian Water Balance Model
AWS	automatic weather station
BOM	Commonwealth Bureau of Meteorology
CHPP	coal handling and preparation plant
CL	continuing loss
Dams Safety Act	Dams Safety Act 1978
DEHP	Queensland Department of Environment and Heritage Protection
DES	Queensland Department of Environment and Science
DGV	default guideline values
DRNME	Queensland Department of Natural Resources, Mining and Energy
EA	Environmental Authority
EC	Electrical Conductivity
EIS	Environmental Impact Statement
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
EPL	Environment Protection Licence
EPP (Water)	The Environmental Protection (Water) Policy 2009
ESC	erosion and sediment control
ESCP	erosion and sediment control plan
EV	environmental value
FSL	full supply level
ha	hectare
IL	initial loss
IPE	Isaac Plains East

Term	Definition
IPEE	Isaac Plains East Extension
IPC	Isaac Plains Complex
IPM	Isaac Plains Mine
IPU	Isaac Plains Underground Mine
km	kilometres
km^2	square kilometres
kt/yr	kilotonnes per year
LIDAR	Light Detection and Ranging
m	metre
m^2	Square metre
m^3	Cubic metres
mAHD	metres Australian Height Datum
mGH	metres Gauge Height
m/s	metres per second
m^3/s	cubic metres per second
MEA	mine entry area
mg/L	milligrams per litre
ML	megalitres
ML boundary	mining lease boundary
ML/a	megalitres per annum (year)
ML/d	megalitres per day
mm	millimetres
mm/hr	millimetres per hour
mm/month	millimetres per month
Mtpa	million tonnes per annum
MOL	maximum operating level
MOV	maximum operating volume
NTU	Nephelometric Turbidity Units
NWQMS	National Water Quality Management Strategy
OPSIM	A computer-based operational simulation model (OPSIM) was used to assess the dynamics of the mine water balance under conditions of varying rainfall and catchment conditions throughout the development of the Project
QWQ	Queensland Water Quality
REMP	Receiving Environment Monitoring Program
RMS error	Root Mean Square error
ROM	run-of-mine
RRL	Rainfall Runoff Library

Term	Definition
SILO	Scientific Information for Land Owners
SO_4	sulphate
TDS	total dissolved solids
TSS	total suspended solids
TUFLOW	1-dimensional and 2-dimensional flood simulation software used to simulate the complex movement of floodwaters across a particular area of interest using mathematical approximations to derive information on floodwater depths, velocities and levels.
w/w	weight/weight
WMS	water management system
WQO	water quality objectives
WRM	WRM Water & Environment Pty Ltd
WTP	water treatment plant
XP-RAFTS	Rainfall runoff routing hydrological model used for hydrologic and hydraulic analysis of stormwater drainage and conveyance systems.
µS/cm	microSiemens

1 Introduction

1.1 BACKGROUND

WRM Water & Environment Pty Ltd was commissioned by Stanmore IP Coal Pty Ltd (the proponent), to complete a Surface Water Impact Assessment as part of the Environmental Authority (EA) Amendment for the Isaac Plains East Extension Project (the project). The EA amendment is in support of an application to amend the Isaac Plains Complex EA. Relevant information from the EA Amendment will also be used in support of a referral for the project under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

The collective mining lease areas and operations associated with the approved Isaac Plains Mine (IPM), approved Isaac Plains East (IPE) and proposed Isaac Plains East Extension (IPEE) are referred to as the Isaac Plains Complex (IPC) in this report.

The Isaac Plains Complex (IPC) is an operating open cut coal mine located approximately 5 km north-east of Moranbah township in Central Queensland (Figure 1.1), and comprises Isaac Plains Mine (IPM) and Isaac Plains East (IPE). A future Isaac Plains underground (IPU) mine is proposed within the IPC mining leases following open cut operations. Production at IPM commenced in 2006 (under a previous owner) as a truck and shovel operation, and dragline operations commenced in 2011/12. The operation was placed under care and maintenance by the previous owner in late 2014, and was acquired by the proponent in November 2016. Mining operations at IPM recommenced in January 2016. Expanded operations at IPE were approved in March 2018, with mining operations commencing in July 2018.

Current mining operations include removal of overburden by dragline with truck and shovel pre-stripping. ROM coal is hauled by truck from the open cut pits to an on-site Coal Handling and Preparation Plant (CHPP) for washing and processing. Product coal is loaded to trains for transport from site via an on-site rail loop and train loading facility. The mine has approval to produce up to 4 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal which equates to approximately 2.8 Mtpa of product coal.

The layout of the approved IPC disturbance area, and proposed disturbance areas associated with the IPEE EA Amendment, is shown in Figure 1.2.

1.2 PROJECT DESCRIPTION

The proposed IPE Extension involves three key changes:

- Extension of the IPE open cut pits to increase total production volume, allowing the duration of open cut mining to be extended by approximately 4 years;
- Additional required supporting infrastructure for mining such as haul roads, power lines and water management infrastructure; and
- Upgrade to the CHPP and associated stockpiling areas to increase processing capacity to allow operational flexibility.

The proposed extension of the IPE open cut pits will provide access to an additional 8.2 Mt of high-quality coking coal (increasing the total for IPE from 10.2 to 18.4 Mt). The following aspects are required to enable the IPE open cut pit extension:

- Extension of the permitted IPE open cut area towards the eastern mining lease boundary of ML 700017 and ML 700019;
- Clean water diversion on the high wall side of the pit extension;

- Pit flood levees during operations; and
- Access road to the east of the highwall.

This application is seeking to extend the surface area and depth of the IPE open cut pits towards the east. Mining will continue to target the Leichhardt coal seam and progress down dip from west to east towards the boundary of the mining leases. The approved IPE open cut mining operations are scheduled to cease in 2024 to 2025. The proposed IPE open cut extension will allow four years additional production, with a proposed scheduled end of operations in 2027 to 2028. Progressive rehabilitation will be undertaken during mine life with final decommissioning and rehabilitation occurring post mine life for a period of approximately 10 years.

The IPE Extension will continue to use the existing infrastructure and services at the Isaac Plains Complex to process the additional extracted ROM material. New infrastructure associated with the IPE Extension, includes:

- Powerline corridor, substation and powerlines;
- Haul roads and access roads, including connections to the existing IP Mine road network
- New haul road to connect Pit 5 with Pit 4 extension (Pit 4N, south of Smoky Creek), with a crossing of Smoky Creek;
- Operational levees along Smoky Creek and Billy's Gully;
- Clean water diversion; and
- Minor laydown areas, stormwater drains, pit water pipelines and sediment control work.

The project requires a creek crossing (with associated culvert crossing) for the haul roads and a dragline between Pit 4 and Pit 5. Allowance has been made for an 80 m wide crossing construction width which includes the required surface width for the dragline (approximately 40m) plus embankments. The haul road crossing of Smoky Creek northern tributary and Billy's Gully is proposed to expand from 40 m width (allowed under current approvals) to 80 m width, to allow for the dragline to be walked across the creeks in these locations.

Stanmore proposes to increase the CHPP capacity and ROM and product coal stockpile area to provide additional capacity for operational flexibility. Components of the IPE Extension proposed to facilitate this include:

- A modular upgrade to the CHPP to increase ROM production capacity by 2 Mtpa; and
- Additional ROM and product coal stockpile area for the coal wash plant on ML 70342.

The proposed layout of IPC (including the proposed IPE Extension) in Years 2020, 2021, 2024, 2028, 2033 and 2038 is provided in Figure 1.3 to Figure 1.8. Mining of the approved Pit 1 area is currently on hold, subject to agreement with the landholder. There are no changes proposed to the approved Pit 1 mining area as a result of the IPEE project and therefore Pit 1 is not considered further in this assessment.

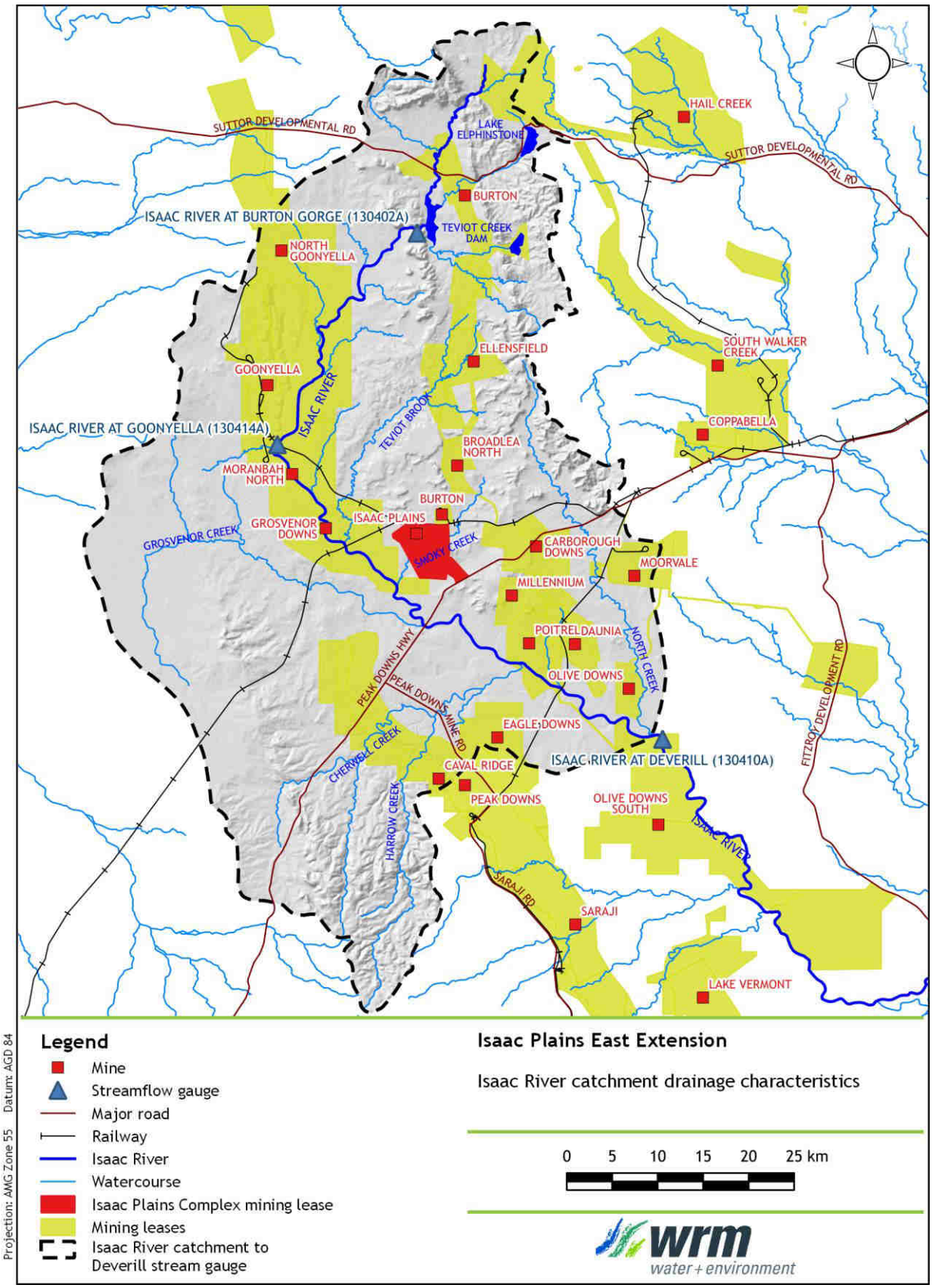

Figure 1.1 – IPC locality and regional drainage characteristics

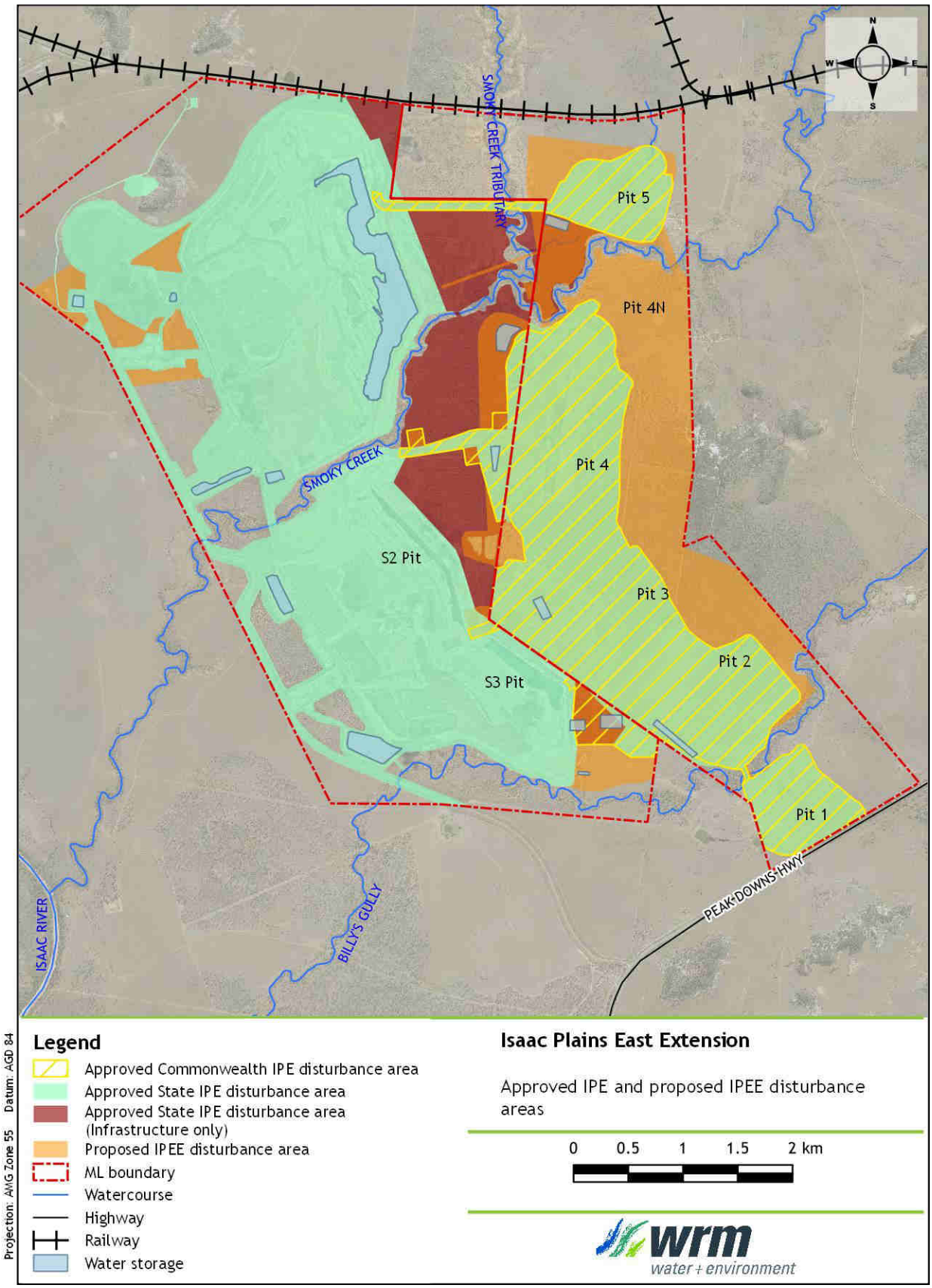

Figure 1.2 – Approved and proposed mine disturbance areas

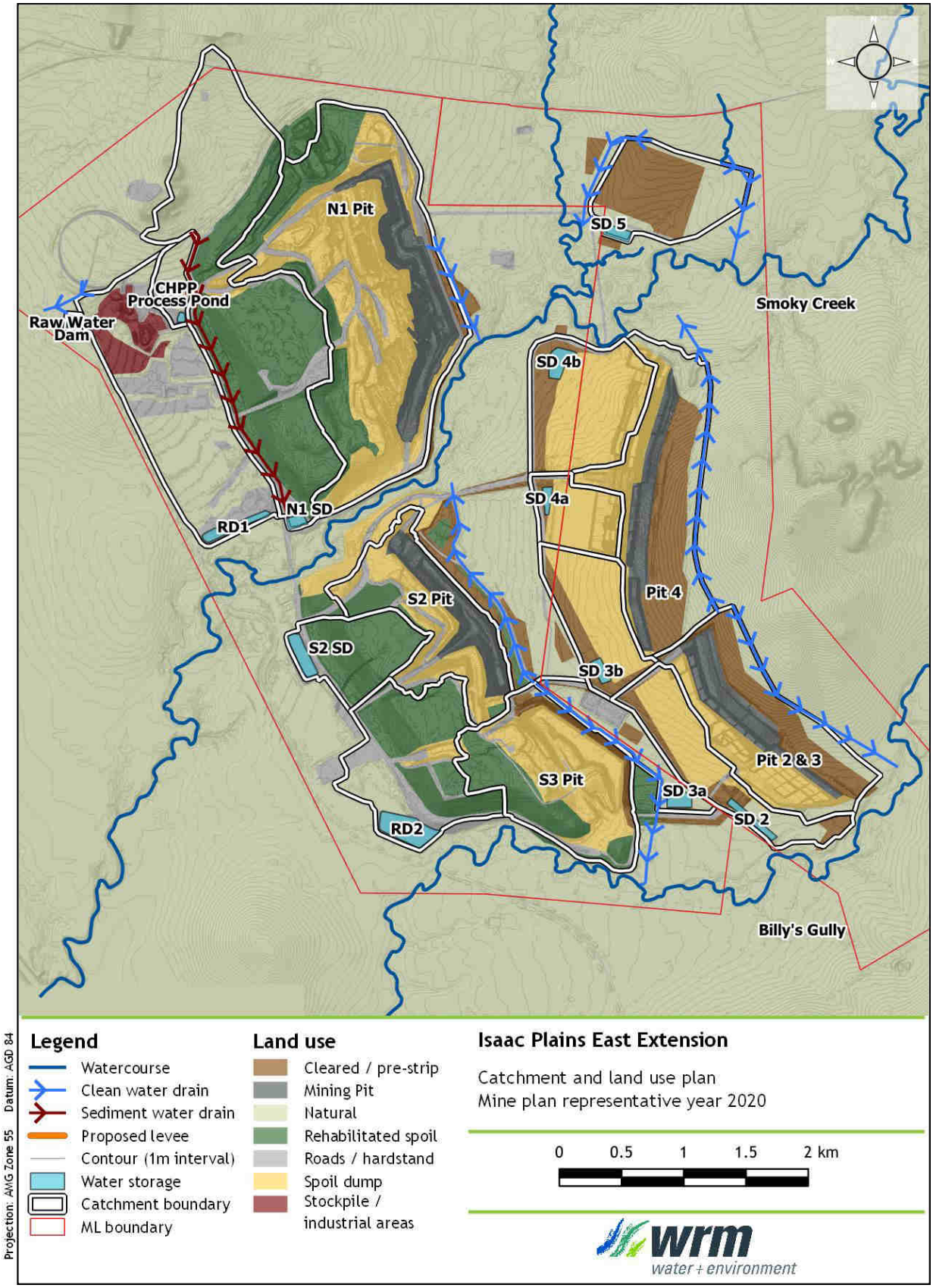

Figure 1.3 – Proposed IPC general layout – Year 2020 (Stage 1)

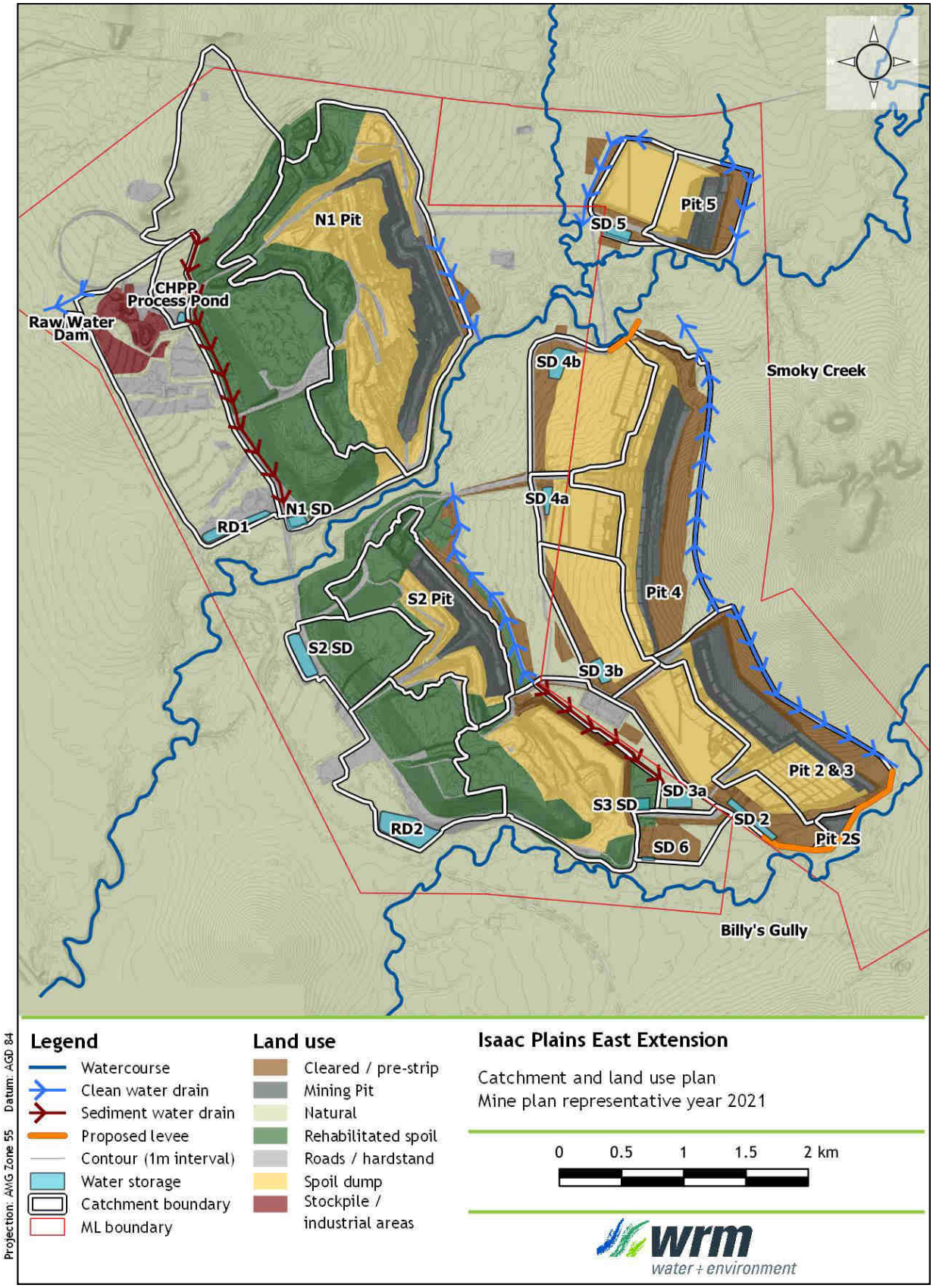

Figure 1.4 – Proposed IPC general layout – Year 2021 (Stage 2)

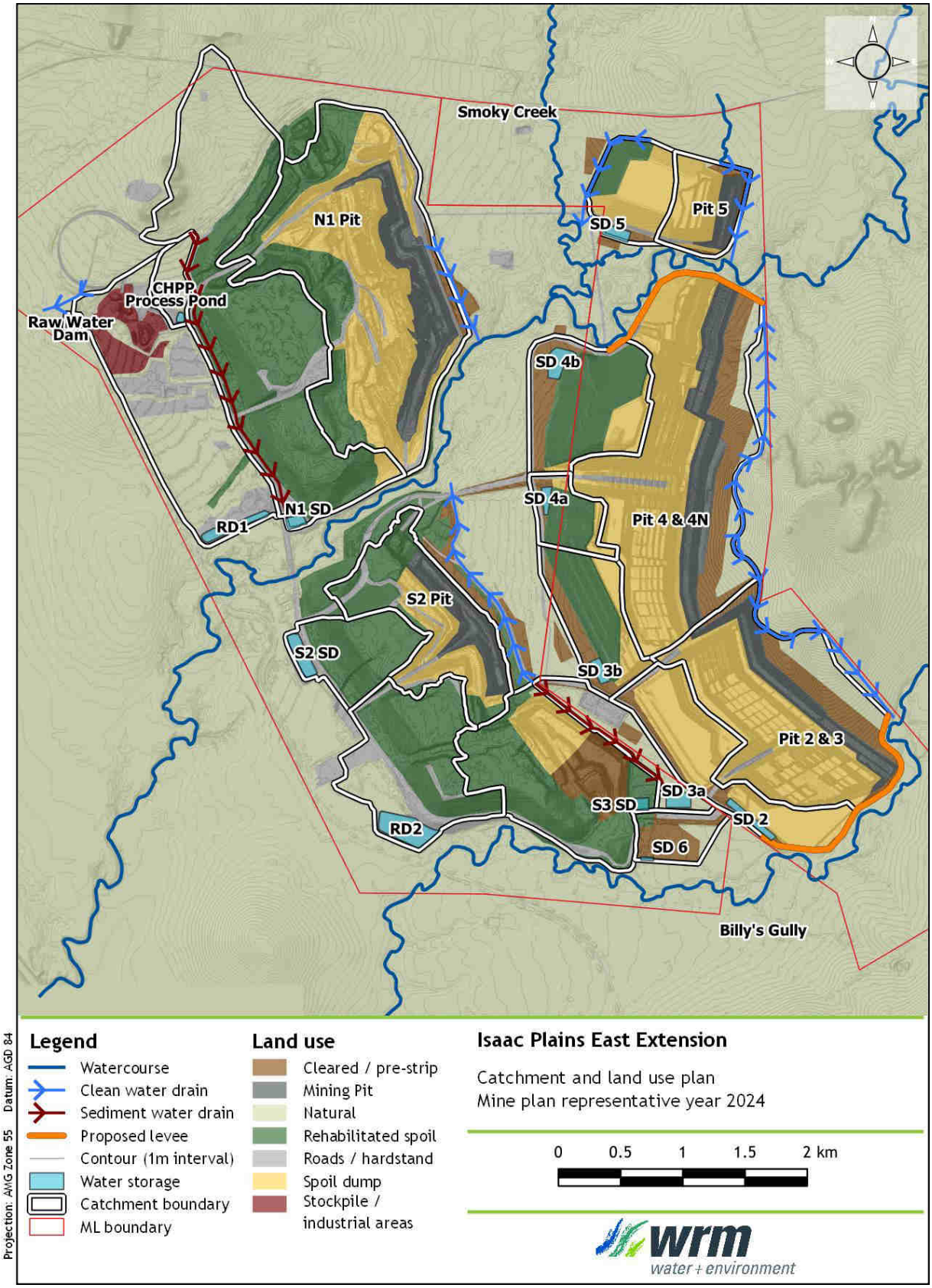

Figure 1.5 - Proposed IPC general layout - Year 2024

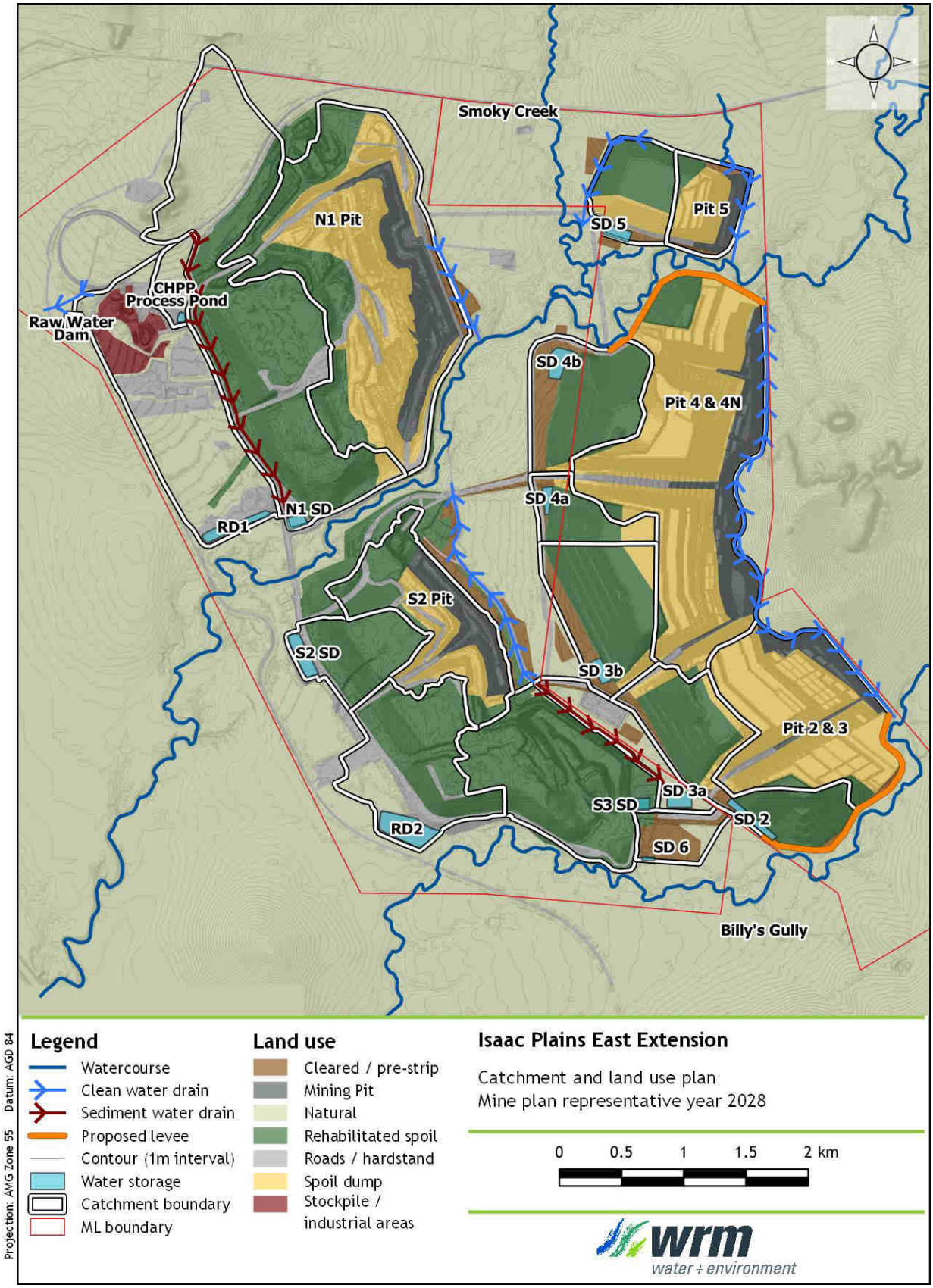

Figure 1.6 – Proposed IPC general layout – Year 2028

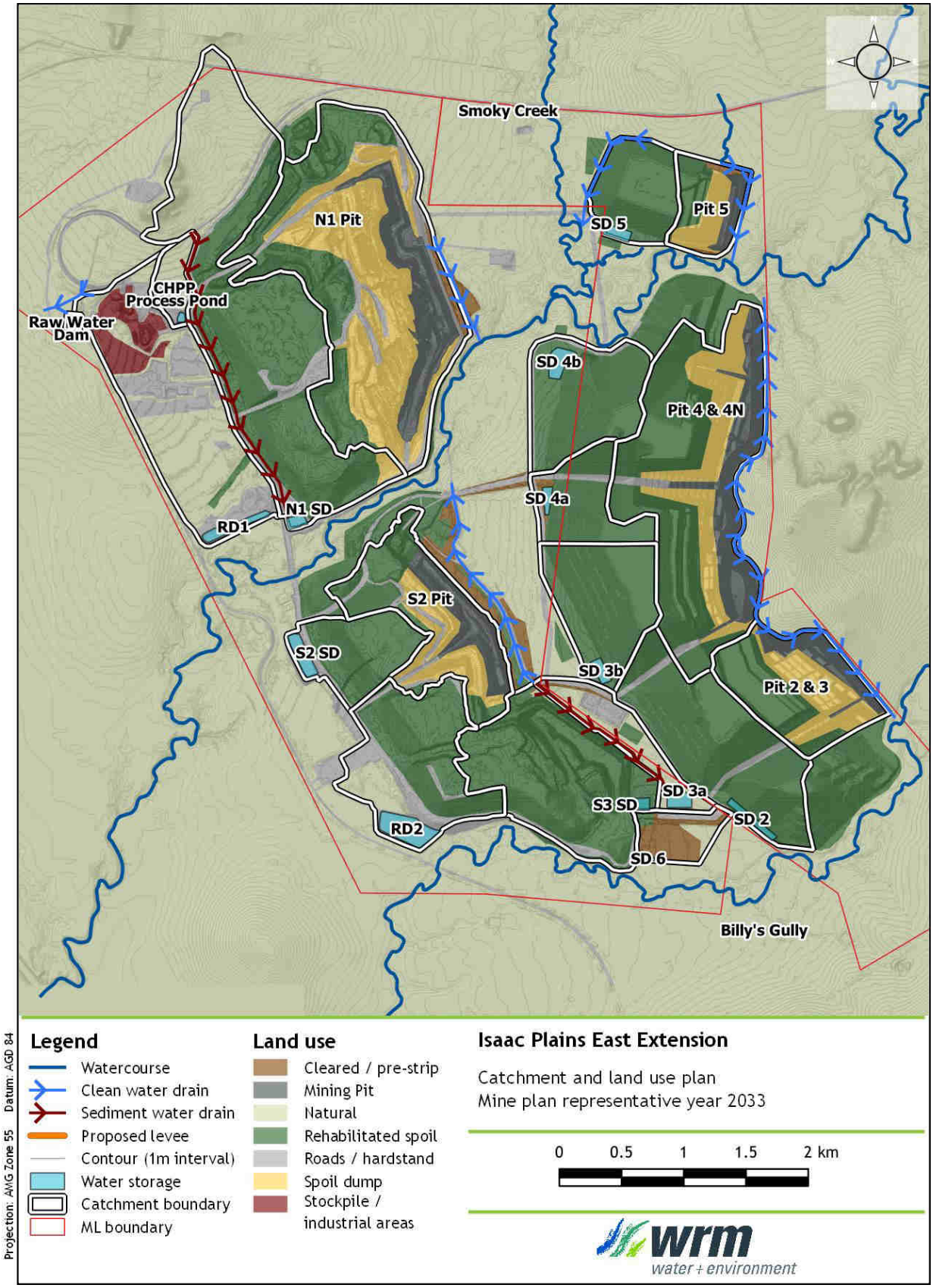

Figure 1.7 – Proposed IPC general layout – Year 2033

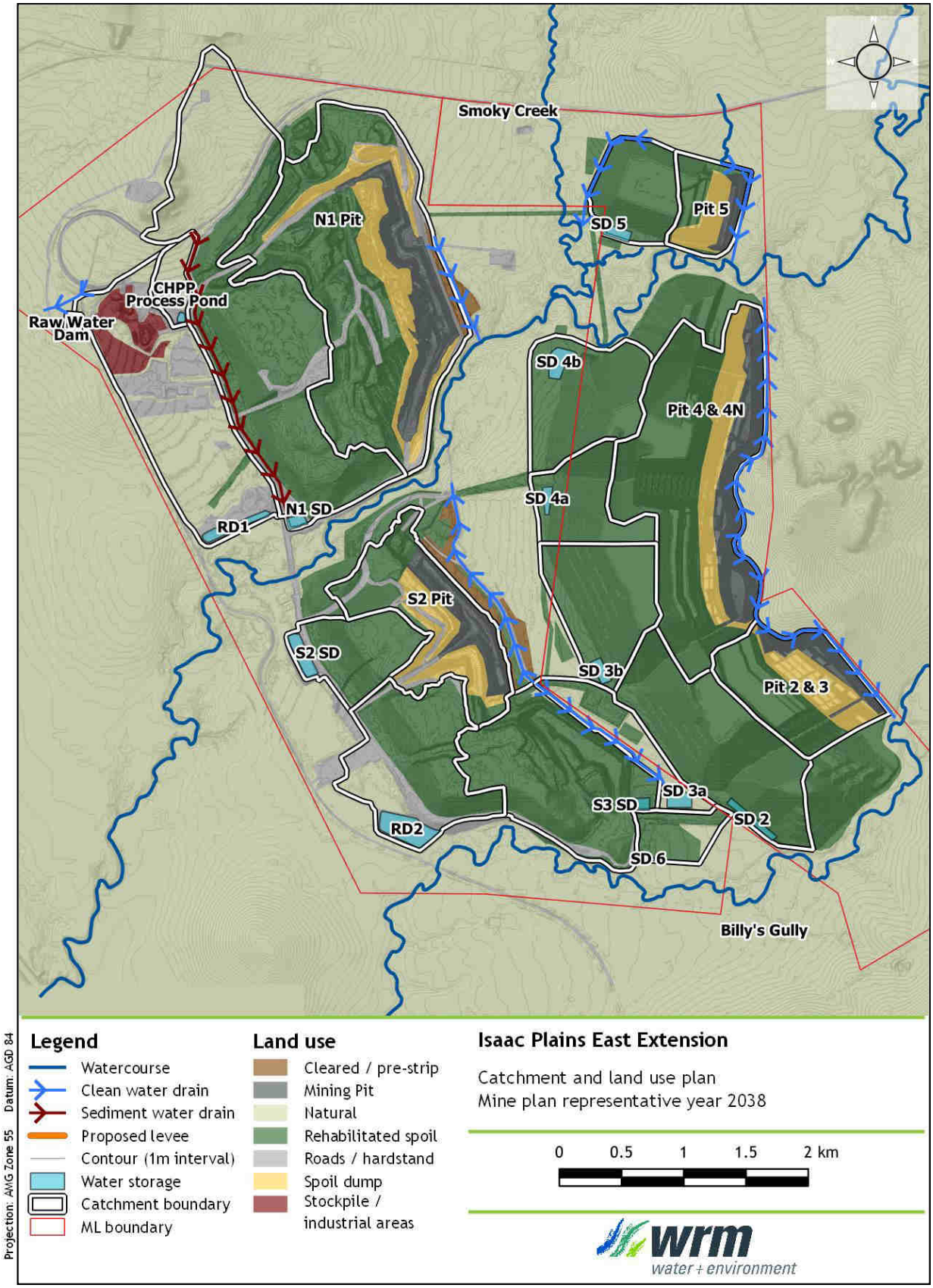

Figure 1.8 – Proposed IPC general layout – Year 2038

1.3 INDEPENDENT EXPERT SCIENTIFIC COMMITTEE GUIDELINES

The Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Development has published information guidelines (IESC, 2018) for advice on coal seam gas and large coal mining development proposals. The WRM report sections where the IESC information requirements have been addressed are outlined in Table 1.1.

Table 1.1- IESC information requirements

Project information	Report section
Description of the proposal	
Provide a regional overview of the proposed project area including a description of the geological basin; coal resource; surface water catchments; groundwater systems; water-dependent assets; and past, current and reasonably foreseeable coal mining and CSG developments.	Sections 2, 3 & 4
Describe the proposal's location, purpose, scale, duration, disturbance area, and the means by which it is likely to have a significant impact on water resources and water-dependent assets.	Sections 1, 4 & 5
Describe the statutory context, including information on the proposal's status within the regulatory assessment process and any applicable water management policies.	Refer to Main Report
Describe how impacted water resources are currently being regulated under state or Commonwealth law, including whether there are any applicable standard conditions.	Refer to Main Report
Surface water - context and conceptualisation	
Describe the hydrological regime of all watercourses, standing waters and springs across the site including:	
• geomorphology, including drainage patterns, sediment regime, and floodplain features;	Section 2.2
• spatial, temporal and seasonal trends in streamflow and/or standing water levels;	Section 2.3
• spatial, temporal and seasonal trends in water quality data (such as turbidity, acidity, salinity, relevant organic chemicals, metals, metalloids and radionuclides); and	Section 2.4
• current stressors on watercourses, including impacts from any currently approved projects.	Section 2.7
Describe the existing flood regime, including flood volume, depth, duration, extent and velocity for a range of annual exceedance probabilities. Provide flood hydrographs and maps identifying peak flood extent, depth and velocity. This assessment should be informed by topographic data that has been acquired using lidar or other reliable survey methods with accuracy stated.	Appendix B Section 8
Provide an assessment of the frequency, volume, seasonal variability and direction of interactions between water resources, including surface water/groundwater connectivity and connectivity with sea water.	Refer to Groundwater Report
Surface water - analytical and numerical modelling	
Provide conceptual models at an appropriate scale, including water quality, stores, flows and use of water by ecosystems.	Appendix A, Appendix B, Sections 6 & 8
Use methods in accordance with the most recent publication of *Australian Rainfall and Runoff* (Ball et al. 2016).	Appendix B

Develop and describe a program for review and update of the models as more data and information becomes available.	Appendix A
Describe and justify model assumptions and limitations, and calibrate with appropriate surface water monitoring data.	Section 6.14 & Appendix B1.3
Provide an assessment of the risks and uncertainty inherent in the data used in the modelling, particularly with respect to predicted scenarios.	Section 7.4
Provide a detailed description of any methods and evidence (e.g. expert opinion, analogue sites) employed in addition to modelling.	Models verified against historical data
Surface water – impacts to water resources and water-dependent assets	
Describe all potential impacts of the proposed project on surface waters. Include a clear description of the impact to the resource, the resultant impact to any assets dependent on the resource (including water-dependent ecosystems such as riparian zones and floodplains), and the consequence or significance of the impact. Consider:	
• impacts on streamflow under the full range of flow conditions.	Section 8
• impacts associated with surface water diversions.	n/a
• impacts to water quality, including consideration of mixing zones.	Section 7
• the quality, quantity and ecotoxicological effects of operational discharges of water (including saline water), including potential emergency discharges, and the likely impacts on water resources and water-dependent assets.	Sections 4 & 7
• landscape modifications such as subsidence, voids, post rehabilitation landform collapses, onsite earthworks (including disturbance of acid-forming or sodic soils, roadway and pipeline networks) and how these could affect surface water flow, surface water quality, erosion, sedimentation and habitat fragmentation of water-dependent species and communities.	Section 9
Discuss existing water quality guidelines, environmental flow objectives and requirements for the surface water catchment(s) within which the development proposal is based.	Section 3
Identify processes to determine surface water guidelines and quantity thresholds which incorporate seasonal variation but provide early indication of potential impacts to assets.	Section 5.2 & 5.3
Propose mitigation actions for each identified significant impact.	Section 10
Describe the adequacy of proposed measures to prevent or minimise impacts on water resources and water-dependent assets.	Section 10
Describe the cumulative impact of the proposal on surface water resources and water-dependent assets when all developments (past, present and/or reasonably foreseeable) are considered in combination.	Section 10
Provide an assessment of the risks of flooding (including channel form and stability, water level, depth, extent, velocity, shear stress and stream power), and impacts to ecosystems, project infrastructure and the final project landform.	Section 8
Surface water – data and monitoring	
Identify monitoring sites representative of the diversity of potentially affected water-dependent assets and the nature and scale of potential impacts, and match with suitable replicated control and reference sites (BACI design) to enable detection and monitoring of potential impacts.	Section 4

Ensure water quality monitoring complies with relevant National Water Quality Management Strategy (NWQMS) guidelines (ANZECC/ARMCANZ 2000) and relevant legislated state protocols (e.g. QLD Government 2013).	Section 4
Identify data sources, including streamflow data, proximity to rainfall stations, data record duration and a describe of data methods, including whether missing data has been patched.	Section 2.3 & 6.3
Develop and describe a surface water monitoring programme that will collect sufficient data to detect and identify the cause of any changes from established baseline conditions, and assess the effectiveness of mitigation and management measures. The program will: • include baseline monitoring data for physico-chemical parameters, as well as contaminants (e.g. metals); • comparison of physico-chemical data to national/regional guidelines or to site-specific guidelines derived from reference condition monitoring if available; and, • identify baseline contaminant concentrations and compare these to national guidelines, allowing for local background correction if required.	Section 4.4
Describe the rationale for selected monitoring parameters, duration, frequency and methods, including the use of satellite or aerial imagery to identify and monitor large-scale impacts.	Section 4.4
Develop and describe a plan for ongoing ecotoxicological monitoring, including direct toxicity assessment of discharges to surface waters where appropriate.	n/a
Identify dedicated sites to monitor hydrology, water quality, and channel and floodplain geomorphology throughout the life of the proposed project and beyond.	Section 3.4
Water-dependent assets - context and conceptualisation	
Identify water-dependent assets, including: • water-dependent fauna and flora and provide surveys of habitat, flora and fauna (including stygofauna) (see Doody et al. [in press]). • public health, recreation, amenity, Indigenous, tourism or agricultural values for each water resource.	Section 3 Refer to Ecology report
Identify GDEs in accordance with the method outlined by Eamus et al. (2006). Information from the GDE Toolbox15 (Richardson et al. 2011) and GDE Atlas (CoA 2017a) may assist in identification of GDEs (see Doody et al. [in press]).	Refer to Groundwater Report
Describe the conceptualisation and rationale for likely water-dependence, impact pathways, tolerance and resilience of water-dependent assets. Examples of ecological conceptual models can be found in Commonwealth of Australia (2015).	Refer to Groundwater Report
Estimate the ecological water requirements of identified GDEs and other water-dependent assets (see Doody et al. [in press]).	Refer to Groundwater Report
Identify the hydrogeological units on which any identified GDEs are dependent (see Doody et al. [in press]).	Refer to Groundwater Report
Provide an outline of the water-dependent assets and associated environmental objectives and the modelling approach to assess impacts to the assets.	Section 3
Describe the process employed to determine water quality and quantity triggers and impact thresholds for water-dependent assets (e.g. threshold at which a significant impact on an asset may occur).	Section 5.8
Water-dependent assets - impacts, risk assessment and management of risks	

Provide an assessment of direct and indirect impacts on water-dependent assets, including ecological assets such as flora and fauna dependent on surface water and groundwater, springs and other GDEs (see Doody et al. [in press]).	Refer to Groundwater Report
Describe the potential range of drawdown at each affected bore, and clearly articulate the scale of impacts to other water users.	Refer to Groundwater Report
Indicate the vulnerability to contamination (e.g. from salt production and salinity) and the likely impacts of contamination on the identified water-dependent assets and ecological processes.	Section 4
Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion and habitat fragmentation of water-dependent species and communities.	Section 9
Provide estimates of the volume, beneficial uses and impact of operational discharges of water (particularly saline water), including potential emergency discharges due to unusual events, on water-dependent assets and ecological processes.	Section 10
Assess the overall level of risk to water-dependent assets through combining probability of occurrence with severity of impact.	Section 10
Identify the proposed acceptable level of impact for each water-dependent asset based on leading-practice science and site-specific data, and ideally developed in conjunction with stakeholders.	Section 5.8
Propose mitigation actions for each identified impact, including a description of the adequacy of the proposed measures and how these will be assessed.	Section 10
Water-dependent assets – data and monitoring	
Identify an appropriate sampling frequency and spatial coverage of monitoring sites to establish pre-development (baseline) conditions, and test potential responses to impacts of the proposal (see Doody et al. [in press]).	
Consider concurrent baseline monitoring from unimpacted control and reference sites to distinguish impacts from background variation in the region (e.g. BACI design, see Doody et al. [in press]).	
Develop and describe a monitoring program that identifies impacts, evaluates the effectiveness of impact prevention or mitigation strategies, measures trends in ecological responses and detects whether ecological responses are within identified thresholds of acceptable change (see Doody et al. [in press]).	Section 5.8 and Section 10
Describe the process for regular reporting, review and revisions to the monitoring program.	
Ensure ecological monitoring complies with relevant state or national monitoring guidelines (e.g. the DSITI guideline for sampling stygofauna (QLD Government 2015)).	
Water and salt balance, and water management quality	
Provide a quantitative site water balance model describing the total water supply and demand under a range of rainfall conditions and allocation of water for mining activities (e.g. dust suppression, coal washing etc.), including all sources and uses.	Sections 6, 7 & Appendix A
Describe the water requirements and on-site water management infrastructure, including modelling to demonstrate adequacy under a range of potential climatic conditions.	Sections 6, 7 & Appendix A
Provide estimates of the quality and quantity of operational discharges under dry, median and wet conditions, potential emergency discharges due to unusual events and the likely impacts on water-dependent assets.	Sections 6, 7 & Appendix A

Provide salt balance modelling that includes stores and the movement of salt between stores, and takes into account seasonal and long-term variation.	Sections 6, 7 & Appendix A
Cumulative impacts – context and conceptualisation	
Provide cumulative impact analysis with sufficient geographic and temporal boundaries to include all potentially significant water-related impacts.	Section 10.6
Consider all past, present, and reasonably foreseeable actions, including development proposals, programs and policies that are likely to impact on the water resources of concern in the cumulative impact analysis. Where a proposed project is located within the area of a bioregional assessment consider the results of the bioregional assessment.	Section 10.6
Cumulative impacts – impacts	
Provide an assessment of the condition of affected water resources which includes: • identification of all water resources likely to be cumulatively impacted by the proposed development; • a description of the current condition and quality of water resources and information on condition trends; • identification of ecological characteristics, processes, conditions, trends and values of water resources; • adequate water and salt balances; and • identification of potential thresholds for each water resource and its likely response to change and capacity to withstand adverse impacts (e.g. altered water quality, drawdown).	Section 10.6
Assess the cumulative impacts to water resources considering: • the full extent of potential impacts from the proposed project, (including whether there are alternative options for infrastructure and mine configurations which could reduce impacts), and encompassing all linkages, including both direct and indirect links, operating upstream, downstream, vertically and laterally; • all stages of the development, including exploration, operations and post closure/decommissioning; • appropriately robust, repeatable and transparent methods; • the likely spatial magnitude and timeframe over which impacts will occur, and significance of cumulative impacts; and • opportunities to work with other water users to avoid, minimise or mitigate potential cumulative impacts.	Section 10.6
Cumulative Impacts – Mitigation, monitoring and management	
Identify modifications or alternatives to avoid, minimise or mitigate potential cumulative impacts. Evidence of the likely success of these measures (e.g. case studies) should be provided.	
Identify measures to detect and monitor cumulative impacts, pre and post development, and assess the success of mitigation strategies.	Section 10.6
Identify cumulative impact environmental objectives.	
Describe appropriate reporting mechanisms.	
Propose adaptive management measures and management responses.	
Final landform and voids – coal mines	

Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion, sedimentation and habitat fragmentation of water-dependent species and communities.	
Assess the adequacy of modelling, including surface water and groundwater quantity and quality, lake behaviour, timeframes and calibration.	
Provide an assessment of the long-term impacts to water resources and water-dependent assets posed by various options for the final landform design, including complete or partial backfilling of mining voids. Assessment of the final landform for which approval is being sought should considers: • groundwater behaviour – sink or lateral flow from void. • water level recovery – rate, depth, and stabilisation point (e.g. timeframe and level in relation to existing groundwater level, surface elevation). • seepage – geochemistry and potential impacts. • long-term water quality, including salinity, pH, metals and toxicity. • measures to prevent migration of void water off-site. For other final landform options considered sufficient detail of potential impacts should be provided to clearly justify the proposed option.	Section 9
Assess the probability of overtopping of final voids with variable climate extremes, and management mitigations.	
Acid-forming materials and other contaminants of concern	
Identify the presence and potential exposure of acid-sulphate soils (including oxidation from groundwater drawdown).	
Identify the presence and volume of potentially acid-forming waste rock, fine-grained amorphous sulphide minerals and coal reject/tailings material and exposure pathways.	
Identify other sources of contaminants, such as high metal concentrations in groundwater, leachate generation potential and seepage paths.	Refer to Main Report
Describe handling and storage plans for acid-forming material (co-disposal, tailings dam, encapsulation).	
Assess the potential impact to water-dependent assets, taking into account dilution factors, and including solute transport modelling where relevant, representative and statistically valid sampling, and appropriate analytical techniques.	
Describe proposed measures to prevent/minimise impacts on water resources, water users and water-dependent ecosystems and species.	

1.4 REPORT STRUCTURE

This report is structured as follows:

- Section 2 describes the regional and local drainage characteristics;
- Section 3 describes the Environmental Values of the regional receiving waters;
- Section 4 presents the surface water characteristics of the mine site;
- Section 5 describes the surface water management system including the management objectives and principles;
- Section 6 describes the site water balance model configuration;
- Section 7 provides a summary of the water balance model results for the site water management system;
- Section 8 presents the outcomes from the flood modelling assessment;
- Section 9 presents the outcomes from the final void water balance assessment;
- Section 10 describes the outcomes from the impact assessment for surface water (including cumulative impacts);
- Section 11 presents the assessment of significance of impacts relating to Matters of National Significance (MNES) for surface water-related components;
- Section 12 provides a list of references;
- Appendix A provides catchment areas, land use breakdowns and storage curves adopted for the water balance model; and
- Appendix B describes the setup and configuration of the flood model.

2 Catchment hydrology and drainage characteristics

2.1 REGIONAL DRAINAGE CHARACTERISTICS

The main regional drainage feature is the Isaac River, which is a major tributary within the Fitzroy River basin. Figure 1.1 shows the drainage characteristics of the Isaac River catchment and Figure 2.1 shows the drainage characteristics across the various mining leases. The Isaac River is an ephemeral watercourse flowing for short periods following rainfall. The catchment commences at the Denham Range located about 60 km to the north of the IPC. The Isaac River flows in a south-westerly direction through Burton Gorge Dam towards Goonyella, then flows in a south-easterly direction past Moranbah. The river then crosses the Peak Downs Highway and eventually discharges into the Mackenzie River some 153 km to the south-east of the IPC. The Mackenzie River is a major tributary of the Fitzroy River.

The total catchment area of Isaac River downstream of the confluence with Billy's Gully is approximately 1,922 km^2. The IPC mining leases cover an area of approximately 34.0 km^2 or 1.8% of the Isaac River catchment (to downstream of the confluence with Billy Gully). There are two water supply dams located in the upper catchment of the Isaac River, Teviot Creek Dam and Burton Gorge Dam, as well as a natural lake called Lake Elphinstone.

The Isaac River catchment upstream of the mine site comprises mainly scattered to medium dense bushland, grazing land and the township of Moranbah. Several coal mines exist in the catchment upstream of the site, including Burton Downs, Moranbah North, Grosvenor, Goonyella-Riverside, Broadmeadow, North Goonyella and Broadlea; and several downstream, including Carborough Downs, Poitrel, Daunia and Millennium.

The IPC lease areas are drained by:

- Smoky Creek, a small tributary with a catchment area of 164.9 km^2 which discharges to the Isaac River about 4.2 km downstream of the IPC lease boundary;
- An unnamed tributary of Smoky Creek, which joins Smoky Creek near the northeastern extent of the IPC lease boundary; and
- Billy's Gully, a small tributary with a catchment area of 67.5 km^2 which discharges to the Isaac River about 3.5 km downstream of the IPC lease boundary.

2.2 LOCAL DRAINAGE CHARACTERISTICS

2.2.1 Smoky Creek

Smoky Creek is an ephemeral creek draining through the existing IPM and IPE mining areas to the Isaac River. Its confluence with the Isaac River is approximately 5.5 km upstream of the Peak Downs Highway. The Broadlea Mine (closed) is located within the headwaters of Smoky Creek.

The lower reaches of Smoky Creek are relatively flat (0.2% slope) and the main channel of the creek is highly sinuous. There are a number of minor gullies that drain into the creek including a large unnamed tributary that drains into Smoky Creek to the west of Pit 5.

The overall channel dimensions of Smoky Creek remain largely unchanged throughout the project site. The typical dimensions of the creek channel are:

- bed width of 5 to 10 m;
- top width of 20 to 30 m with steep banks; and

- depth of 3 to 5 m.

Previous broad-scale grazing has resulted in relatively sparse riparian vegetation. The riparian zone is narrow with scattered mature trees on both banks. Pastures are the dominant groundcover in the riparian zone. The main features of the waterway are:

- the creek channel and riparian zone have been impacted by cattle grazing;
- the creek channel bed sediments are mobile and there is considerable erosion of the outside bends of meanders; and
- there is no aquatic vegetation in the bed of the channel.

Smoky Creek drains through the project area between the proposed Pit 4/4N and Pit 5 mining areas.

2.2.2 Billy's Gully

Billy's Gully is an ephemeral gully that drains into the Isaac River about 2.5 km to the south east of Smoky Creek and 3.0 km upstream of the Peak Downs Highway. The Carborough Downs Underground Mine is located in the upper headwaters of the Billy's Gully catchment. The entire catchment of Billy's Gully is relatively flat with the upper slopes generally limited to 5% and the lower channel draining at a slope of about 0.3%.

The typical dimensions of the creek channel are:

- bed width 1 to 2 m;
- top width 10 m; and
- depth 1 to 2 m.

Billy's Gully drains through the project area southeast of the proposed Pit 2 and Pit 2S mining area.

2.3 STREAMFLOWS

2.3.1 Regional flows - Isaac River

The nearest gauges on the Isaac River upstream and downstream of the project are located at Goonyella (upstream) and Deverill (downstream), both of which are operated by the Department of Natural Resources, Mines and Energy (DNRME). The details of these gauges are provided in Table 2.1.

Table 2.1 - DNRME stream gauges along the Isaac River in the vicinity of the project

Gauge no.	Gauge name	AMTD (km)	Catchment area (km^2)	Distance from IPC (km)	Start	End
130414A	Goonyella	242.8	1,214	22 km (upstream)	24/05/1983	-
130410A	Deverill	174.7	4,092	36 km (downstream)	20/05/1968	-

Historical flow and river height monitoring data at the Goonyella and Deverill gauges provide an indication of the local flow regime (gauges shown in Figure 1.1).

The mean river height data shown in Figure 2.2 suggests that flow at the Goonyella gauge is more likely to occur only in the wetter months from November to April, reducing to shallow subsurface flows from about May to October in an average year.

Surveyed cross section data for the Deverill gauging station in September 2014 (DNRME, 2017a) indicates that sediment covers the bottom one metre of the gauge range. The mean river height data shown in Figure 2.3 suggests that surface flow above the sand is

more likely to occur only in the wetter months from November to April, reducing to shallow subsurface flows from about May to October in an average year.

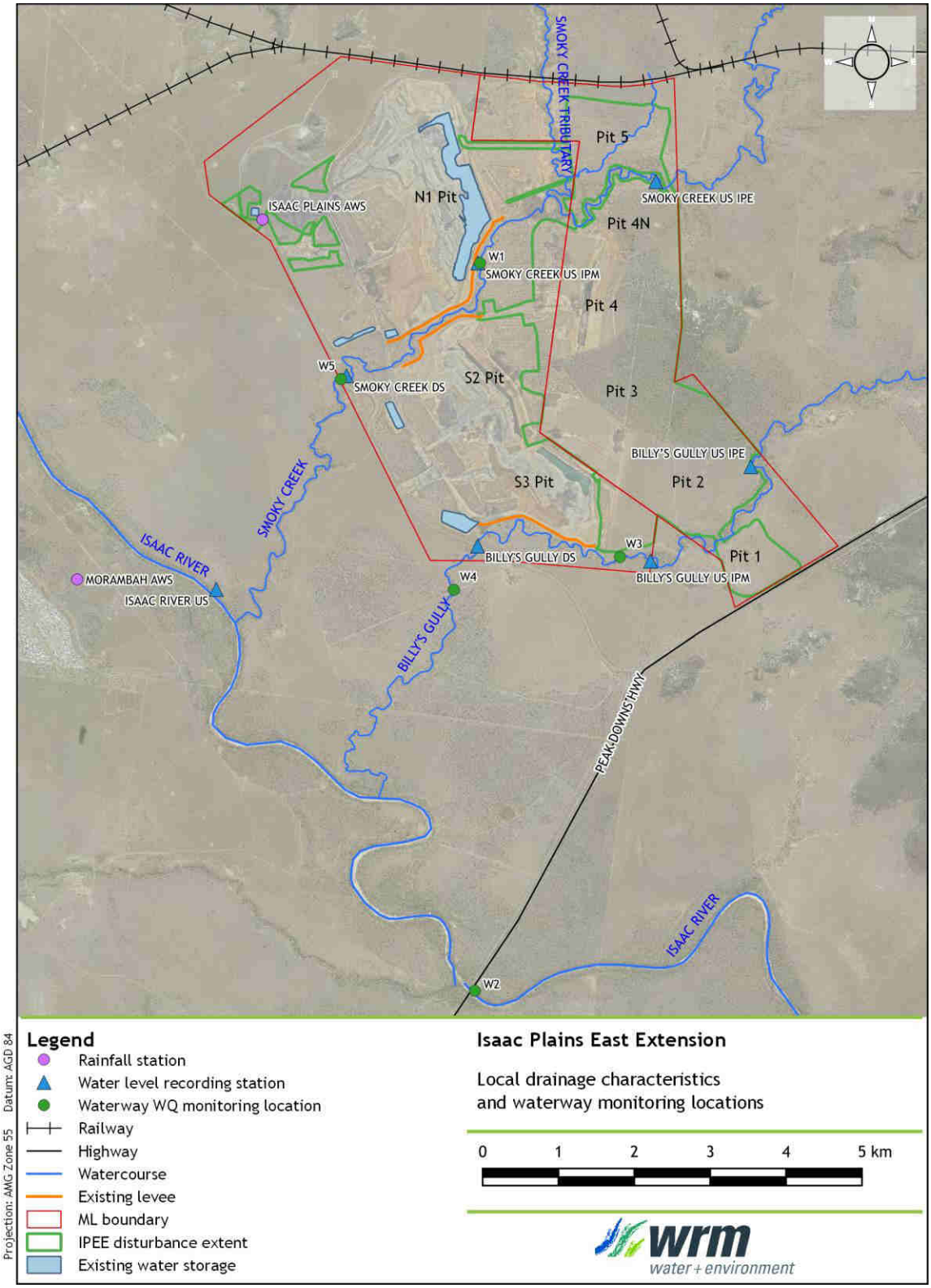

Figure 2.1 – IPC local drainage characteristics and general arrangement

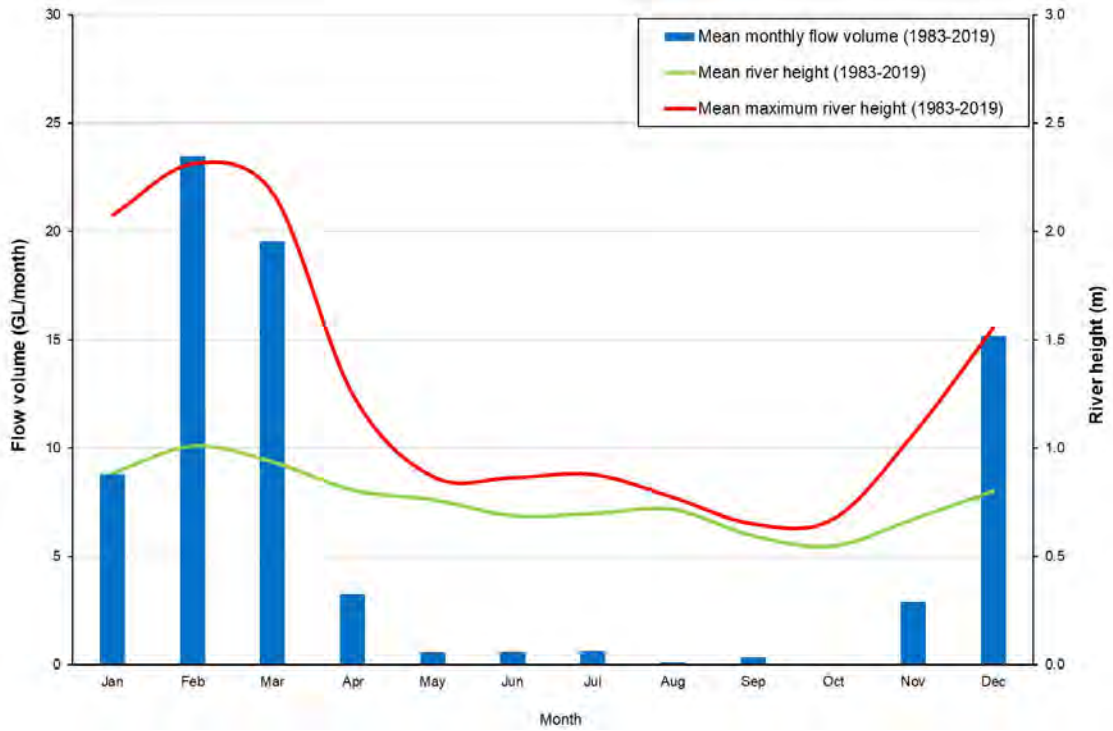

Figure 2.2 – Flow volume and river height in the Isaac River at Goonyella (DNRME station 130414A, located downstream of the project)

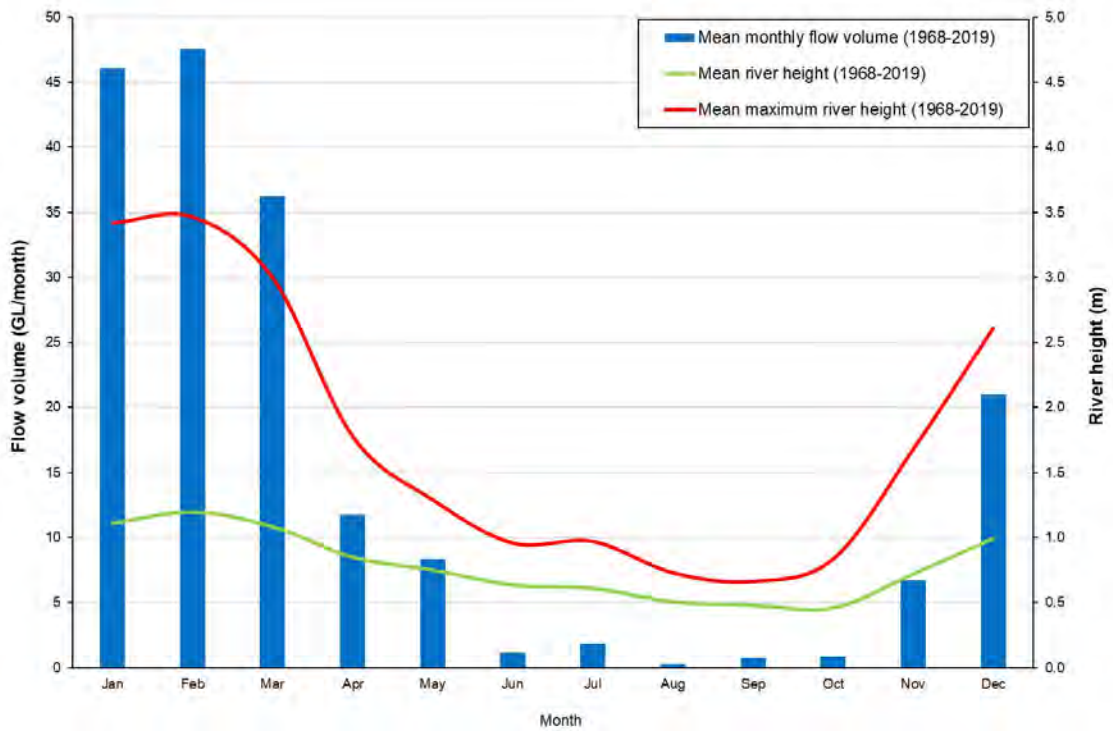

Figure 2.3 – Flow volume and river height in the Isaac River at Deverill (DNRME station 130410A, located downstream of the project)

A stream flow gauge (Gauge no. 332417) was installed on the Isaac River upstream of its confluence with Smoky Creek in May 2018. To date, the station has only captured one flow event which occurred in March 2019 and reached a maximum height of 12.4 metres gauge height (mGH). This is equivalent to a flow depth of around 2.1 m at the gauge.

2.3.2 Local flows - Smoky Creek and Billy's Gully

Stream flows are recorded in both Smoky Creek and Billy's Gully at the locations shown in Figure 2.1. The flow gauges are located at the following key points:

- Downstream of IPM (Smoky Creek DS & Billy's Gully DS);
- Upstream of IPM and downstream of IPE (Smoky Creek US IPM & Billy's Gully US IPM); and
- Upstream of IPE (Smoky Creek US IPE & Billy's Gully US IPE).

The details of these gauges are provided in Table 2.2.

Table 2.2 -Stream gauges on Smoky Creek and Billy's Gully

Gauge no.	Gauge name	Start	End
332400	Smoky Creek DS	24/09/2014	-
332402	Billy's Gully DS	06/06/2013	-
332401	Smoky Creek US IPM	08/01/2014	-
332403	Billy's Gully US IPM	*unknown*	-
332415	Smoky Creek US IPE	01/08/2018	-
332416	Billy's Gully US IPE	*unknown*	-

Figure 2.4 shows the recorded water levels in Smoky Creek and Billy's Gully at the downstream gauges (gauge no. 332400 and 332402, respectively). Note that the data obtained for Smoky Creek DS has been filtered to remove erroneous data points.

At Smoky Creek DS, flows were recorded on approximately 15% of the days. The maximum water level recorded at Smoky Creek DS was 18.2 mGH in February 2016 (flow depth of around 7.8 m at the gauge).

At Billy's Gully DS, flows were recorded on approximately only 0.2% of the days. The water levels recorded in Billy's Gully were consistently lower than those recorded in Smoky Creek. The maximum water level recorded at Billy's Gully DS was 12.6 mGH in February 2016 (flow depth of around 2.6 m at the gauge).

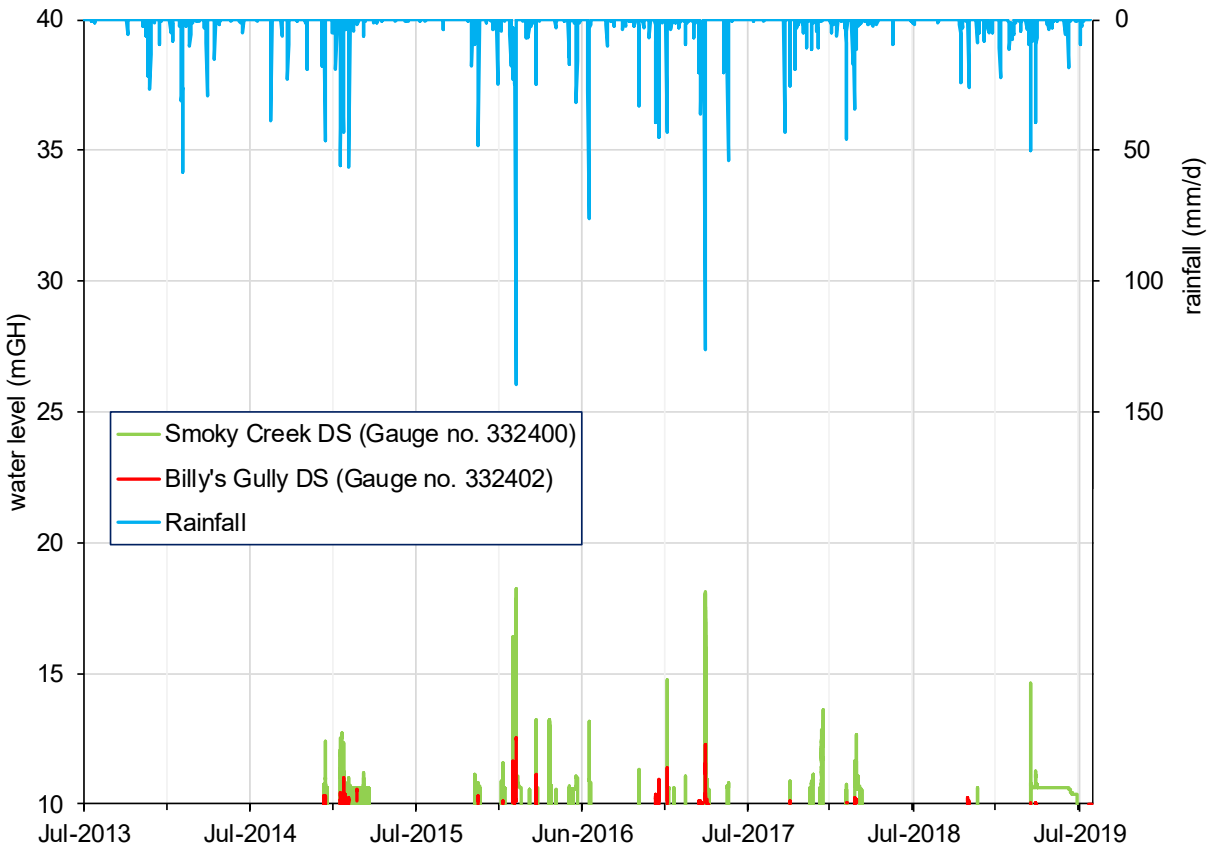

Figure 2.4 - Recorded water level at Smoky Creek DS (gauge no. 332400) and Billy's Gully DS (gauge no. 332402)

2.3.3 Watercourse classification

The Ordered Drainage 100K from the Queensland Government QSpatial website identifies riverine systems, watercourses, waterways or drainage lines (here referred to collectively as waterways) for the project area.

There are 7 waterways mapped within the IPC mining lease areas, including:

- one waterway of (Strahler) stream order four (4) (Smoky Creek);
- two waterways of stream order three (3) (Billy's Gully and Smoky Creek tributary); and
- four waterways of stream order two (2), minor drainage features that feed into Smoky Creek and Billy's Gully.

2.4 WATER QUALITY

2.4.1 Isaac River water quality

Water quality monitoring in the Fitzroy Basin is undertaken by the Department of Natural Resources, Mines and Energy (DNRME). Of relevance to this project are the monitoring stations at three sites on the Isaac River; Burton Gorge, Deverill and Goonyella (see Figure 1.1):

- The Burton Gorge station is located approximately 70 km upstream of IPC and was operational between 1964 and 1988;

- The Goonyella station is located approximately 22 km upstream of IPC and has been operational since 1983; and
- The Deverill station is located approximately 36 km downstream of IPC and has been operational since 1968.

The Isaac River catchment has seen significant changes in land use over the past 50 years. Widespread land clearing and coal mine development have occurred throughout the catchment. The extent to which these activities have affected water quality is difficult to ascertain. Coal mines have historically discharged mine-affected water immediately following significant rainfall events, but few records are available of the timing and quality of these releases. Typically, under normal conditions, water is conserved on site to provide water for site use. It is likely that streamflow and water quality records are not significantly affected by mine releases except for potentially during the recession of flood events when mine affected water is more likely to be released.

The water quality data from the downstream Isaac River monitoring station (Monitoring Point W2) for 2016 and 2017 is summarised as follows:

- EC values in the Isaac River vary from 110 µS/cm to 450 µS/cm;
- pH is generally neutral to slightly alkaline;
- Total suspended solids (TSS) values in the Isaac River vary between 130 mg/L and 4,800 mg/L; and
- All metal toxicants, with the exception of aluminium, copper, silver and iron are significantly lower than the ANZECC (2018) water quality objectives for aquatic ecosystem protection (for slightly to moderately disturbed level of protection).

2.4.2 Smoky Creek and Billy's Gully water quality

Water quality at the existing IPC is monitored in Smoky Creek and Billy's Gully upstream and downstream of the existing mine. Routine water quality samples for the upstream and downstream Smoky Creek monitoring points show the following:

- Typical EC values in Smoky Creek vary from 94 µS/cm (10th percentile) to 541 µS/cm (90th percentile), with a median value of 222 µS/cm from 2016 to 2019;
- pH is slightly alkaline;
- Typical TSS values in Smoky Creek vary from 60 mg/L (10th percentile) to 1,386 mg/L (90th percentile), with a median value of 278 mg/L from 2016 to 2019; and
- Copper, lead, silver, nickel and aluminium concentrations exceed the ANZECC (2018) WQO's for multiple samples over 2016 to 2019.

There is limited water quality sampling data available for Billy's Gully due to its ephemeral nature.

2.5 EXISTING WATER USE ENTITLEMENTS

Advice from the Queensland Government indicates that there are no licensed surface water users along any of the waterways that traverse IPC. That is, there are no users with an extraction volume issued under the provisions of the *Water Act 2000*.

There are 7 licences to take water from the Isaac River downstream of IPC which have been issued for mining, irrigation, stock watering, domestic supply and water harvesting. There are also several historical riparian water access notifications along the Isaac River which authorise stock and domestic supplies only. Section 20 of the *Water Act 2000* provides that an owner of land adjoining a watercourse may take water for domestic and stock purposes without the need for a permit or licence.

The above information indicates that there is currently minimal use of surface water from the tributaries that drain the mining leases. Water use from the Isaac River is limited to mining, irrigation and stock watering downstream of IPC.

3 Environmental values

The Environmental Protection (Water) Policy 2009 (EPP (Water)), which is subordinate legislation to the *Environmental Protection Act 1994*, provides a framework for identifying environmental values (EV) for a waterway and deciding water quality objectives (WQO) to protect or enhance those EV's. EV's for water are the qualities of water that make it suitable for supporting aquatic ecosystems and human water uses. These EVs are to be protected from the effects of habitat alteration, waste releases, contaminated runoff and changed flow to ensure healthy aquatic ecosystems and waterways that are safe for community use.

Smoky Creek and Billy's Gully are located within the Isaac northern tributaries region of the Isaac River Sub-Basin (WQ1301). The EV's selected for protection include:

- aquatic ecosystem protection (slightly to moderately disturbed ecosystems, QWQG 2009);
- irrigation, farm use and stock watering;
- human consumption;
- primary, secondary and visual recreation;
- drinking water;
- industrial use; and
- cultural and spiritual values.

In summary, the key EV's for water that are to be protected are:

- physical, chemical and biological integrity of the watercourses within the catchment and their amenity as potential water sources for human use and to support aquatic ecosystems;
- the qualitive and quantitative integrity of local groundwater as a potential water source for agriculture or other suitable uses; and
- the integrity of raw water supplies and associated infrastructure in the region.

Draft EV's for the Isaac River have been released by DES. While they are not yet current, they appear to be consistent with the 2009 EVs.

The most relevant EV's associated with current and proposed operations are aquatic ecosystem protection and irrigation, farm use and stock watering. The WQO's to protect these EV have already been developed as part of the existing approvals, and the associated release contaminant trigger levels are provided in Table 3 of the IPC EA.

There are no proposed changes to the current WQO's (and associated release contaminant trigger levels) proposed as part of the IPEE project.

Draft EV's for groundwater alluvium for the Isaac River have also been released by DES. The EVs selected for protection include:

- aquatic ecosystems;
- irrigation;
- stock watering;
- aquaculture;
- drinking water;
- industrial use; and
- cultural and spiritual values.

4 Existing site characteristics

4.1 OVERVIEW

This section describes the activities at the existing IPC operations that could potentially generate contaminants that may impact on the environmental values of the receiving waters, if not managed. The source of the contaminants has been identified and evaluated based on water quality data that has been collected on site.

4.2 EXISTING SITE OPERATING ACTIVITIES

The major components of the existing, approved operations at IPC include:

- open cut mining pits;
- out-of-pit spoil dumps;
- access and haul roads;
- mine infrastructure areas including:
  - office buildings and workshops;
  - ROM coal stockpiles; and
  - a CHPP including crushing facility, a product coal stockpile pad, a rail loop and rail loading facilities;
- sewerage treatment;
- flood protection levees; and
- mine water management structures.

4.3 SURFACE WATER TYPES

IPC has monitored water quality in dams that capture surface runoff since mining commenced. The water quality results are all stored in the sites' water quality database. A summary of water quality in dams with catchments of different water types is provided below.

For water management system purposes, the water generated at IPC is divided into four types:

- **Raw water**: is water sourced external to the mine operations.
- **Clean water**: surface runoff from areas where water quality is unaffected by mining operations. Clean water includes runoff from undisturbed areas and any fully rehabilitated areas (i.e. rehabilitated areas with established vegetation and stable landforms). It also includes runoff from the surrounding natural catchment that is diverted around the mine site with no direct impact on the water quality from the mining operations.
- **Mine affected water**:
  - means the following types of water
    - pit water, processing plant water;
    - rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated, excluding rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed in accordance with that standards and requirements of an Erosion and Sediment Control Plan

(ESCP) to manage such runoff, provided that this water has not been mixed with pit water, processing plant water or workshop water;

    - groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated;
    - groundwater from the mine's dewatering activities;
    - a mix of mine affected water and other water.
  - does not include surface water runoff which, to the extent that it has been in contact with areas disturbed by mining activities that have not yet been completely rehabilitated, and has only been in contact with:
    - land that has been rehabilitated to a stable landform and either capped or revegetated in accordance with the acceptance criteria set out in the environmental authority but only still awaiting maintenance and monitoring of the rehabilitation over a specified period of time to demonstrate rehabilitation success; and/or
    - land that has partially been rehabilitated and monitoring demonstrates the relevant part of the landform with which the water has been in contact does not cause environmental harm to waters or groundwater.
- **Sediment water**: rainfall runoff from catchments which can discharge through release points associated with erosion and sediment control structures that have been installed in accordance with that standards and requirements of an ESCP to manage such runoff, provided that this water has not been mixed with pit water, processing plant water or workshop water.

4.4 SITE WATER QUALITY

4.4.1 Raw water

Raw water is imported into site via external pipeline, where it is stored in Raw Water Dam and made available for use at IPC. A total of 5 individual samples measuring pH, EC and various metals were taken from Raw Water Dam over 2017. These are summarised in Table 4.1.

Table 4.1 - Water quality sampling results - Raw Water Dam (2017)

Contaminant	Units	No. of samples	Median	10%ile	90%ile
pH	-	5	7.6	7.8	7.8
EC	µs/cm	5	184	184	186
SO_4	mg/L	5	3.0	2.0	4.0
Turbidity	NTU	5	11.1	8.3	13.9
Suspended Solids	mg/L	5	5.0	5.0	5.0

4.4.2 Clean water quality

Clean runoff areas include the diverted catchments to the east of the pits at IPM, and the future diverted catchments to the east of IPE/IPEE. The catchments draining to RD1 and RD2 also contain significant areas of clean catchment. There are no dams at IPM which solely capture runoff from clean catchments. However, it is likely that the runoff from the natural catchments would produce runoff with similar characteristics to Smoky Creek and Billy's Gully.

A total of 35 samples measuring pH, EC and various metals were taken at Smoky Creek (upstream and downstream of the site) over 2016 and 2017. These are summarised in Table 4.2.

Table 4.2 - Water quality sampling results - Smoky Creek (2016/17)

Contaminant	Units	No. of samples	Median	10%ile	90%ile
pH	-	35	7.8	7.6	8.0
EC	µs/cm	35	230	110	675
SO_4	mg/L	32	8.0	3.1	41.3
Turbidity	NTU	35	455	60	1,470
Suspended Solids	mg/L	32	335	75	1,375

Full characterisation of water quality within the natural waterways is provided in the latest REMP assessment report (C&R, 2018b).

4.4.3 Sediment water quality

Sediment water includes runoff from the overburden dumps which can discharge through release points associated with existing erosion and sediment control structures that have been installed in accordance with that site's ESCP (C&R, 2018a).

No data is currently collected for runoff that drains specifically from the overburden dumps. Overburden dump runoff drains to RD1 and S2 SD on IPM, which receives runoff from multiple sources. The proposed IPE sediment dams will capture sediment water runoff from the IPE overburden dumps.

Monitoring of water quality in RD1 suggests that the overburden dump runoff has characteristics similar to clean runoff but with elevated EC and TSS concentrations. This is supported by overburden characterisation provided in the site's Mining Waste Management Plan (C&R 2018c). Once constructed and operating, the proposed IPE sediment dams will be monitored to confirm the overburden dump runoff characteristics.

4.4.4 Mine affected water quality

Mine affected water includes all runoff collected within the open cut pits (includes groundwater) and runoff from the ROM and product stockpiles. It also includes runoff from areas disturbed by mining which are not rehabilitated, except for areas managed under the site's ESCP (C&R, 2018a).

A total of seven lab samples measuring pH and EC, and seven samples testing the full suite of metals were taken in S3 Pit at IPC over 2017 and 2018. S3 Pit was the primary mine affected water storage over this period. The following is of note:

- The pH of pit water is reasonably high with values ranging between 8.45 and 8.60. Note that in December 2017 the pH is S3 Pit was recorded at 4.9, which is not consistent with the historical pH;
- The electrical conductivity is high with values ranging between 5,820 and 6,690 µs/cm;
- Metal toxicants are generally below the onsite water storage contaminant limit and release contaminant trigger investigation level except for aluminium.

Mine affected water is primarily recycled and reused on site.

Given the high EC values, pit water is unlikely to be able to be directly released, except during high to flood flow conditions in the receiving waters (Isaac River).

4.5 CHEMICAL AND FUEL STORAGE

Primary chemical storage areas at IPC are located within the mine infrastructure area at the workshop and the CHPP workshop area. These storage facilities have been constructed and bunded generally in accordance with the relevant specifications of *AS1940 - Storage and Handling of Flammable and Combustible Liquid*s (AS1940). Hazardous Substances Safe Operating Procedures (SOP) are in place at these operations. A register is also maintained on site for all chemicals. Where appropriate, Material Safety Data Sheets (MSDS) are kept in storage areas or are available for on-line access, as required.

Fuel storage areas are a potential source of hydrocarbons. Primary fuel storage areas at the mine infrastructure area have been constructed and bunded in accordance with the relevant specifications of *AS1940 - Storage and Handling of Flammable and Combustible Liquids (AS1940)*. Fuel storage areas have also been constructed at service and operational points across the mining lease.

Fuel storage areas associated with IPC operations are inspected regularly, with repair and maintenance work completed as required. Bunds filled with stormwater are drained or pumped out by a licensed contractor as soon as practicable to maintain the bund volume.

Incident reporting and the management of spills are undertaken in accordance with the site operational incident reporting forms and the procedures outlined in the IPM '*Spill Clean-up Procedure*' document (IPCM_ENVIRO_PRO.013)

5 Surface water management strategy and infrastructure

5.1 OVERVIEW

This section describes the objectives and principles of the IPC water management system for the existing and proposed mining operations at IPC (including the IPEE project), including a description of the infrastructure and systems that have been put in place to achieve the objectives and principles.

5.2 SURFACE WATER MANAGEMENT OBJECTIVES

The objective of the site water management system is to manage all types of water on site to meet operational, social and environmental objectives encapsulated by the sites Environmental Authority and any other relevant approvals.

There are two key WMS objectives:

- Ensure the IPC minimises mine affected water accumulation, minimises the risk of uncontrolled discharges and that the site has sufficient water available for operation in dry times; and
- Successfully engage with external stakeholders to be seen as a good custodian of society's water resources. The priority issues are the site's impact on surface water and groundwater.

Specific objectives for each water type are as follows:

- External water: Ensure that external water allocation and associated infrastructure is sufficient to meet site demands particularly under low rainfall conditions.
- Mine affected water:
  - Ensure any controlled releases of mine affected water prevents environmental harm.
  - Minimise uncontrolled discharges in wet periods to ensure adequate water supplies are maintained for site demand during dry periods.
  - Understand, manage and minimise the potential impact of the water management system on the regional groundwater system.
- Sediment water: Maintain the quality of water discharging from Erosion and Sediment Control (ESC) structures to as close to background levels as reasonably possible.
- Clean water: Separate from the mine affected and sediment water systems as much as practicable and allow it to pass uninterrupted through the catchment.
- Contaminated water: Ensure full separation from other water sources and manage under the specifications of AS1940 - Storage and Handling of Flammable and Combustible Liquids.

The identified changes to the water management system due to the project will continue to be managed in accordance with these objectives.

5.3 SURFACE WATER MANAGEMENT PRINCIPLES

The general principles to manage surface water for the site are as follows:

- The fullest separation possible of clean, sediment water, mine affected water runoff, within the limitations of operational requirements.
- Minimise the area of surface disturbance, thus minimising the volume of sediment or mine affected runoff.
- Collect and contain on site all potential mine affected water into dedicated mine water storages. The mine water storages will be used as the primary water source for the CHPP and dust suppression.
- Retain and reuse on site any sediment water runoff that has high sediment concentrations whenever possible. If not, release it in a controlled manner (i.e. following settlement) in compliance with the EA conditions.
- Prioritise the use of poor quality water over better quality water.

The identified changes to the water management system due to the project will continue to be managed in accordance with these principles.

5.4 TAILINGS AND REJECTS CIRCUIT

The CHPP tailings circuit currently adopts a 'dry tailings' method. The fine tailings are dewatered at the CHPP using belt press filters, with the extracted water recycled back in the CHPP water circuit. The combined dewatered tailings and coarse rejects are hauled from the CHPP by truck to active overburden emplacement areas for disposal.

The CHPP is currently transitioning to the following waste disposal process:

- Coarse rejects will be transferred by conveyor to the reject stockpile, and then placement within in-pit waste rock emplacement areas.
- Fine rejects will be thickened for pipeline transfer to Fine Rejects Cells (located within in-pit disposal areas, where flocculants are added and water recovered for reuse within CHPP.
- Both the Coarse and Fine Reject Cells will be later capped and rehabilitated.

5.5 MINE AFFECTED WATER MANAGEMENT

The existing mine affected water containment is provided by the following existing storages:

- RD1;
- N1 Pit;
- S2 Sediment Dam; and
- CHPP Process Pond.

Historically, S3 pit has been used as the primary mine affected water storage at IPC. This function (including stored water) has been transferred to N1 Pit. Once dewatered, S3 Pit will begin the process of backfilling and rehabilitation.

Mine affected water from the active mining pits is pumped to the N1 Pit for storage and later reuse for dust suppression and at the CHPP. Dust suppression water supplies are taken from S2 Sediment Dam, which is primarily supplied by N1 Pit. A series of pumps and pipelines are in place to transfer water around the mine.

There are no proposed changes to this configuration as part of the IPEE project.

5.5.1 Mine affected water management storages

Figure 5.1 shows the location of the mine water management storages including mine affected water dams. A summary of the mine water storages, their capacities and surface areas are provided in Table 5.1.

Table 5.1 - Existing mine affected water storages

Dam Name	Storage Volume @ Full Supply (ML)	Maximum operating volume (ML)	Storage Surface Area (ha)	Maximum Water Depth (m) (Estimate)	Maximum Catchment Area (ha)	Overflows To
N1 Pit	23,440	17,770	64.7	69.0	326	Smoky Creek
RD1	205	176.3	16.2	5.0	159	Smoky Creek
S2 SD	172	149.4	4.0	8.6	54.2	Smoky Creek
CHPP Process Pond	17	17	0.5	5.5	17.7	RD1

5.6 SEDIMENT WATER MANAGEMENT SYSTEM

5.6.1 Overview

Sediment water containment (runoff from spoil and incomplete rehabilitated areas) is managed in accordance with the site Erosion and Sediment Control Plan (ESCP) (C&R, 2018b). The ESCP adopts the three cornerstones of erosion and sediment control.

- Drainage control – prevention or reduction of soil erosion caused by concentrated flows and appropriate management and separation of the movement of diverted and surface water through the area of concern.
- Erosion control – prevention or minimisation of soil erosion (from dispersive, nondispersive or competent material) caused by rain drop impact and exacerbated overland flow on disturbed surfaces.
- Sediment control – trapping or retention of sediment either moving along the land surface, contained within runoff (i.e. from up-slope erosion) or from windborne particles.

The IPEE project will require a combination of the three control measures to effectively manage sediment and erosion at the site.

5.6.2 Existing and proposed sediment dams

Figure 5.1 shows the location of the existing sediment water management storages including sediment dams at IPM. Figure 5.2 shows the location of the currently approved sediment water management storages for the currently approved IPE configuration.

As part of the IPEE project, the locations and number of proposed sediment dams have been revised to accommodate the changes in disturbance footprint, mining progression and rehabilitation advancement. Figure 5.3 shows the location of the proposed sediment water management storages for the IPEE project.

A summary of the existing and proposed sediment water storages, their capacities and surface areas are provided in Table 5.2.

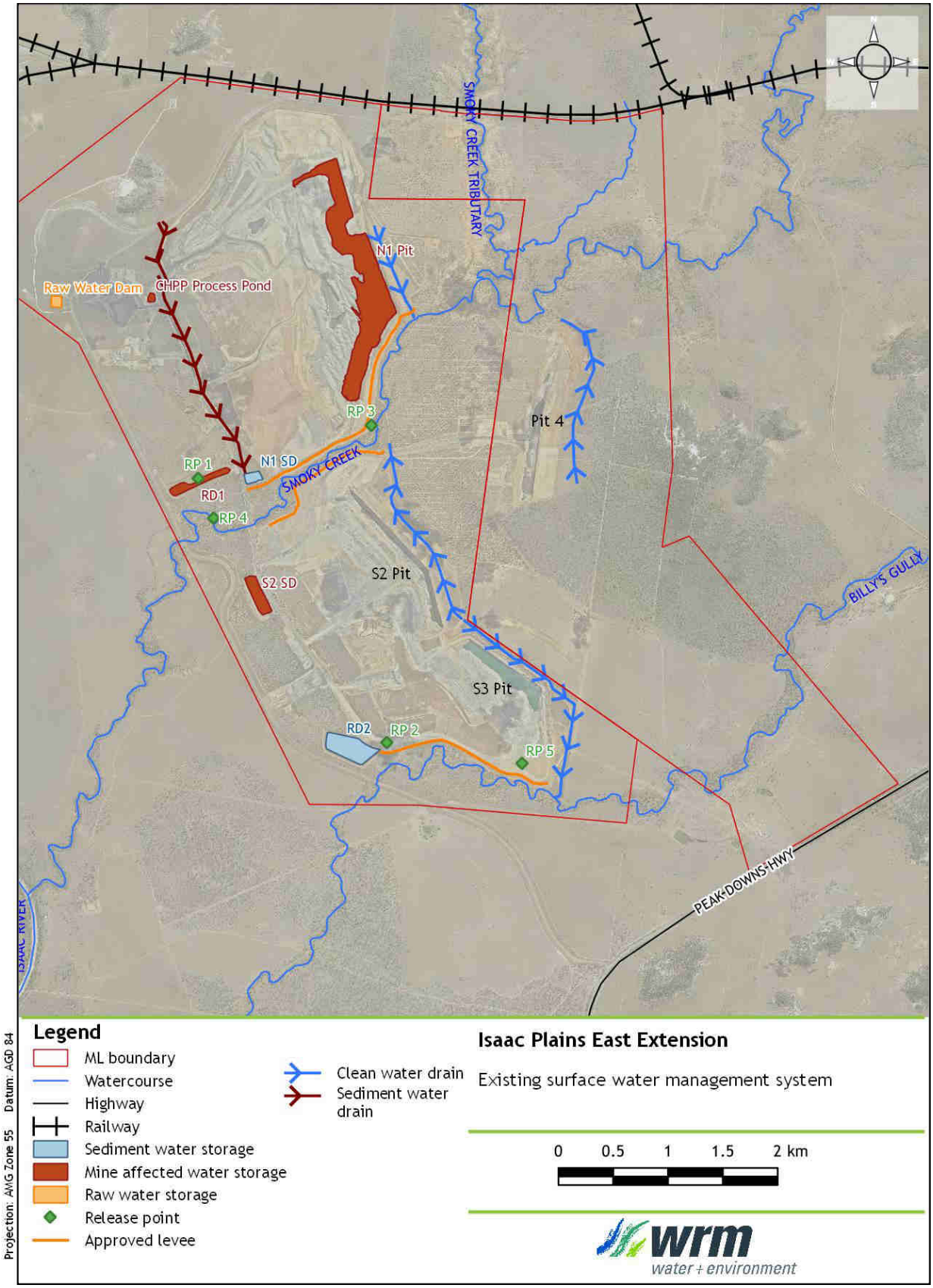

Figure 5.1 – Existing surface water management system

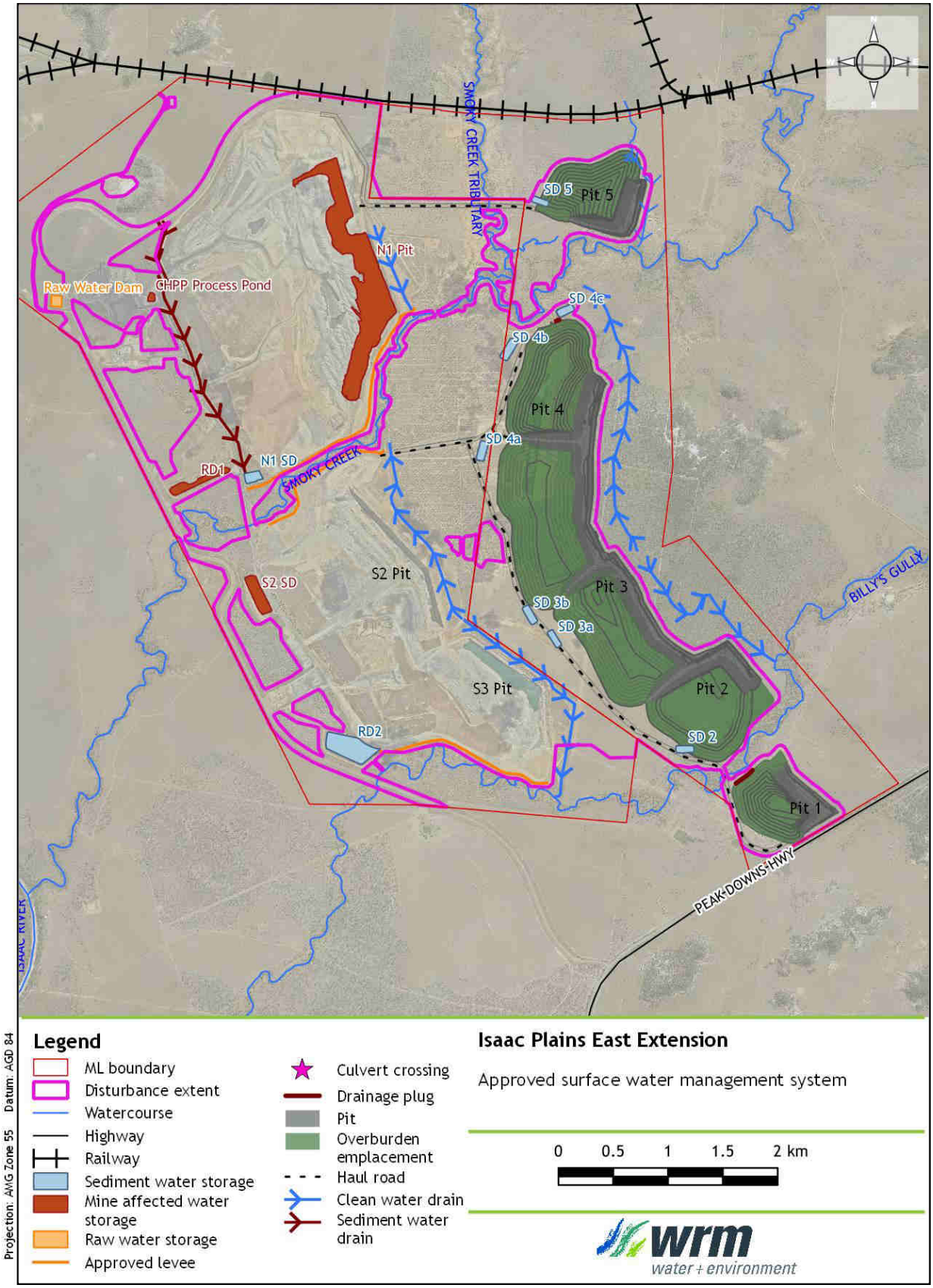

Figure 5.2 – Approved surface water management system

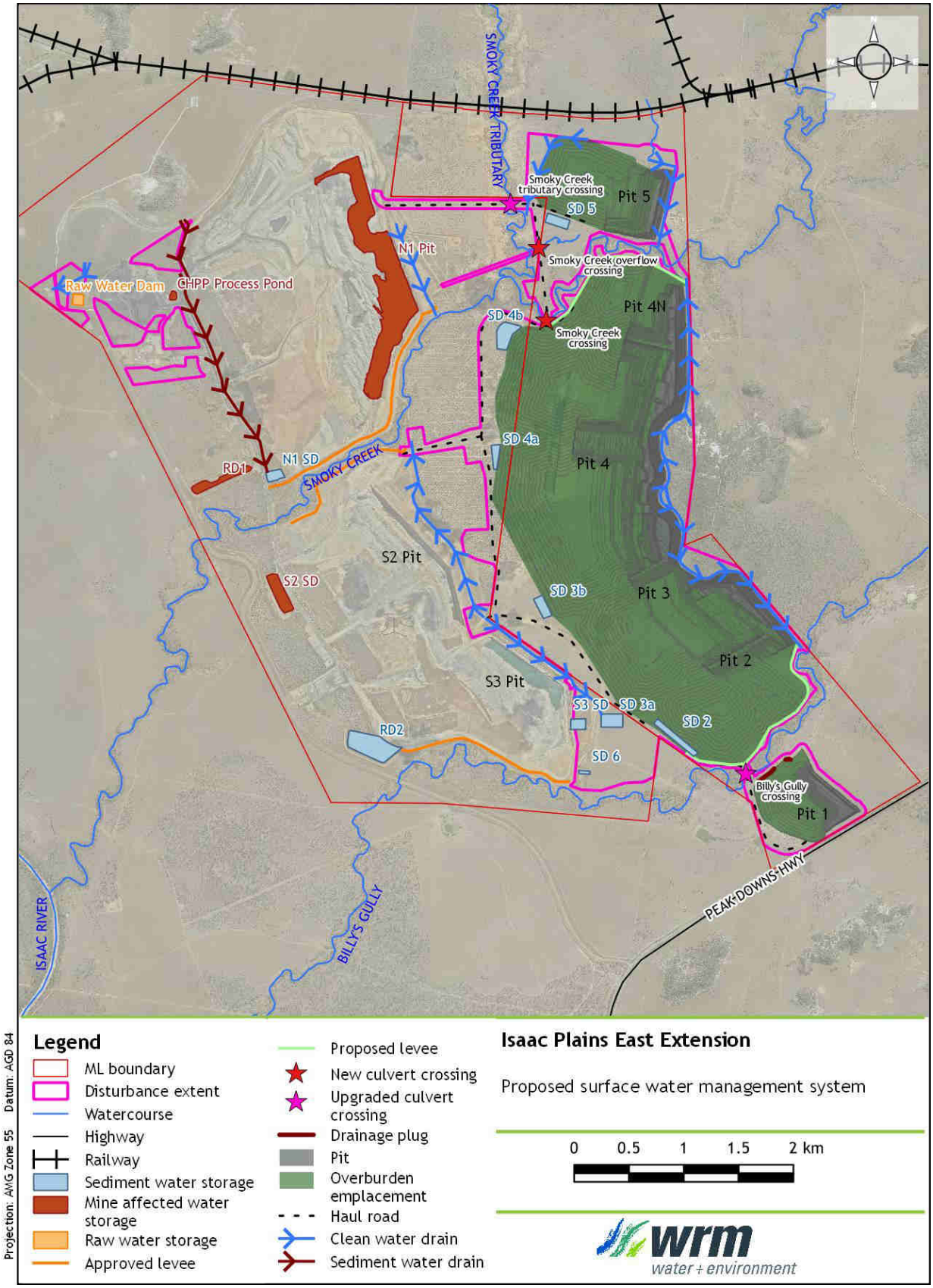

Figure 5.3 - Proposed surface water management system

5.6.3 Sediment dam sizing

Sediment dams capture runoff from overburden dumps in accordance with the IPC ESCP (C&R, 2018b). The proposed sediment dams have been sized in accordance with the Best Practice Erosion and Sediment Control Guidelines (IECA, 2008). Runoff collected in the dams will be released to the downstream environment in accordance with the IPC ESCP or pumped back into the mine water system to maintain capacity.

The proposed sediment dams have been based on the following design standards and methodology:

- "Type D/F" sediment basins;
- total sediment basin volume = settling zone + sediment storage volume. The sediment storage volume is the portion of the basin storage volume that progressively fills with sediment until the basin is de-silted. The settling zone is the minimum required free storage capacity that must be restored within 5 days after a runoff event;
- sediment basin settling volume based on 85th percentile 5-day duration rainfall of 33.5 mm with an adopted volumetric event runoff coefficient for disturbed catchments of 0.46 (Group C soils – loamy clay); and
- solids storage volume = 50% of settling zone volume.

Five sediment dams (SD 2, SD 3a, SD 3b, SD 4a, SD 4b and SD5) would be constructed as part of the project to capture runoff from the overburden dump. S3 SD and SD 6 are proposed as part of IPM. Table 5.2 shows the maximum contributing catchment areas and design volumes for each of the proposed sediment dams. The locations of the proposed sediment dams are shown in Figure 5.3.

Table 5.2 – Proposed and existing sediment water storages

Dam Name	Storage Volume @ Full Supply (ML)	Dam Surface Area (ha)	Max Water Depth (m) (Estimate)	Maximum Catchment Area (ha)	Overflows To
IPM (existing)					
N1 SD	31.3	3.5	1.5	169.8	Smoky Creek
RD2	147.7	8.8	2.2	112.2	Smoky Creek
IPM (proposed)					
S3 SD	31.6	1.4	3.0	138.0	SD 6
SD6	6.1	0.3	3.0	26.5	Billy's Gully
IPE (proposed)					
SD 2	23.9	1.1	3.0	103.0	Billy's Gully
SD 3a	9.0	0.4	3.0	39.4	Billy's Gully / SD 6
SD 3b	18.2	0.8	3.0	79.2	Smoky Creek
SD 4a	11.9	0.5	3.0	52.1	Smoky Creek
SD 4b	20.9	0.9	3.0	91.1	Smoky Creek
SD 5	17.1	0.8	3.0	74.6	Smoky Creek

5.7 CLEAN WATER MANAGEMENT SYSTEM

5.7.1 Flood protection levees

Flood levees are proposed across the IPEE Project to prevent floodwater from Smoky Creek and Billy's Gully from entering the mine water management system. There are existing approved levees at IPM along Smoky Creek and Billy's Gully. The location of the proposed IPEE levees and existing, approved levees is shown in Figure 5.3.

The levees will be regulated structures under the EP Act and will therefore be required to have a crest above the 0.1% AEP event. An assessment of the levee against the requirements of the EP Act is given in Section 8.4.

5.7.2 Clean water diversions

A series of clean water diversion drains are proposed to capture and divert catchment runoff water around the mining areas. The indicative locations of the proposed drain and dams for the various mine stages are shown Figure 1.3 to Figure 1.8. Descriptions of the drains are as follows:

- By 2020, two intermediate clean water diversions drains (Pit 2 Drain, Pit 4 Drain) and two permanent clean water diversion drains (Pit 5 East Drain and Pit 5 West Drain) will be constructed to divert runoff area the mining area; and
- By 2024, the two intermediate clean water diversions drains will be replaced by two permanent clean water diversion drains, located further to the east.

Additional catchment diversions and drainage around the CHPP area will be undertaken as part of the project to reduce clean water catchments from entering the water management system, and further improve the separation of clean and mine affected waters.

A summary of the proposed changes is provided below and presented in Figure 5.4.

- Divert the clean catchment north of the CHPP away to the west. This catchment previously drained to RD1 (via CHPP Process Pond).
- Divert the clean catchment northeast of the CHPP away towards N1 SD (rather than CHPP Process Pond).
- Significantly reduce the catchment area of CHPP Process Pond and RD1.
- Increase the catchment area of N1 SD, which is primarily made up of clean and rehabilitated spoil areas.

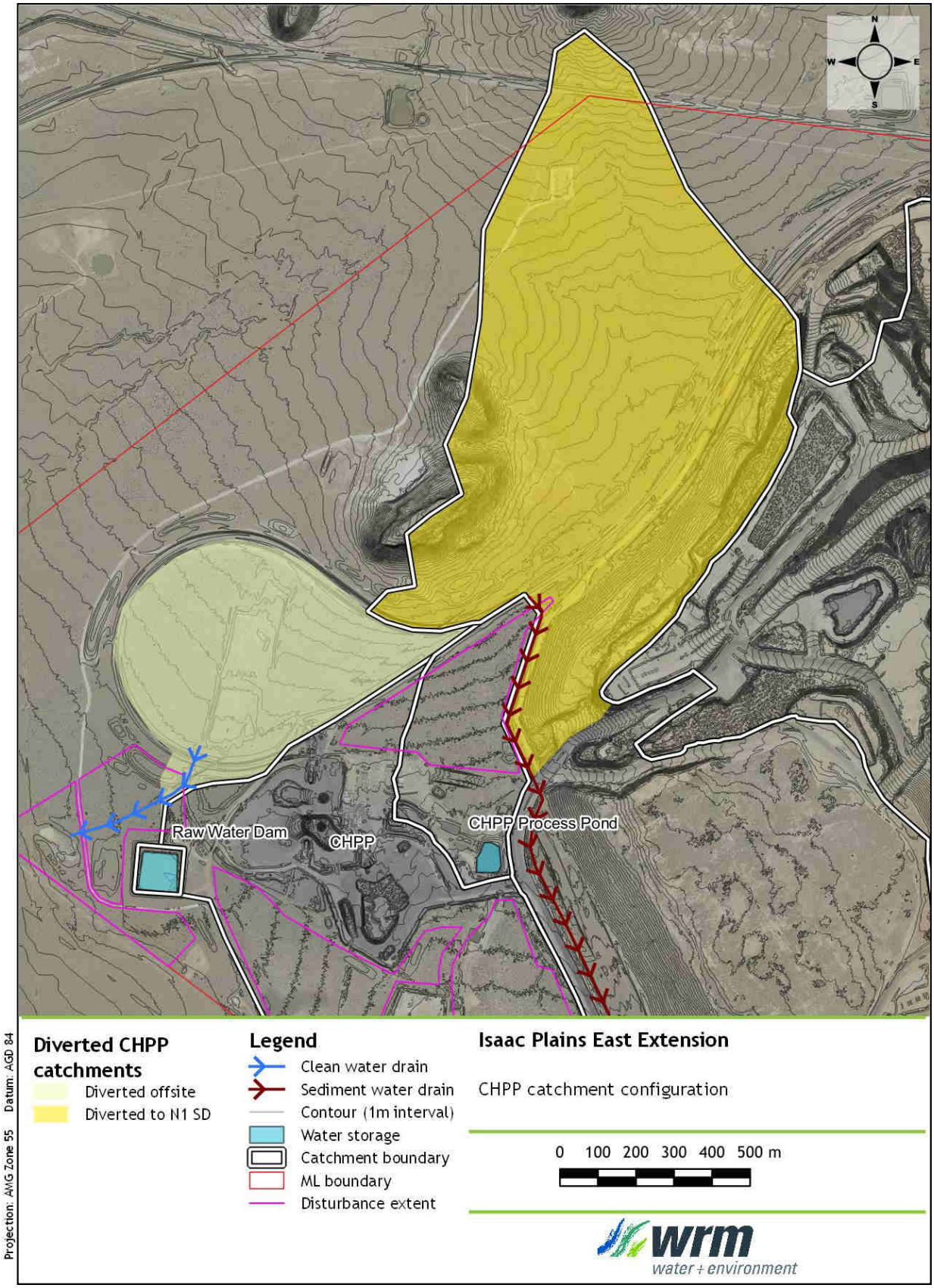

Figure 5.4 – Proposed catchment re-configuration around the CHPP area

5.8 APPROVED RELEASE CONDITIONS

The current IPC EA (EPML00932713; DES 2018) took effect on 8 May 2019 and include the amendments resulting from the IPE project which were approved on 24 January 2018. The EA conditions require that mine affected water may only be released from designated release points when water quality is within defined end-of-pipe limits. A description of these compliance conditions is given below.

Table 5.3 lists all the mine affected water release points and associated receiving water for the current water management system (Table 1 in the IPC EA). The locations of the existing release points are shown in Figure 5.1. However, as S1 pit is now completely backfilled and S3 Pit is currently in the process of being backfilled, Table 1 and Table 5 of the IPC EA will require amending to remain consistent with existing and proposed operations. Proposed changes to Table 1 and Table 5 of the IPC EA are discussed in Section 10.7.

Table 5.4 and Table 5.6 shows the contaminant release conditions given in the EA. Under these conditions, the release of mine affected water from authorised release points to receiving waters must not exceed those values (dependant on receiving water flow for some contaminants). Table 5.5 shows the release contaminant trigger investigations levels currently set in the IPC EA.

Table 5.3 - Mine affected water release points (EA table 1)

Release point	Easting	Northing	Mine affected water source and location	Monitoring point	Receiving waters
RP 1	614974	7569713	Release Dam 1	Spillway	Smoky Creek
RP 2	616695	7567301	Release Dam 2	Spillway	Billy's Gully
RP 3*[1]	616554	7570197	S1 pit	Pump intake (via bleed-off valve)	Smoky Creek
RP 4*[2]	615114	7569350	S2 SD	Pump intake (via bleed-off valve)	Smoky Creek
RP 5*[3]	617929	7567111	S3 pit	Pump intake (via bleed-off valve)	Billy's Gully

Notes: 1/ RP 3 is now backfilled and no longer a release point.
2/ In practice, RP 4 is not used for controlled releases.
3/ S3 Pit will cease to function as a release point once backfilling operations are finished.

Table 5.4 - Mine affected water release limits (EA table 2)

Quality Characteristic	Units	Minimum	Maximum
Electrical Conductivity (EC)	µs/cm	n/a	Variable[1]
pH	pH units	6.5	9.0
Total Suspended Solids (TSS)	mg/L	n/a	See footnote 2
Sulphate (SO_4^{2-})	mg/L	n/a	Variable[1]

Note: 1/ Release limits for EC and SO_4 are dependent on receiving water flow and are specified in EA Table 4 (see Table 5.6 below).
2/ Release limits for TSS must be determined and submitted to the administering authority via an amendment to the EA by 30 June 2020.

Table 5.5 – Release contaminant trigger investigations levels (EA table 3)

Quality Characteristic	Trigger level (µg/L)
Aluminium	55[1]
Arsenic	13[1]
Cadmium	0.2[1]
Chromium	1.0[1]
Copper	2.0[1]
Iron	300[1]
Lead	10[1]
Mercury	0.2[1]
Nickel	11[1]
Zinc	8.0[1]
Boron	370[1]
Cobalt	90[1]
Manganese	1,900[1]
Molybdenum	34[1]
Selenium	10[1]
Silver	1.0[1]
Uranium	1.0[1]
Vanadium	10[1]
Ammonia	900[1]
Nitrate	1,100
Petroleum hydrocarbons (C6-C9)	20
Petroleum hydrocarbons (C6-C9)	100
Fluoride (total)	2,000[2]
Sodium	See footnote 3

Note: 1/ For aquatic ecosystem protection.
2/ For protection of livestock and short-term irrigation guideline
3/ Trigger level for Sodium must be determined and submitted to the administering authority via an amendment to the EA by 30 June 2020.

There are no proposed changes to the currently approved release limits or release contaminant trigger investigation levels as a result of the IPEE project.

5.9 CONSEQUENCE CATEGORY ASSESSMENT

The proposed sediment dams associated with IPEE will be included in future consequence category assessments, however it is highly unlikely that any of these dams will be classified as regulated structures as they will not receive mine affected water.

Table 5.6 - Mine affected water release during flow events (EA table 4)

Receiving Waters/Streams	Release Point (RP)	Gauging Station	GS Latitude (dec. degree, GDA94)	GS Latitude (dec. degree, GDA94)	Receiving Water Flow Criteria for Discharge (m^3/s)	Maximum release rate (for all combined RP flows)	Electrical Conductivity and Sulphate Release Limits
Isaac River (via Smoky Creek & Billy's Gully)	RP1, RP2 RP3, RP4, & RP5	130414A Isaac River @ Goonyella	-24.8555°S	-147.9726°E	**Low Flow**		
					<4 m^3/s for a period of 28 days after natural flow events that exceed 4 m^3/s	<2 m^3/s	Electrical conductivity 720 µs/cm Sulphate (SO_4^{2-}) 250 mg/L
					Medium Flow		
					4 m^3/s	0.142 m^3/s	Electrical conductivity 3,000 µs/cm Sulphate (SO_4^{2-}) 300 mg/L
					10 m^3/s	0.257 m^3/s	Electrical conductivity 4,000 µs/cm Sulphate (SO_4^{2-}) 300 mg/L
					High Flow		
					50 m^3/s	1.09 m^3/s	Electrical conductivity 5,000 µs/cm Sulphate (SO_4^{2-}) 4000 mg/L
					Very High Flow		
					100 m^3/s	2.02 m^3/s	Electrical conductivity 5,000 µs/cm Sulphate (SO_4^{2-}) 400 mg/L
					Flood Flow		
					250 m^3/s	3.07 m^3/s	Electrical conductivity 8,000 µs/cm Sulphate (SO_4^{2-}) 400 mg/L

6 Water balance model configuration

6.1 OVERVIEW

A computer-based operational simulation model (OPSIM) was used to assess the dynamics of the water balance under varying rainfall and catchment conditions throughout the development of the IPEE project. This model has been in operation since the conception of the mine and has been continually updated as data becomes available or mining operations have changed. The model will be continually updated throughout the life of the project.

The OPSIM model dynamically simulates the operation of the water management system and keeps account of all site water volumes and representative water quality on a daily time step.

The model has been configured to simulate the operation of all major components of the water management system. The simulated inflows and outflows included in the model are given in Table 6.1.

Table 6.1 - Simulated inflows and outflow to the mine affected water management system

Inflows	Outflows
Direct rainfall on water storage surface	Evaporation from water surface of storage
Catchment runoff	CHPP demand
Groundwater inflows	Dust suppression demand
External water supply	Miscellaneous raw water demand
	Offsite spills from storages
	Controlled releases

6.2 SIMULATION METHODOLOGY

The water balance model has been run on a daily time step for a 19-year period, corresponding to the period of operation between 2020 and 2038. This period includes current approved mining activities at IPM and IPE, incorporates the changes to operations and rehabilitation resulting from the IPEE project, and includes the future underground operations which follow open cut mining. The model has been broken down into six discrete stages over the 19-year period, as shown in Table 6.2.

Table 6.2 - Project staging

Stage	Mine plan representative year	Modelled period	No. of model years
1	2020	2020	1
2	2021	2021 – 2022	2
3	2024	2023 – 2025	3
4	2028	2026 – 2028	3

Stage	Mine plan representative year	Modelled period	No. of model years
5	2033	2029 – 2033	5
6	2038	2034 - 2038	5

The model has been run for 111 climate sequences, each referred to as a "realisation". Each realisation is based on a 19-year sequence extracted from the historical rainfall data. The first realisation was based on rainfall data from 1889 to 1907. The second used data from 1890 to 1908 and so on. This approach provides the widest possible range of climate scenarios covering the full range of climatic conditions represented in the historical rainfall record. Statistical analysis of the results from all realisations provides a probability distribution of key hydrologic parameters, such as storage inventories and pit inundation.

6.3 RAINFALL AND EVAPORATION

6.3.1 Local climate data

Table 6.3 provides a summary of the available rainfall and evaporation recording stations in the vicinity of the project.

Table 6.3 – Rainfall and evaporation stations in the vicinity of the project

Station no.	Station name	Data obtained	Data owner	Distance from IPE	Opened	Closed
332404	Isaac Plains AWS	Rainfall	Stanmore	4 km W	2014	-
332405	Morambah AWS	Rainfall	Stanmore	7 km SW	2014	-
534003	Isaac River at Deverill	Rainfall	DRNME	33 km SSE	1968	-
130414	Isaac River at Goonyella	Rainfall	DRNME	22 km NNW	1983	2011
034035	Moranbah Airport	Rainfall, min. and max. temp.	BOM	13 km SW	2012	-
034038	Moranbah Water Treatment Plant	Rainfall, evaporation min. and max. temp.	BOM	12 km W	1972	2012

Table 6.4 shows the average monthly rainfall for the period of record at the Isaac Plains AWS, Morambah AWS, Moranbah Airport and Moranbah Water Treatment Plant (WTP).

The data from the Moranbah Water Treatment Plant station has the longest concurrent rainfall and evaporation dataset within the region. Table 6.5 shows the variability in monthly rainfall at the Moranbah WTP.

Figure 6.1 shows the annual distribution of monthly rainfall and evaporation at the Moranbah WTP. Both rainfall and evaporation are higher in the warmer months, with evaporation substantially exceeding rainfall in all months.

Table 6.4 - Mean monthly rainfall for local rainfall stations

Month	Isaac Plains AWS (Sept 2014 to Jul 2019)	Morambah AWS (Mar 2014 to Jul 2019)	Moranbah Airport (Mar 2012 to Jul 2019	Moranbah WTP (Apr 1972 to Mar 2012)
January	93.6	89.7	86.2	98.7
February	76.8	102.0	117.9	95.8
March	115.7	56.1	97.7	51.4
April	4.4	11.1	26.2	34.6
May	21.8	19.4	27.4	33.7
June	29.4	17.8	17.3	21.6
July	34.7	24.0	32.1	17.1
August	10.6	19.0	8.7	24.4
September	4.4	9.1	8.4	8.4
October	36.4	30.3	26.3	33.9
November	39.3	37.3	46.2	65.9
December	81.2	75.8	63.3	98.9
TOTAL	548.3	491.5	557.5	584.4

Table 6.5 - Monthly rainfall statistics for Moranbah WTP

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	99	96	51	35	34	22	17	24	8.4	34	66	99	584
Maximum	315	347	268	271	197	170	104	247	61	147	220	350	1,109
90th %ile	214	214	185	81	75	48	63	72	21	104	154	200	877
Median	89	86	33	24	19	10	5.8	9.8	3.6	15	53	82	543
10th %ile	17	6.0	1.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	4.0	18	327
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	101

Rainfall across the project area is expected to be greatest during the summer months, with the lowest rainfalls occurring mid-winter, as inferred from the 40 years of data collected at the Moranbah WTP

Evaporation across the project area is also expected to be greatest during the summer months, with the lowest evaporation rates generally occurring mid-winter, as inferred from the 40 years of data collected at the Moranbah WTP.

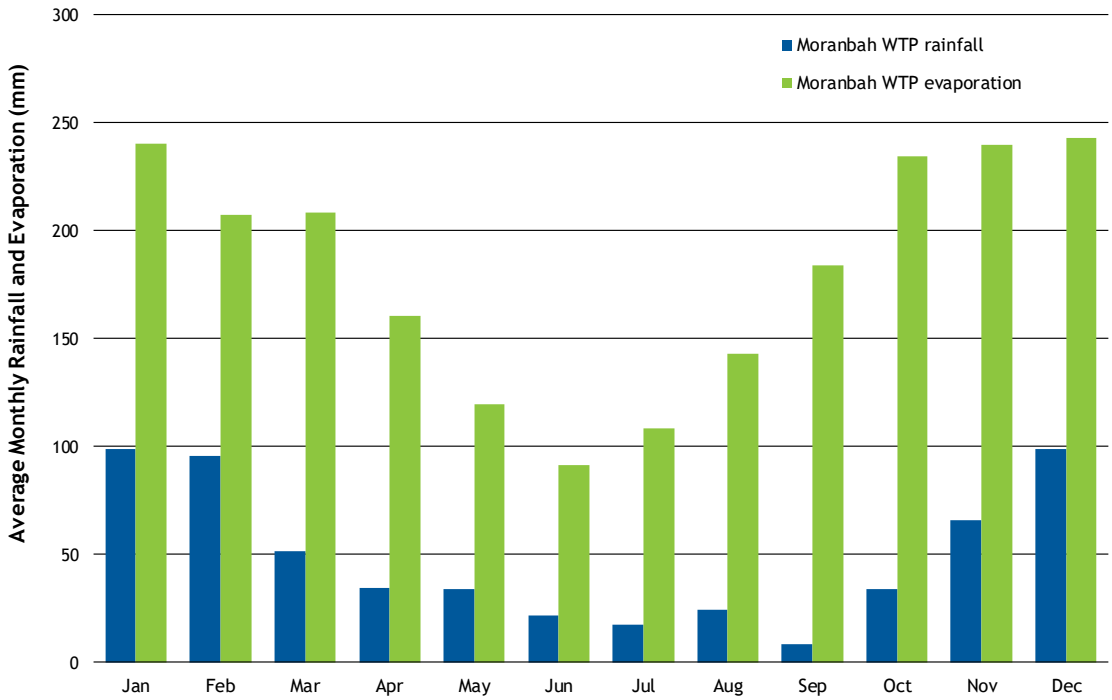

Figure 6.1 - Distribution of monthly rainfall and pan evaporation, Moranbah WTP

6.3.2 DataDrill climate data

As described in Section 6.3, there is around 48 years of recorded rainfall data available for the Moranbah WTP and Moranbah Airport gauges. In order to extend the dataset, long term daily rainfall data for the project area from 1 January 1889 to 31 December 2018 (130 years) was obtained from the DSITIA Data Drill service. This data set is corrected for accumulated daily rainfall totals and missing data.

Morton's equation for lake evaporation has been used to estimate evaporation losses from storages. Table 6.6 shows the long-term monthly averages for Morton's Lake evaporation and DataDrill rainfall.

Figure 6.2 shows the annual distribution of monthly rainfall and Morton's Lake evaporation. Average annual lake evaporation is more than three times the average annual rainfall.

Table 6.6 - Long-term average rainfall and evaporation

Month	SILO DataDrill rainfall (mm)	Morton's Lake evaporation (mm)
January	108.2	201.1
February	100.7	170.0
March	70.3	169.7
April	31.5	135.4
May	25.8	105.0
June	29.3	83.8
July	20.3	94.5
August	18.2	122.3

September	14.7	155.1
October	29.2	192.3
November	48.8	203.2
December	85.5	213.2
TOTAL	583	1,846

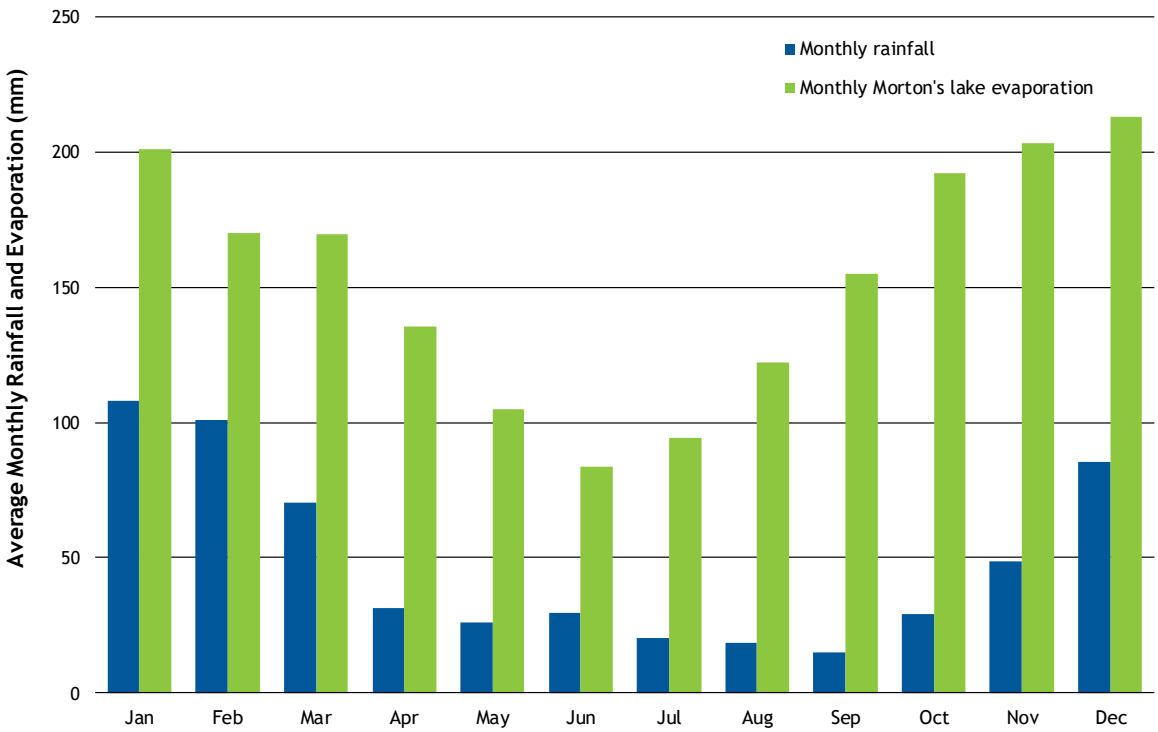

Figure 6.2 – Distribution of monthly rainfall and evaporation, DataDrill (1889-2018)

6.4 CATCHMENT YIELD PARAMETERS

6.4.1 Overview

The OPSIM model uses the Australian Water Balance Model (AWBM) (Boughton, 2003) to estimate runoff from rainfall. The AWBM is a saturated overland flow model which allows for variable source areas of surface runoff. The AWBM uses a group of connected conceptual storages (three surface water storages and one ground water storage) to represent a catchment. Water in the conceptual storages is replenished by rainfall and is reduced by evaporation (surface stores only). Simulated surface runoff occurs when the conceptual storages fill and overflow.

The model uses daily rainfalls and estimates of catchment evapotranspiration to calculate daily values of runoff using a daily water balance of soil moisture. The model has a baseflow component which simulates the recharge and discharge of a shallow subsurface store. Runoff depth calculated by the AWBM model is converted into runoff volume by multiplying the contributing catchment area.

The model parameters define the storage depths (C1, C2 and C3), the proportion of the catchment draining to each of the storages (A1, A2 and A3), and the rate of flux between them (K_{base}, K_{surf} and BFI).

To adequately simulate the site water balance, it is necessary to define the runoff characteristics of the various catchment surface types. Catchments across the site were characterised into the following land use types:

- Natural, representing areas undisturbed by mining;
- Compacted, representing haul roads, hardstand areas, stockpiles and the pit floor;
- Cleared or pre-strip areas ahead of mining;
- Rehabilitated areas; and
- Spoil dump; representing uncompacted dumped overburden material.

6.4.2 Natural catchment AWBM parameters

An AWBM model was calibrated to the recorded daily Phillips Creek flows at Tayglen, using the Rainfall Runoff Library (RRL) developed by the CRC for Catchment Hydrology (Podger, 2004). The model was run for a warm-up period (19/5/1968 to 27/8/1968) to initialise the various model storages and calibrated over the period 28/8/1968 to 29/9/1988. The model was calibrated to achieve a similar total volumetric runoff coefficient to the recorded data. Table 6.7 shows the calibration data statistics and Table 6.8 shows the adopted AWBM parameters and calculated volumetric runoff coefficient for the natural catchment.

Table 6.7 – Calibration data statistics, Phillips Creek

Parameter	Total runoff (mm)	Mean (mm)	Std. deviation (mm)	Skew (mm)
Observed runoff	740.07	0.101	0.858	15.867
Modelled runoff	740.44	0.101	0.756	14.807

6.4.3 Adopted AWBM parameters

To represent undisturbed areas on the mine site (or “natural” catchments), the same calibrated parameters developed for Phillips Creek were used. When this parameter set is applied to the synthetic long-term rainfall data at IPC, the runoff coefficient is around 4.5%.

Compacted catchments (including mining pit, roads/hardstand and stockpile/industrial areas) are characterised by hard surfaces which inhibit water infiltration, resulting in much higher rates of surface runoff. To represent compacted catchments, the depth of the model surface stores was substantially reduced and baseflow eliminated. The simulated volumetric runoff coefficient for disturbed catchments was 27.5%, about 6 times higher than natural catchments. This value is similar to typical values for urban catchments, which have similar characteristics.

The adopted model parameters for “rehabilitated spoil” assume lower opportunities for evapotranspiration than natural catchments and also that a significant component of runoff will seep through the spoil, discharging over several weeks rather than running off within a few hours of rainfall. The modelled runoff coefficient of 9.0% is around double than that for natural catchments.

The adopted model parameters for “spoil” represents the uncompacted dumped overburden material. The runoff coefficient of 11.9% is around 2.6% higher than rehab catchments.

The adopted AWBM parameters used for modelling are summarised in Table 6.8. Validation of these parameters against observed site performance is provided in Section 6.14.

Table 6.8 – Adopted AWBM parameters

Parameter	Natural/ Undisturbed	Cleared/ Pre-strip	Compacted	Rehabilitated spoil	Spoil dump
A1	0.013	0.1	0.134	0.1	0.1
A2	0.444	0.9	0.433	0.4	0.4
A3	0.543	-	0.433	0.5	0.5
C1	15	12	1.9	15	15
C2	100	54	19.1	100	100
C3	651	-	80.0	200	100
C_{av}	398.1	49.8	43.2	141.5	91.5
K_{base}	0.914	-	-	0.8	0.8
K_{surf}	0.502	-	-	-	-
BFI	0.21	-	-	0.9	0.9
Average Annual Runoff Co-efficient (C_v)	4.5%	19.4%	27.5%	9.0%	11.9%

6.5 CATCHMENT AREAS AND LANDUSE CLASSICATIONS

Catchment areas for the various pits and site water management infrastructure have been based on the latest topographic information provided by Stanmore (current as of March 2019) and discussions with Stanmore personnel.

A breakdown of each catchment by land use classification has been undertaken using the latest aerial photography provided by Stanmore for the existing IPC (current as of March 2019), discussions with Stanmore personnel and the proposed mine stage plans.

A summary of adopted catchment areas and land use types for each modelled stage are provided in Appendix A. Figures showing the representative disturbance footprints and adopted land use breakdown for each modelled stage are shown in Figure 1.3 to Figure 1.8. Note that Pit 2 and Pit 3 were modelled as a single combined pit, as well as Pit 4 and Pit 4N.

6.6 STORAGE CURVES

The storage curves for each of the modelled storages were based on the latest topographic information, discussions with IPC personnel and proposed mine stage plans. The adopted storage curves are provided in Appendix A.

6.7 EXTERNAL WATER SUPPLY

External water for use at IPC is supplied via the Eungella/Burdekin pipeline, via the Raw Water Dam. Currently, 50% of the CHPP water usage and 100% of the industrial/miscellaneous usage is supplied by raw water from the Eungella/Burdekin pipeline. In addition, any shortfall in dust suppression demand or in the CHPP from the mine affected water system is made up from the raw water supply.

The maximum annual allocation of external water is 920 ML/a.

6.8 WATER DEMANDS

6.8.1 Coal handling and preparation plant (CHPP)

The key parameters for the CHPP water balance are shown in Table 6.9.

There are two waste products generated by the CHPP; coarse rejects and fine rejects. Coarse rejects from the coarse coal circuit will be transferred by conveyor to the CHPP rejects stockpile for reclaim by excavator/truck and placement to Coarse Reject Cells located within the in-pit waste rock emplacement areas, wholly within the final pit footprint.

Fine rejects from the fines coal circuit will be thickened for transfer (via pipeline) to the Fine Reject Cells, where flocculants will be added and water recovered and recycled in the CHPP. The Fine Rejects Cells will also be located wholly within the in-pit disposal area.

The effective decant return rate from the Fine Rejects Cells to the CHPP (via N1 Pit) is about 94%. This is the effective proportion of water that is returned to the water management system compared with the volume entrained with the tailing stream at 80% moisture content. The effective decant rate significantly reduces the net CHPP makeup water requirement.

Both Coarse Rejects Cells and Fine Rejects Cells will be later capped by spoils, recontoured and topsoiled for final rehabilitation.

For IPC life of mine (i.e. open cut and future underground which would follow after open cut operations), the projected annual ROM coal feed and the estimated gross and net annual CHPP water makeup requirement for each year is provided in Table 6.10 and presented in Figure 6.3.

Table 6.9 - Key CHPP water balance parameters

Item	Value
Moisture contents	
ROM coal feed	7.0% w/w
Primary product coal	10.5% w/w
Secondary product coal	10.0% w/w
Coarse rejects	10.0% w/w
Fine tailings (initial)	80.0% w/w
Fine tailings (decanted)	20.0% w/w
Primary product yield (dry)	60.9% of ROM coal feed
Secondary product yield (dry)	15.5% of ROM coal feed
Course rejects (dry)	70% of total rejects
Fine tailing (dry)	30% of total rejects

Table 6.10 - Forecast annual coal production and estimated CHPP makeup requirements

Stage	Year	ROM (Mtpa) (wet)	Gross CHPP makeup requirement (ML/a)	Decant return volume (ML/a)	Net CHPP makeup requirement (ML/a)
1	2020	2.12	638.9	526.0	112.9
2	2021	2.31	693.1	570.4	122.7
	2022	2.17	651.6	536.2	115.4
3	2023	2.11	632.9	520.9	112.0
	2024	1.89	567.4	466.9	100.5
	2025	1.94	581.1	478.2	102.9
4	2026	1.68	503.0	413.9	89.1
	2027	1.62	487.3	401.0	86.3
	2028	0.88	265.2	218.2	47.0
5	2029	1.60	479.5	394.6	84.9
	2030	1.60	481.3	396.1	85.2
	2031	1.56	468.7	385.7	83.0
	2032	1.45	435.8	358.7	77.1
	2033	1.46	437.4	360.0	77.4
6	2034	1.56	468.1	385.2	82.9
	2035	1.58	474.6	390.6	84.0
	2036	1.66	497.4	409.3	88.1
	2037	1.39	418.0	344.0	74.0
	2038	0.21	62.6	51.5	11.1

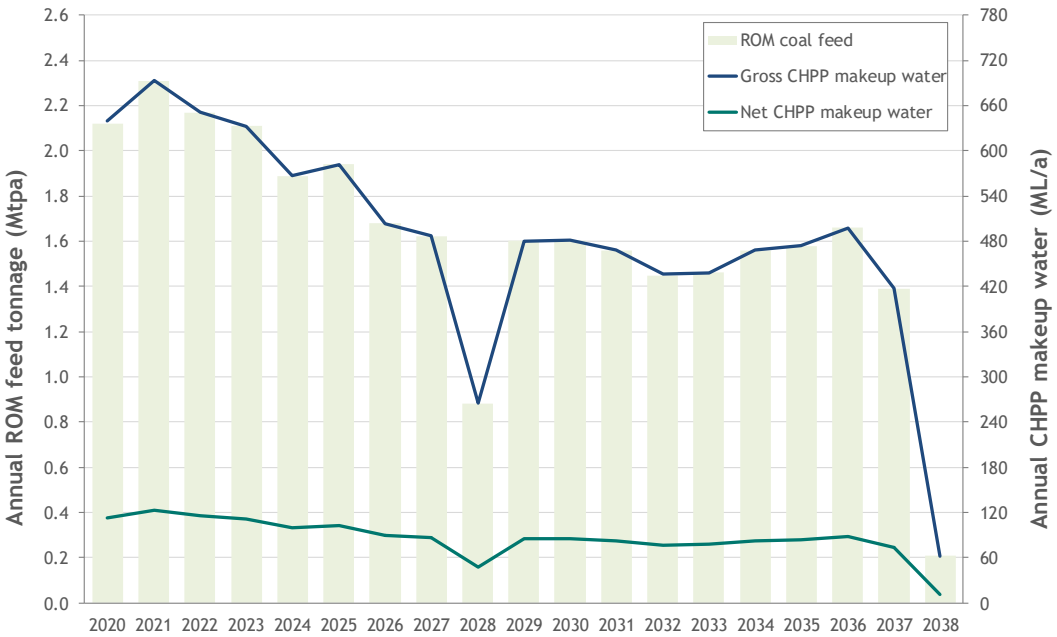

Figure 6.3 - CHPP annual net water consumption

6.8.2 Industrial/miscellaneous usage

Monthly water usage for the CHPP (measured by the raw water meter) was provided by IPC for January 2017 to December 2018. This data indicates that, on average, around 1.2 ML/d of raw water is imported to site.

Based on the CHPP operating specifications listed in Section 6.8.1, a CHPP water mass balance indicates that the average daily net processing requirement is 377 kL/d, or 115 ML over the 2-year period for a 3.46 Mt of feed tonnage. Therefore, the CHPP material processing circuit consumes around 37% of the total raw water consumption.

Based on these calculations, the miscellaneous raw water use is around 825 kL/d, or around 63% of the total imported raw water. This includes usages such as washdown, fire circuit, pump gland seals and sprays.

Forecast industrial/miscellaneous usage has been scaled up based on the forecast annual feed tonnage. The adopted annual industrial/miscellaneous usage is shown in Figure 6.4.

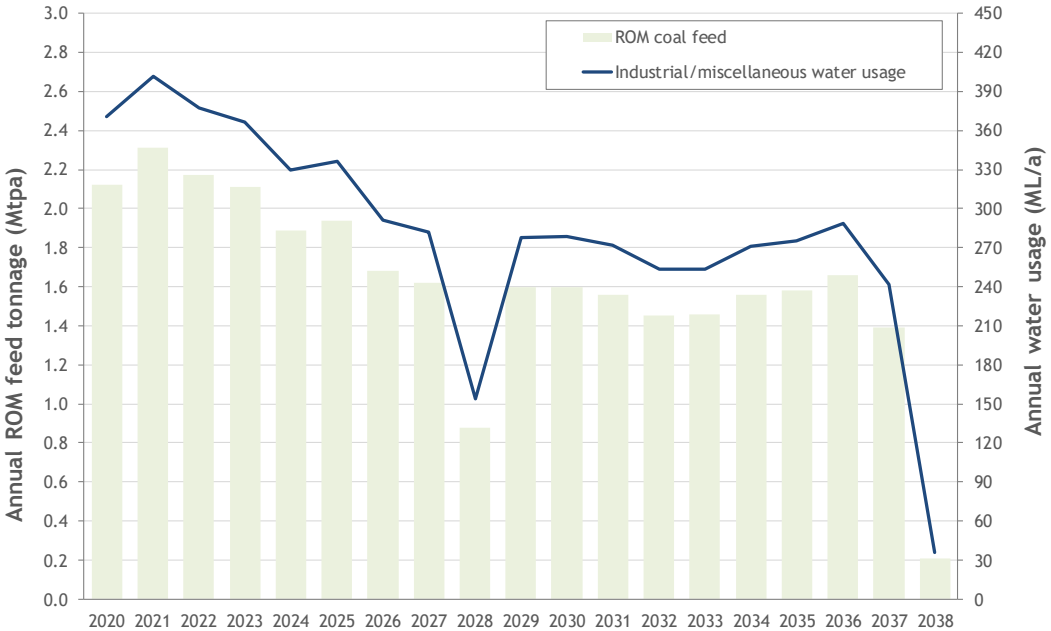

Figure 6.4 - Annual industrial/miscellaneous water usage

6.8.3 Haul road dust suppression usage

Water from haul road dust suppression is sourced solely from S2 SD, which is supplied with mine affected water from N1 Pit. Forecast dust suppression usage rates have been based on recent observed usage at IPC between January 2017 and December 2018 (around 82.9 ML/a per Mt of ROM tonnage), scaled up based on expected future annual ROM coal tonnage. During years 2028 to 2038 (model stages 5 and 6), the dust suppression calculated from the annual IPU ROM tonnage was halved.

The proposed annual dust suppression usage is shown in Figure 6.5.

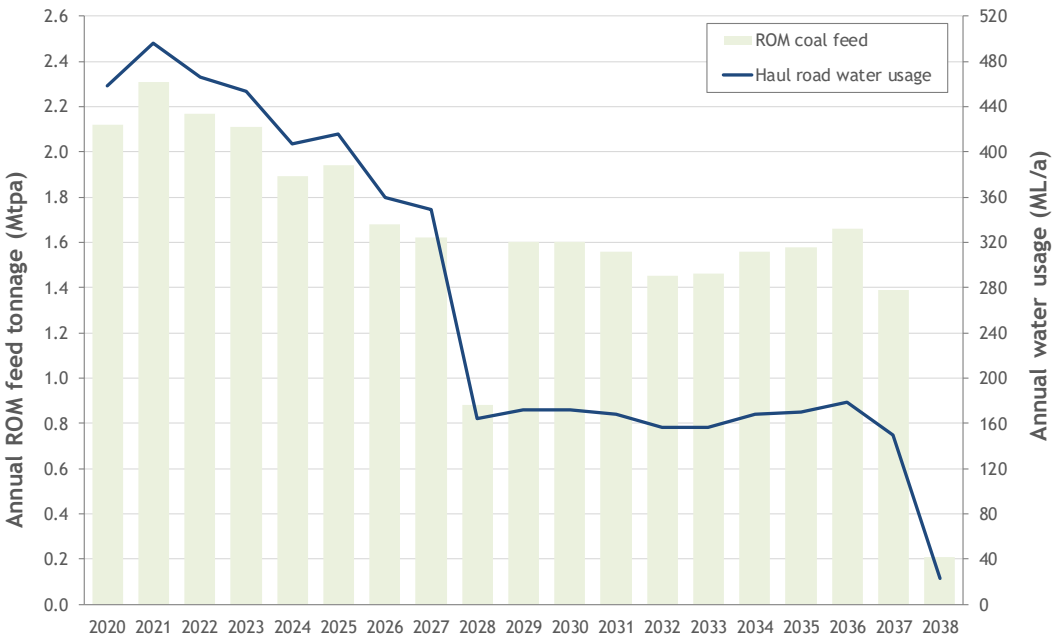

Figure 6.5 - Proposed annual dust suppression

6.9 GROUNDWATER INFLOWS TO MINING PITS

The previous water balance models for IPC (WRM, 2018) have adopted a net groundwater inflow of zero to the existing inactive IPM pits. This was based on based on recent site observations and advice from KCB (hydrogeologists) that minimal groundwater inflow into the IPM pits would occur as the regional hydraulic gradient will be towards IPE pits. As part of the model calibration/validation process, a net groundwater inflow rate of 0.26 ML/d to the inactive IPM pits (S2 Pit and N1 Pit) was required to achieve a good calibration fit (see Section 6.14). For the forecast model, we have applied a groundwater rate of 0.13 ML/d to S2 Pit (as N1 Pit is now the primary water storage onsite).

For the IPE pits, the adopted groundwater inflows rates to the open cut pits are based on estimates provided by KCB for the groundwater impact assessment and have been provided as a lumped monthly inflow. The monthly inflow was applied proportionally to each active pit as a daily inflow. KCB also provided the monthly groundwater inflow estimates for IPU, which were applied directly to S2 Pit. The adopted groundwater inflow rates for the IPE pits and IPU are shown in Figure 6.6.

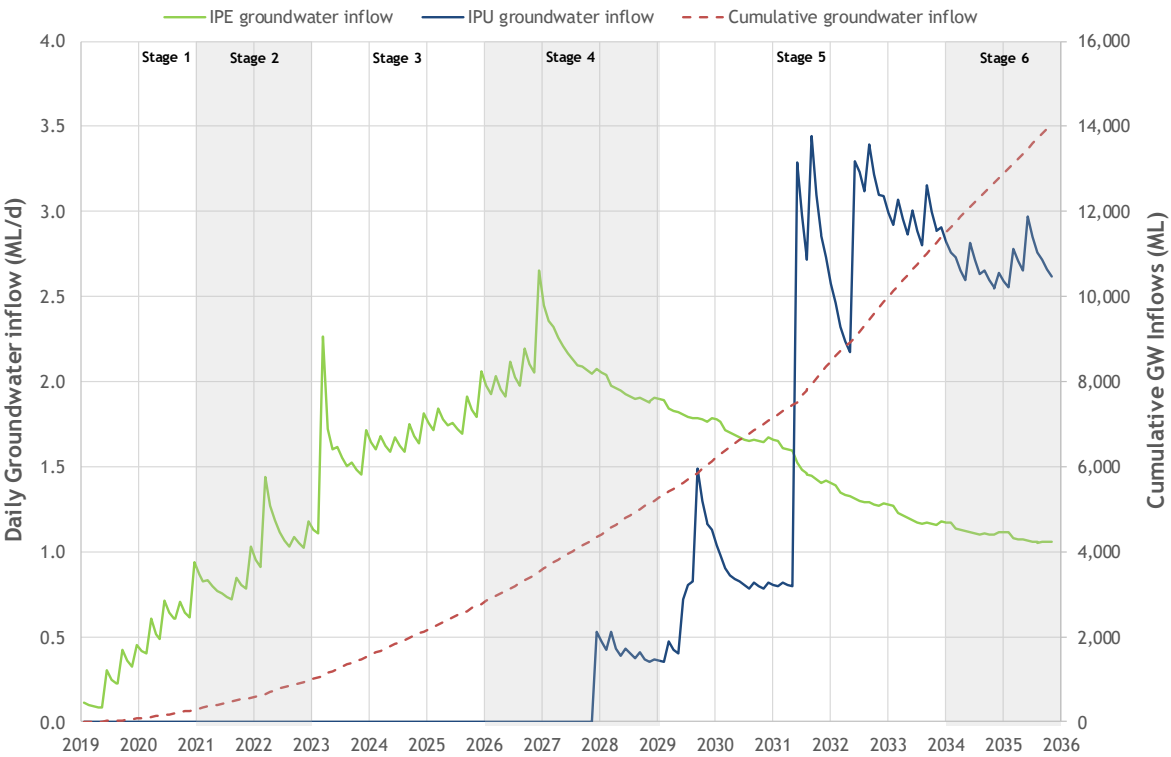

Figure 6.6 - Adopted groundwater inflow rates for IPE and IPU

6.10 CONCEPTUAL WATER MANAGEMENT SYSTEM CONFIGURATION AND SCHEMATIC

A schematised plan of the proposed water management system configuration is shown in Figure 6.7. A summary of the modelled water management system operating rules is outline in Table 6.11.

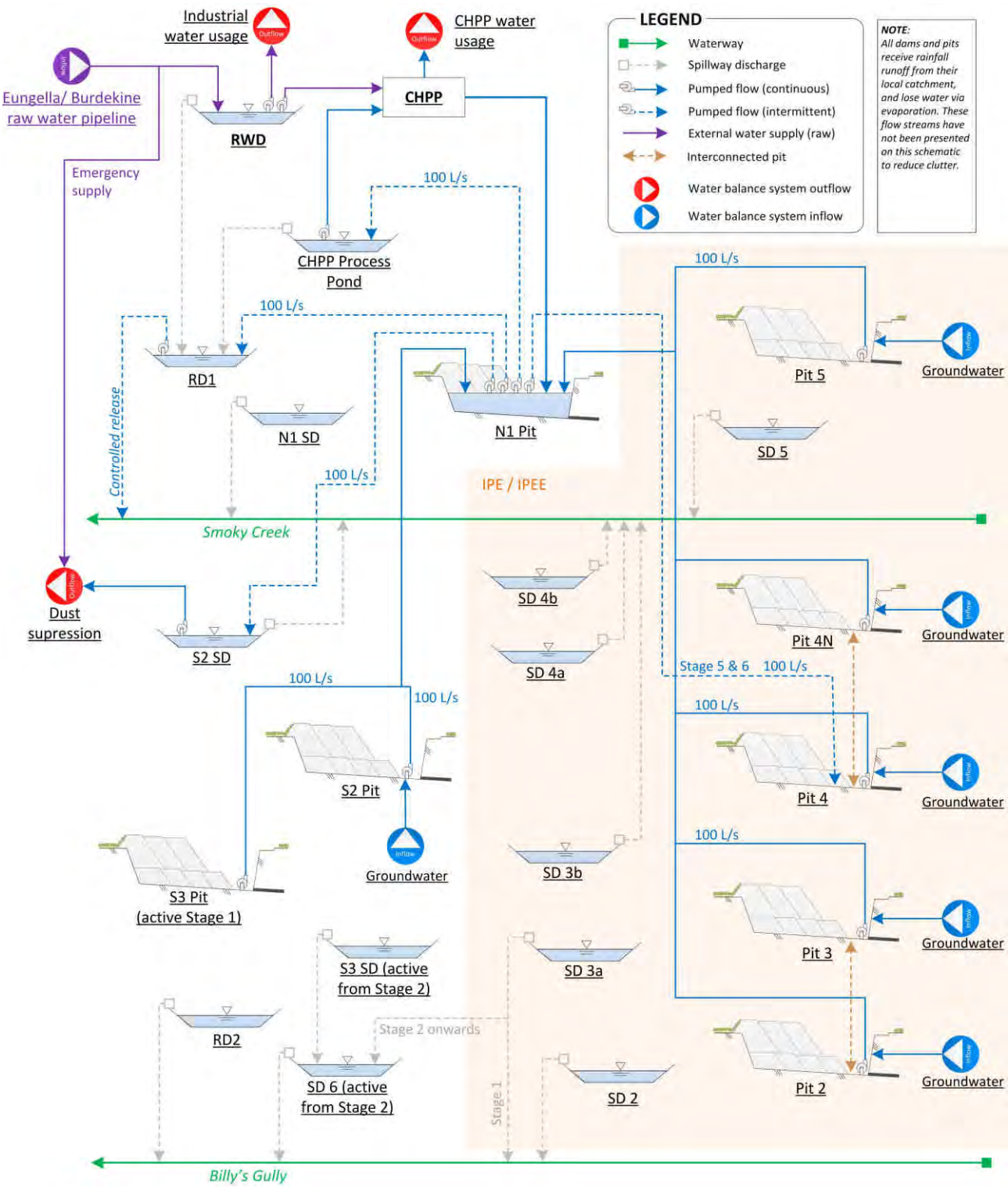

Figure 6.7 – Proposed water management system schematic

Table 6.11 - Proposed water management system operating rules

Item	Node Name	Operating Rules
1.0	***External Water Supply***	
1.1	Eungella/Burdekin Pipeline	• Supplies the CHPP (via Raw Water Dam) • Supplementary supply to dust suppression and raw water demands • Maximum yearly allocation of 920 ML/a
2.0	***Supply to Demands***	
2.1	CHPP	• Demands from the following sources: ○ Raw Water Dam (50%) ○ CHPP Process Pond (50%) • Transfers water to the Rejects Cells within the tailings waste stream
2.2	Miscellaneous raw water demands	• Demand suppled from Raw Water Dam • 100% loss assumed
2.3	Haul road dust suppression	• Demands from the following sources: ○ S2 SD ○ Eungella/Burdekin Pipeline (emergency supply) • 100% loss assumed
3.0	***Transfer of pit water***	
3.1	S2 Pit	• Existing inactive void • Continuous pumping from pit dewatering pumps at a nominal maximum rate of 100 L/s (8,640 kL/d), pending available capacity on receiving storage • Pit dewatering directed to N1 Pit • From Stage 5, becomes underground portal
3.2	S3 Pit	• During Stage 1, dewaters to N1 Pit water storage at a maximum rate of 100 L/s (8,640 kL/d), pending available capacity on receiving storage • Backfilled from Stage 2, with rehabilitated catchment directed to Billy's Gully via a sediment dam (S3 SD) • Licensed discharge point (RP5), which discharges to Billy's Gully
3.3	Pit 2	• Proposed mining pit, active from Stage 1 onwards • Continuous pumping from pit dewatering pumps at a nominal maximum rate of 100 L/s (8,640 kL/d), pending available capacity on receiving storage • Pit dewatering directed to N1 Pit • From Stage 5 onwards, pit inactive and dewatering ceases
3.4	Pit 2S	• Proposed mining pit, active during Stage 2 • Continuous pumping from pit dewatering pumps at a nominal maximum rate of 100 L/s (8,640 kL/d), pending available capacity in receiving storage • Pit dewatering directed to N1 Pit • From Stage 3 onwards, pit is backfilled, with catchment directed to a sediment dam (SD 2)
3.5	Pit 3	• Proposed mining pit, active from Stage 1 onwards • Continuous pumping from pit dewatering pumps at a nominal maximum rate of 100 L/s (8,640 kL/d), pending available capacity in receiving storage • Pit dewatering directed to N1 Pit • From Stage 5 onwards, pit inactive and dewatering ceases
3.6	Pit 4	• Active mining pit • Continuous pumping from pit dewatering pumps at a nominal maximum rate of 100 L/s (8,640 kL/d), pending available capacity in receiving storage • Pit dewatering directed to N1 Pit

Item	Node Name	Operating Rules
		• From Stage 5 onwards dewatering to N1 Pit ceases and void acts as a backup mine affected water storage for site, up to a volume of around 28,000 ML at 210 mAHD
3.7	Pit 4N	• Proposed pit, active from Stage 3 onwards • Continuous pumping from pit dewatering pumps at a nominal maximum rate of 100 L/s (8,640 kL/d), pending available capacity on receiving storage • Pit dewatering directed to N1 Pit • From Stage 5 onwards dewatering to N1 Pit ceases and void acts as a backup mine affected water storage for site, up to a volume of around 28,000 ML at 210 mAHD
3.8	Pit 5	• Proposed mining pit, active from Stage 2 onwards • Continuous pumping from pit dewatering pumps at a nominal maximum rate of 100 L/s (8,640 kL/d), pending available capacity on receiving storage • Pit dewatering directed to N1 Pit • From Stage 4 onwards, pit inactive and dewatering ceases
4.0	***Operation of site dams***	
4.1	Raw Water Dam	• Receives external water supply from the Eungella pipeline • Supplies the 50% of the CHPP water demand • Overflows to RD1

4.2	RD1
	(Release Dam 1)
		• Existing mine affected water dam
		• Licensed discharge point (RP1), which discharges to Smoky Creek
		• May receive uncontrolled overflows from the following storages:
		  ○ CHPP Process Pond
		  ○ Raw Water Dam
		• Overflows to Smoky Creek

4.3	RD2 (Release Dam 2)	• Existing sediment dam • Former mine affected water dam • Licensed discharge point (RP2), which discharges to Billy's Gully • Overflows to Billy's Gully

4.4	N1 Pit	• Existing inactive void, which acts as the primary mine affected water storage for site
		• Receives excess water from CHPP waste disposal process
		• Receives pumped transfers from the following locations, up to a maximum level of 217.0 mAHD (17,770 ML):
		  ○ S2 Pit
		  ○ S3 Pit
		  ○ Pit 2
		  ○ Pit 2S
		  ○ Pit 3
		  ○ Pit 4
		  ○ Pit 4N
		  ○ Pit 5
		• Pumps water to S2 SD at a maximum rate of 100 L/s (8,640 kL/d), as required
		• Pumps water to CHPP Process Pond at a maximum rate of 100 L/s (8,640 kL/d), as required
		• During Stage 5 pumps water to Pit 4 and 4N at a maximum rate of 100 L/s (8,640 kL/d) if water level is above 205.2 mAHD (11,197 ML)
		• By Stage 6, the storage volume is reduced to exclude the tailing deposits cell A.
		• During Stage 6 pumps water to Pit 4 and 4N at a maximum rate of 100 L/s (8,640 kL/d) if water level is above 217 mAHD (11,197 ML)

4.5	S2 SD	• Existing mine affected water dam

Item	Node Name	Operating Rules
		• Supplies to dust suppression demands via a fill point • Demands from N1 Pit up to a maximum level of 221.6 mAHD • Licensed discharge point (RP4), which discharges to Smoky Creek • Overflows to Smoky Creek
4.6	CHPP Process Pond	• Existing mine affected water dam • Receives pumped transfers from N1 Pit, up to a maximum level of 232.9 mAHD (9.9 ML) • Supplies the 50% of the CHPP water demand • Storage overflows to RD1
4.7	N1 SD	• Existing sediment dam/sump • Overflows to Smoky Creek
4.8	SD 2	• Proposed sediment dam, active from Stage 1 onwards • Storage overflows to Billy's Gully
4.9	SD 3a	• Proposed sediment dam, active from Stage 1 onwards • Storage overflows to Billy's Gully (Stage 1) • Storage overflows to SD 6 (Stage 2 onwards)
4.10	SD 3b	• Proposed sediment dam, active from Stage 1 onwards • Storage overflows to Smoky Creek
4.11	SD 4a	• Proposed sediment dam, active from Stage 1 onwards • Storage overflows to Smoky Creek
4.12	SD 4b	• Proposed sediment dam, active from Stage 1 onwards • Storage overflows to Smoky Creek
4.13	SD 5	• Proposed sediment dam, active from Stage 1 onwards • Storage overflows to Smoky Creek
4.14	S3 SD	• Proposed sediment dam, active from Stage 2 onwards • Storage overflows to SD 6

4.15	SD 6	• Proposed sediment dam, active from Stage 2 onwards
		• May receive uncontrolled overflows from the following storages:
		  ○ S3 SD
		  ○ SD 3a
		• Storage overflows to Billy's Gully

5.0	***Receiving water***	

5.1	Smoky Creek	• Receives controlled discharges from RD1
		• May receive uncontrolled overflows from the following storages:
		  ○ RD1
		  ○ S2 SD
		  ○ N1 SD
		  ○ SD 3b
		  ○ SD 4a
		  ○ SD 4b
		  ○ SD 5

5.2	Billy's Gully	• May receive uncontrolled overflows from the following storages:
		  ○ RD2
		  ○ SD 2
		  ○ SD 3a
		  ○ S3 SD

6.0	***General***	• All storages and pits receive local catchment runoff and lose water through evaporation

6.11 ISAAC RIVER STREAMFLOWS

The Queensland Government maintains a calibrated IQQM model of the Fitzroy River basin, which includes the Isaac River. This model is based on that prepared for the Fitzroy Basin Water Resource Plan (WRP).

The Queensland Government made the results of the IQQM modelling available to WRM for this assessment. These results included modelled daily flows at the gauging station at Goonyella on the Isaac River over the period 1889 to 2007.

The modelled Isaac River flows have been supplemented with flows recorded at the gauging station between 2008 and 2018, to create a composite stream flow covering the period 1889 to 2018 as to align with the adopted climatic sequences.

This composite streamflow file has been used in the water balance model as the receiving water flow criteria for controlled discharges in accordance with the IPC EA.

6.12 SALINITY PARAMETERS

The water balance model has been configured to use electrical conductivity (EC) as an indicator for water quality. Each runoff type has been assigned an EC concentration that has been based on the available historical water quality monitoring data. The adopted EC concentrations are given in Table 6.12. These adopted EC concentrations are consistent with recent water quality samples from site.

Table 6.12 - Adopted salinity runoff parameters

Catchment land use	EC (µS/cm)
Natural	250
Spoil dump	1,000
Mining pit	6,000
Roads/hardstand	1,700
Cleared/pre-strip	600
Rehabilitated spoil	850
Stockpile/industrial area	6,000
Groundwater	15,580
Raw water	180

6.13 INITIAL WATER STORAGE LEVELS AND SALINITY

The adopted initial water level and salinity for the existing water storages is shown in Table 6.13. The latest stored volume for the water storages was current as of 15 July 2019 and the EC concentrations were taken on 3 April 2019.

Table 6.13 - Adopted initial water levels and salinity

Water storage	Initial stored water volume (ML)	Initial EC (µS/cm)
Raw Water Dam	5.0	180
CHPP Process Pond	14.4	2,180
RD1	70.2	2,380
RD2	*dry*	-
S2 SD	148.7	5,560
N1 SD	*assumed dry*	-
N1 Pit	1,560[a]	5,830[b]

[a] sum of recorded volume in S3 Pit in June 2019 and N1 Pit in July 2019
[b] from S3 Pit from December 2018

6.14 MODEL VALIDATION

6.14.1 Model validation overview

Verification of the IPC water balance model has been undertaken against recorded site data (including water storage volumes) over the period from January to December 2018. The model was configured to reflect the site operations during this period, with appropriate transfer rates, system configuration and water inflows and outflows. SILO rainfall and evaporation data was used for the calibration.

During 2018, the primary mine water storage was S3 Pit, therefore the validation of the water balance model was undertaken against the recorded inventory for the S3 Pit between January and December 2018.

6.14.2 Model validation outcomes

The observed and modelled inventory for S3 Pit is presented in Figure 6.8 along with the site rainfall for the verification period. The following model modifications were implemented to achieve the presented results:

- Net groundwater inflow rate to the IPC set at 0.26 ML/d (split uniformly over N1 Pit and S2 Pit); and
- During November and December 2018, an additional inflow of 1.34 ML/d was included to represent Pit 4 dewatering.

Review of Figure 5.2 indicates the following:

- The simulated S3 Pit storage inventory generally reproduces the observed overall mine observed water inventory fluctuations over the verification period between January and December 2018 with the exception of a few data points.
- There is a discrepancy between the observed and modelled inventory in March 2018. This is most likely due the delays in dewatering the inactive mining pits to S3 Pit.
- The calibration results are considered to be within reasonable bounds given the potential variability in mine affected water movements about the site and water losses, and the constraints imposed on the water balance model by the operational guidelines.

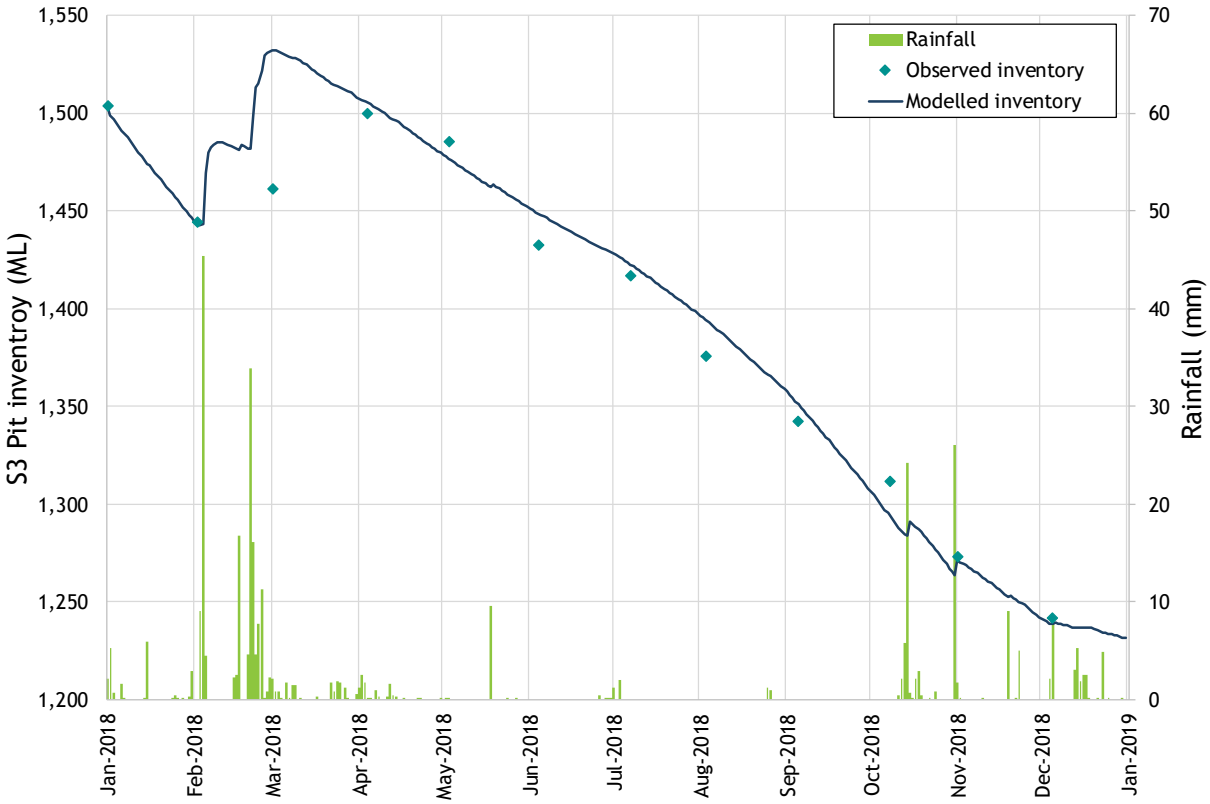

Figure 6.8 - Model validation, S3 Pit inventory

7 Water management system assessment

7.1 OVERVIEW

Assessment of the proposed water management system has been undertaken using the water balance model with the adopted rainfall runoff parameters, against the following key performance indicators:

- Pit inundation characteristics;
- Active mining pit inventory;
- Site raw water requirements;
- Mine affected water inventory;
- Controlled releases; and
- Uncontrolled spillway discharges.

It is important to note that investigation outcomes are dependent on the accuracy of input assumptions. There is inherent uncertainty with respect to some key site characteristics (e.g. catchment yield/rainfall runoff, mining area groundwater inflows). The use of a large number of climate sequences reflecting the full range of historical climatic conditions provides an indication of the system performance may vary under very wet, very dry and average climatic conditions.

7.2 INTERPRETION OF RESULTS

In interpreting the results of the water balance assessment, it should be noted that the results provide a statistical analysis of the water management system's performance over the 19 years of mine life, based on 111 realisations with different climatic sequences.

The model results are presented as a probability of exceedance. For example, the 10th percentile represents 10% probability of exceedance and the 90th percentile results represent 90% probability of exceedance. There is an 80% chance that the result will lie between the 10th and 90th percentile traces.

Whether a percentile trace corresponds to wet or dry conditions depends upon the parameter being considered. For site water storage, where the risk is the storage capacity will be exceeded, the lower percentiles correspond to wet conditions. For example, there is only a small chance that the 1 percentile storage volume will be exceeded, which would generally correspond to wet conditions.

For external site water supply volumes (for example), where the risk is that insufficient water will be available, there is only a small chance that more than the 1 percentile water supply volume would be required. This would generally correspond to dry climatic conditions.

It is important to note that a percentile trace shows the likelihood of a particular value on each day and does not represent continuous results from a single model realisation. For example, the 50th percentile trace does not represent the model time series for median climatic conditions.

7.3 WATER BALANCE MODEL RESULTS

7.3.1 Overall water balance

Water balance results for all of the 111 model realisations are presented in Table 7.1, averaged over each model stage. The results presented in Table 7.1 are the average of all realisations and will include wet and dry periods distributed throughout the mine life. Rainfall yield for each stage is affected by the variation in climatic conditions within the adopted climate sequence.

Table 7.1 provides an indication of the long-term average annual inflows and outflows. Key outcomes from the overall water balance are as follows:

- Average annual inflows from rainfall runoff are largely consistent between Stage 1 and Stage 6.
- The spillway overflows from the sediment dams are highest in Stage 1, and consistently reduce between Stage 2 and Stage 6.
- External raw water requirements will be highest during Stage 1 to Stage 3, and will reduce in Stage 4 onwards.
- During Stage 1 to Stage 3, the change in stored volume per stage is small in comparison to the inflow and outflow volumes and therefore the water management system is generally in balance during this period. More significant volumes of water will begin to accumulate after Stage 3, due to the progressive ceasing of mining activities.

It should be recognised that the following items are subject to climatic variability:

- Rainfall runoff;
- Evaporation;
- External water requirement;
- Controlled releases; and
- Dam overflows.

Whilst it provides an indication of the long-term average annual inflows and outflows, application of the nominated values for other purposes should only be undertaken with due consideration of the suitability of the nominated value and any potential implications.

In particular, the “average” mine affected water discharges do not necessarily mean that discharges occur under median climatic conditions. It means that there was a discharge in at least one of the 111 model realisations. A more detailed analysis of the performance of the various components of the water management system is provided in the following sections.

Table 7.1 - Average annual water balance

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
Inflows (ML/a)						
Rainfall/runoff	1,595	1,725	1,783	1,784	1,767	1,811
Groundwater inflows	269	399	657	857	1,294	1,404
External water from Eungella/Burdekin pipeline	447	461	408	292	319	269
TOTAL INFLOWS	**2,310**	**2,585**	**2,848**	**2,933**	**3,380**	**3,484**
Outflows (ML/a)						
Evaporation from storages	570	639	731	865	1,184	1,417
Dam overflows (offsite)						
Mine affected water	4	4	5	6	6	6
IPE sediment water	181	192	175	172	152	145
IPM sediment water	320	234	216	213	210	192
Controlled releases	34	34	35	30	30	32
Industrial demand	370	389	344	242	267	223
CHPP						
Mine affected water	56	60	52	37	41	34
Raw water	56	60	52	37	41	34
Dust suppression	457	481	425	291	165	137
TOTAL OUTFLOWS	**2,049**	**2,092**	**2,035**	**1,893**	**2,095**	**2,220**
Change in volume (ML)						
Change in stored volume	262	1,351	813	1,040	1,285	1,265

7.3.2 Mine affected water inventory

Figure 7.1 shows the combined forecast inventory for the key mine affected water storages over the 19-year forecast. Also shown is the Maximum Operating Volume (MOV) for N1 Pit (17,770 ML at 217 mAHD), reducing to 11,197 ML by Stage 6 due to utilisation of some of N1 pit for Tailings Cell A.

The model results show the following:

- For the 10th percentile results (wet climatic conditions), the peak inventory in N1 Pit reaches a volume of around 11,550 ML.
- For the 50th percentile results (median climatic conditions), the peak inventory in N1 Pit reaches a volume of around 9,360 ML.

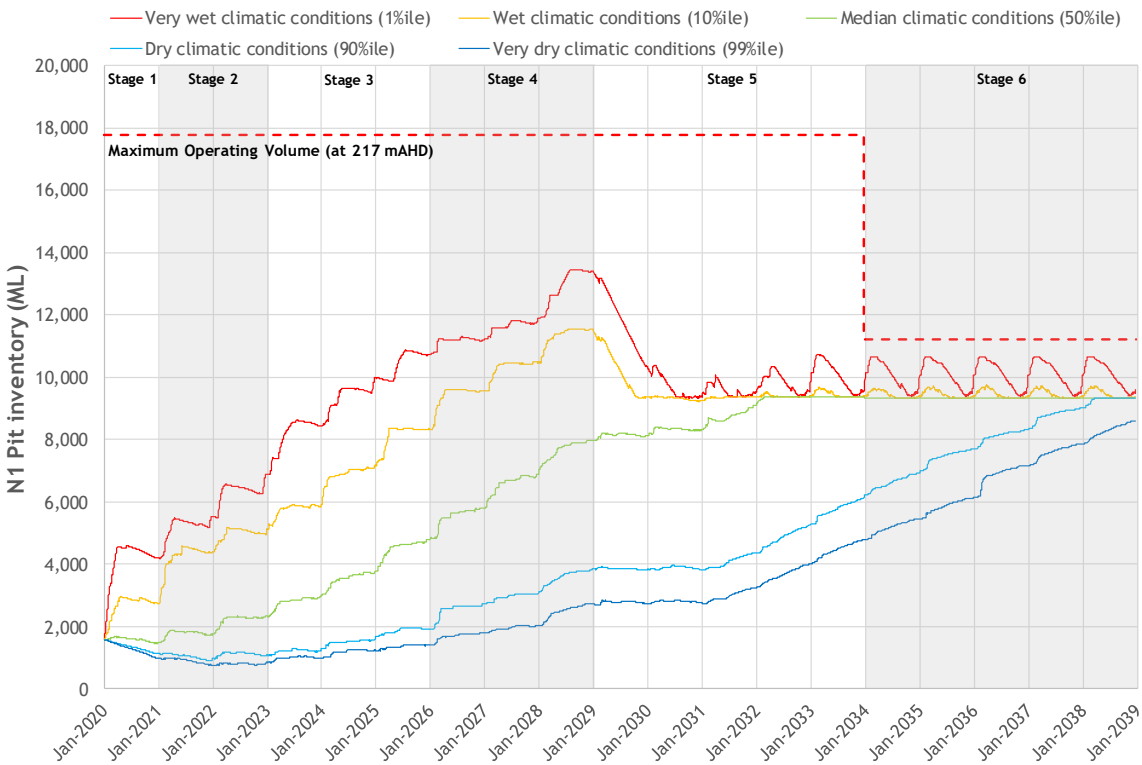

Figure 7.1 – Forecast mine affected water inventory, N1 Pit

7.3.3 In-pit storage

Figure 7.2 to Figure 7.5 shows the forecast inventory for the IPE mining pits over the 19-year simulation. A build-up of water in the mining pit generally occurs when the out-of-pit mine affected water storages are too full to accept additional pit water or the pumping infrastructure is unable to dewater the pits quickly enough. In other words, it is used to determine whether additional out-of-pit storage is required.

By the end of Stage 4, a substantial amount of additional storage capacity (around 400 GL) will be available within the IPE voids as mining has been completed by this time. These voids would be used for storage of excess water as required, depending on the prevailing climatic conditions.

The forecast modelling results for the mining pit's inventories are summarised as follows:

- Pit 2 and 3 (Figure 7.2):
  - During mining of Pit 2 and 3 (Stage 1 to 4), there is a 1% chance that the pit inventory will exceed 375 ML at some point over the 9 years of mining.
  - During mining of Pit 2 and 3 (Stage 1 to 4), there is a 10% chance that the pit inventory will exceed 62 ML at some point over the 9 years of mining.
  - Pit 2 and 3 will accumulate water after mining ceases (Stage 5 onwards) for all climatic sequences assessed. There is a 1% chance that Pit 2 and 3 will accumulate more than 2,330 ML by the end of the project (approximately 24% of Pit 2 and 3's storage volume to 217mAHD).
- Pit 4 and 4N (Figure 7.3):
  - During mining of Pit 4 and 4N (Stage 1 to 4), there is a 1% chance that the pit inventory will exceed 974 ML at some point over the 9 years of mining.
  - During mining of Pit 4 and 4N (Stage 1 to 4), there is a 10% chance that the pit inventory will exceed 169 ML at some point over the 9 years of mining.

- Pit 4 and 4N will accumulate water after mining ceases (Stage 5 onwards) for all climatic sequences assessed. There is a 1% chance that Pit 4 and 4N will accumulate more than 13,250 ML by the end of the project (approximately 42% of Pit 4 and 4N's storage volume to 217mAHD).

- Pit 5 (Figure 7.4):
  - During mining of Pit 5 (Stage 1 to 3), there is a 1% chance that the pit inventory will exceed 37 ML at some point over the 6 years of mining.
  - Pit 5 will accumulate water after mining ceases (Stage 4 onwards) for all climatic sequences assessed. There is a 1% chance that Pit 5 will accumulate more than 1,080 ML by the end of the project (approximately 26% of Pit 5's storage volume to 217mAHD).
- Pit 2S (Figure 7.5):
  - During mining of Pit 2S (Stage 2), there is a 1% chance that the pit inventory will exceed 0.3 ML at some point over the 2 years of mining.
  - Pit 2S will be backfilled following mining.

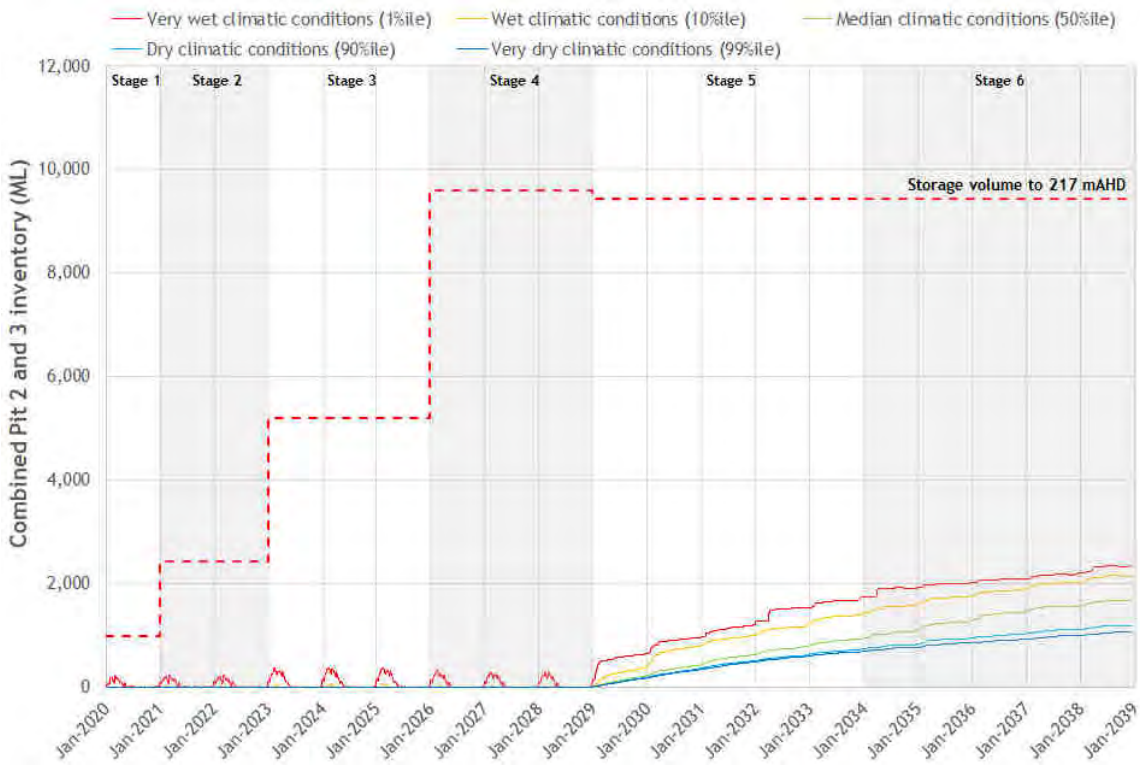

Figure 7.2 – Forecast combined Pit 2 and 3 inventory

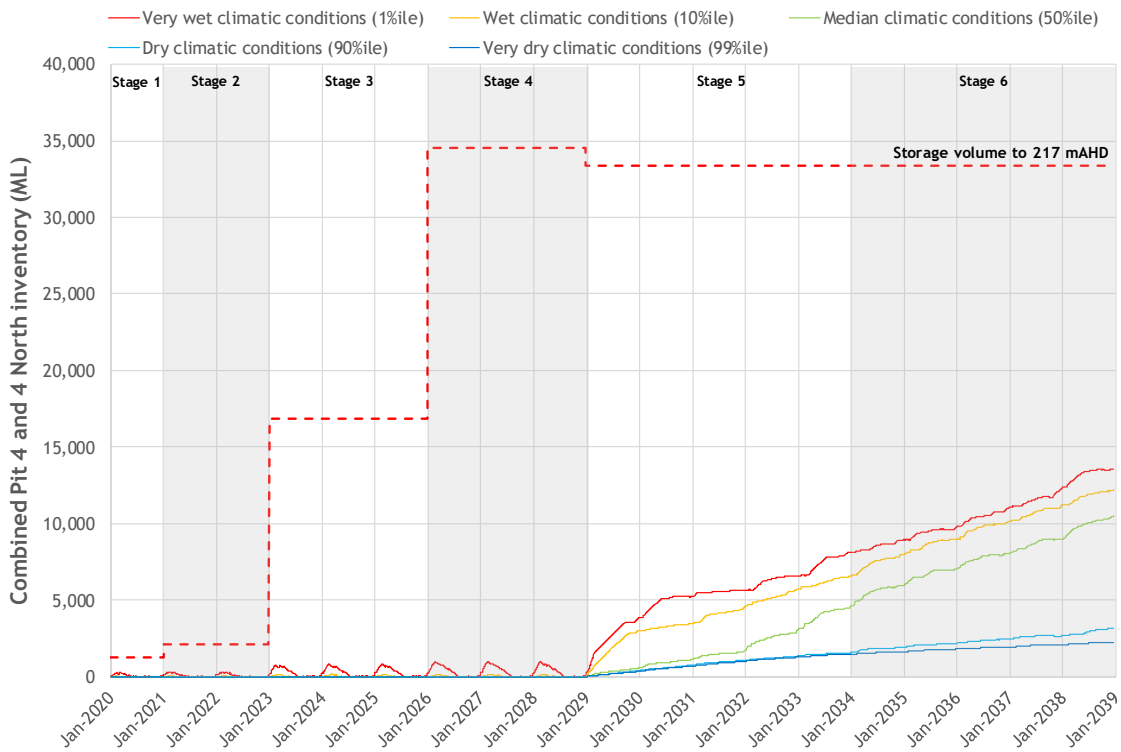

Figure 7.3 - Forecast combined Pit 4 and 4N inventory

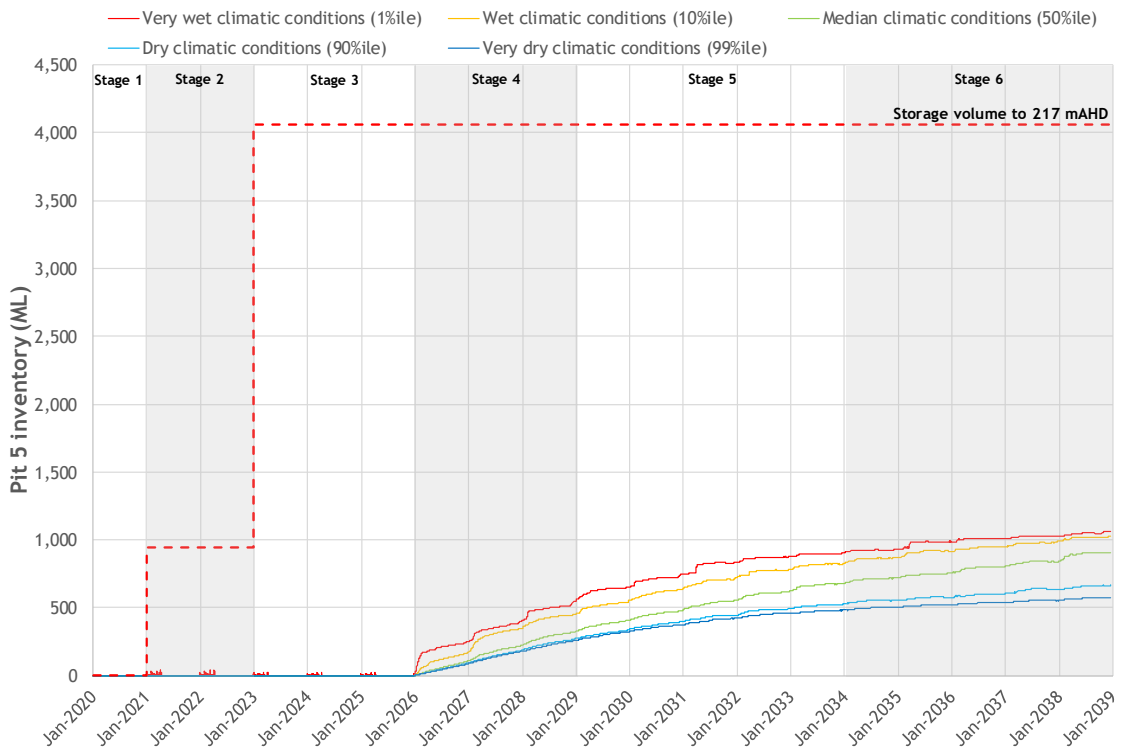

Figure 7.4 - Forecast Pit 5 inventory

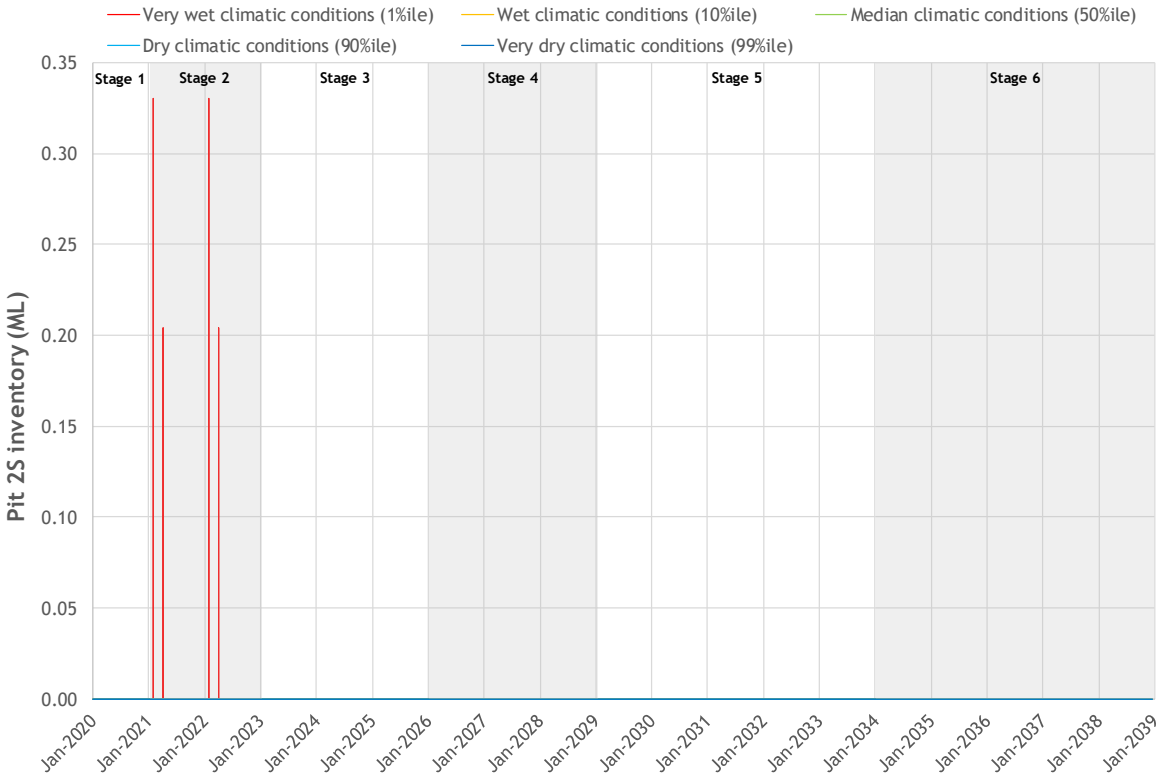

Figure 7.5 - Forecast Pit 2 South inventory

7.3.4 External Makeup Requirements

Water from external sources is required to meet operational water demands, primarily during extended dry climatic periods and periods of low groundwater inflows. In addition to the water captured within the water management system from surface runoff within the operational areas and groundwater inflows, water will also need to be sourced from external sources (e.g. the Eungella/Burdekin raw water pipeline).

A key objective of the mine site water management system is to maximise the reuse of captured surface water runoff and groundwater inflows. Recycling mine water will minimise the volume of water from external sources that is required to satisfy site demands.

However, 50% of the CHPP demand and 100% of the miscellaneous/industrial demand is supplied from the raw water supply. In addition, the modelling has assumed that any shortfall in dust suppression demand from the mine effected water system is made up from the raw water supply. That is, during dry periods, imported water is used to ensure that all operational demands are met.

The annual allocation for IPC is 920 ML/a. The model results have been compared against the allocation to assess the requirement (if any) for external water in addition to the approved allocation.

The modelled imported water requirements during the life of mine are provided in Figure 7.6. Review of the annual raw water requirements indicates:

- For all simulations, the imported raw water requirements does not exceed 480 ML/a.
- No imported water was required for dust suppression use or for shortages in the CHPP over the simulation period.
- The slight difference in volume between the 1% and 99% is due to the small local runoff from the surface of the Raw Water Dam.

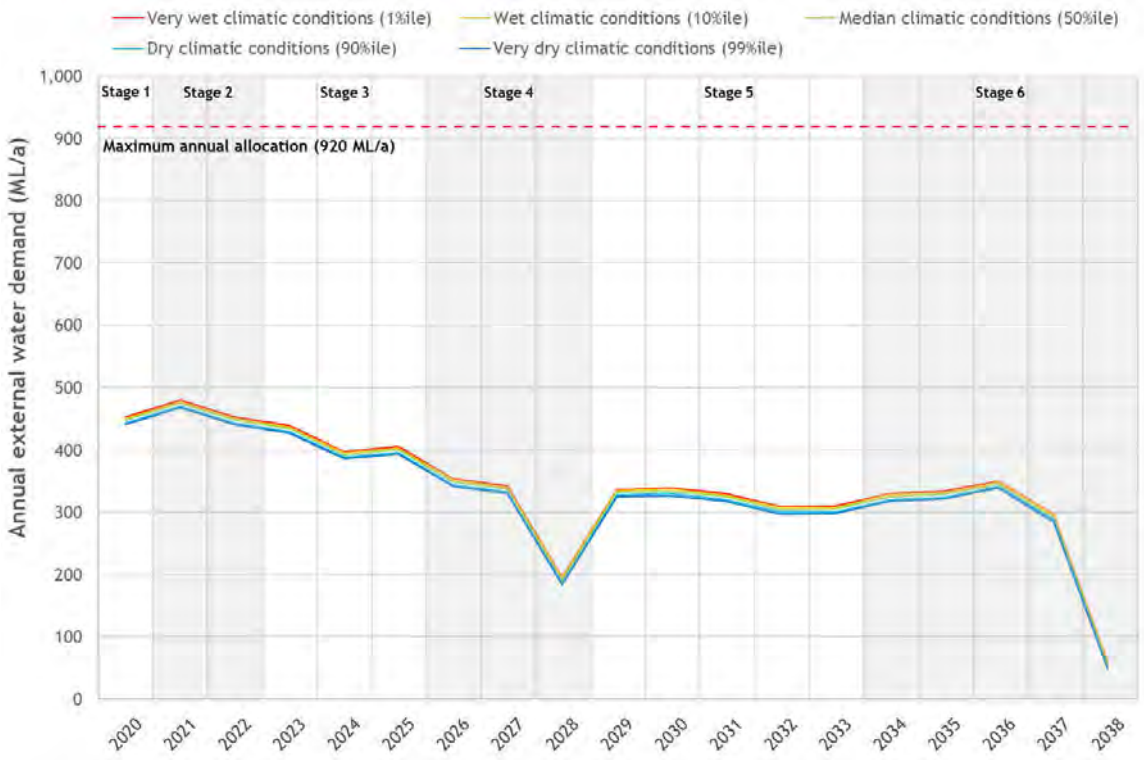

Figure 7.6 - Annual demand from Eungella/Burdekin raw water pipeline

7.3.5 Controlled Water Releases

The water balance model is configured to simulate releases of water from the water management system to the receiving environment via the RP1 release point (located at RD1), in accordance with the approved IPC EA release criteria. Although controlled releases can be made from other storages, it is only made from the RD1 under the current mine affected water management system. Note that salinity (as EC) is the only water quality parameter that has been modelled in the water balance model.

The current release conditions provide significant opportunity to release mine affected water to receiving waters. However, it is unlikely that controlled discharges would actually occur during all release opportunities, due to timing of flows, time of day etc. As such, the modelling has been based on the assumption that suitable infrastructure is available to release mine affected water 66% of the time.

The predicted annual controlled release volumes from the mine affected water dams are provided in Table 7.2 and Figure 7.7 .The results show that:

- For very wet climatic conditions (1%ile), predicted annual controlled releases range between 331 and 466 ML/a.
- For wet climatic conditions (10%ile), predicted annual controlled releases range between 124 and 145 ML/a.
- For median climatic conditions (50%ile), there are no predicted annual controlled releases.

Table 7.2 – Summary of simulated controlled releases, annual volume

Stage	Year	Annual controlled releases (ML/a)		
		1%ile	10%ile	50%ile
1	2020	331.2	139.1	0
2	2021	408.9	139.1	0
	2022	408.9	129.9	0
3	2023	416.5	139.1	0
	2024	416.5	144.6	0
	2025	416.5	129.9	0
4	2026	416.6	124.4	0
	2027	416.6	124.4	0
	2028	416.8	124.4	0
5	2029	466.1	124.4	0
	2030	411.6	124.4	0
	2031	411.6	124.4	0
	2032	411.6	124.4	0
	2033	411.6	129.1	0
6	2034	411.6	128.7	0
	2035	411.6	128.7	0
	2036	411.6	128.6	0
	2037	411.6	135.6	0
	2038	411.8	135.6	0

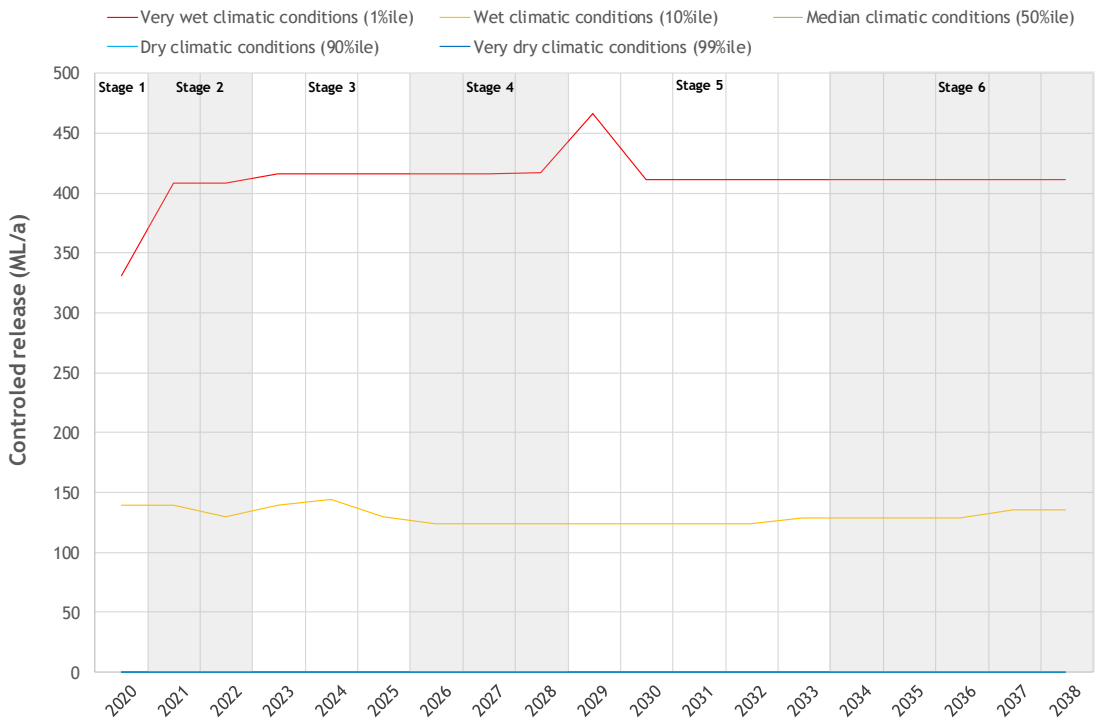

Figure 7.7 - Forecast annual controlled release volumes

7.3.6 Uncontrolled Spillway Discharges

7.3.6.1 Mine Affected Water Dams

The project water balance model was used to assess the risk of uncontrolled offsite spills from the mine affected water management system. The mine water dams that could potentially overflow directly to the receiving environment if rainfall exceeded the storage design criteria include RD1 and S2 SD.

The water balance model has been configured to minimise off-site spills from mine affected water storages to the receiving environment. However, the results of the water balance model indicate that dams RD1 and S2 SD have some likelihood of discharging to receiving waters in very wet and wet climatic conditions.

The model results for uncontrolled spills over the 19 year forecast are summarised below.

- RD1
  - There is a 1% chance of discharging at least 10 ML of mine affected water over the spillway to the receiving environment, in any one year.
- S2 SD
  - There is a 1% chance of discharging at least 77 ML of mine affected water over the spillway to the receiving environment, in any one year.

An assessment of the predicted salinity of overflows from the mine affected water dams to the receiving environment has been undertaken, including an estimate of the potential dilution ratio within the receiving waters.

The modelling indicates that, during the extreme rainfall events that cause a mine affected water discharges, the water overflowing from the mine affected water dam will typically have a salinity of between 630 to 6,000 µs/cm.

During the overflow event, the coincident flow in Smoky Creek would provide dilutions ratios of between 100 and 1,500. This would result in downstream salinity well below the receiving water contaminant trigger level of 1,000 µs/cm.

7.3.6.2 Sediment Dams

Consistent with the IECA design standard, the IPE sediment dams does not provide 100% containment for captured runoff. Hence overflows will occur from sediment dams when rainfall exceeds the design standard.

The potential for overflows from the proposed IPE sediment dams has been assessed using a forecast assessment simulation. For simplicity, sediment dams have been modelled using a passive overflow rather than active release. Note SD 3a has been included in the IPE sediment dam overflows for the full 19 years, however from Stage 2 onwards, SD 3a overflows to IPM SD 6.

The predicted annual combined IPE sediment dam overflows under this scenario are provided in Figure 7.8. The results show that:

- During very wet climatic conditions (1%ile) where rainfall events often exceed the dam design standard, modelled sediment dam overflows are between 1,040 ML/year and 1,225 ML/year.
- During wet climatic conditions (10%ile) where rainfall events often exceed the dam design standard, modelled sediment dam overflows are between 360 ML/year and 530 ML/year.
- During median climatic conditions (50%ile) where rainfall events sometimes exceed the dam design standard, modelled sediment dam overflows are between 30 ML/year and 65 ML/year.
- During dry and very dry climatic conditions (90%ile and 99%ile) there are no modelled sediment dam overflows.

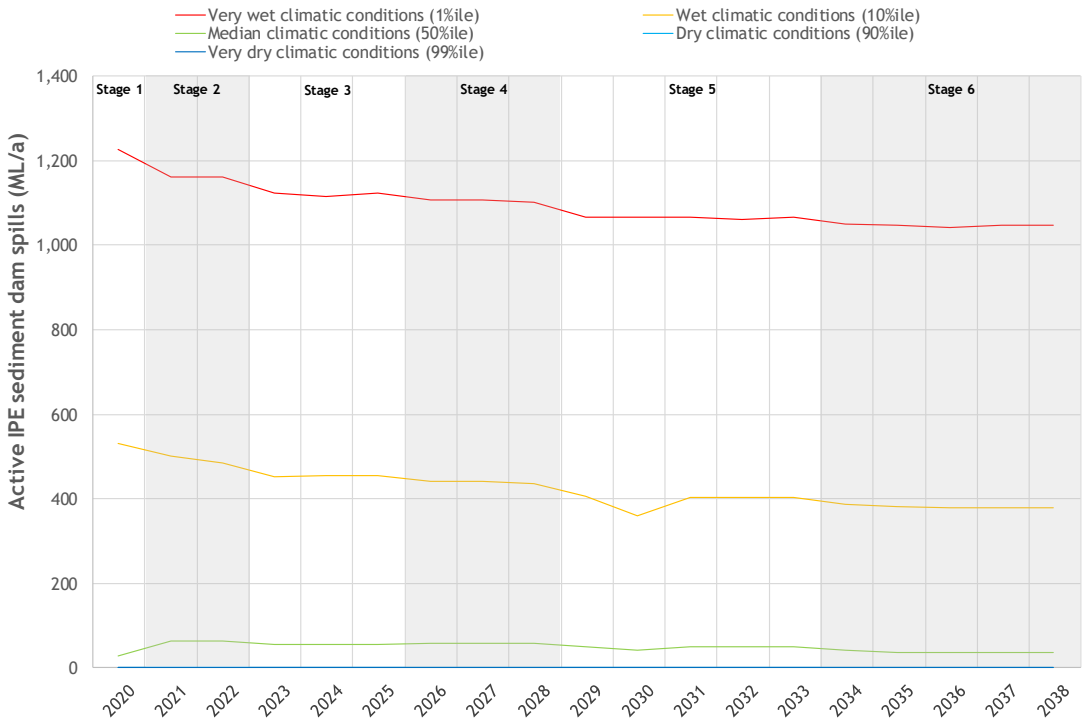

Figure 7.8 - Forecast annual IPE sediment dam overflows to receiving waters

An assessment of the predicted salinity of overflows from the sediment dams to the receiving environment has been undertaken. The modelling indicates that salinity of receiving waters will be between 253 to 690 µs/cm, subsequent to any overflows from the sediment dams (typically during wet or very wet climatic conditions), which is below the EA approved receiving waters contaminant trigger level for EC of 1,000 µs/cm.

7.4 LIMITATIONS OF THE WATER BALANCE MODEL

The water balance model developed for the project is based on information currently available and is expected to provide a reasonable representation of the performance of the mine water management system. The model will be updated and validated in the future when more suitable site-specific data becomes available. The performance of the actual system may differ from the model predictions for a variety of reasons, including different climatic sequences and hydrologic behaviour of catchments, as well as variations in operating procedures due to potential equipment failure or operation system error.

8 Flood modelling assessment

8.1 OVERVIEW

The watercourses and drainage features that cross the project have been assessed to determine the potential impact of the project on flood behaviour.

A hydrological model was developed for Smoky Creek and Billy's Gully using the XP-RAFTS runoff-routing model (Innovyze, 2019). The XP-RAFTS model was calibrated to hydrographs recorded at the stream gauge Smoky Creek Upstream IPM for two flow events (February 2016 and March 2017).

A TUFLOW hydrodynamic model (BMT, 2018a) was used to simulate flow behaviour in the vicinity of the project. TUFLOW modelling represents hydraulic conditions on a fixed grid by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow (BMT, 2018b). The model automatically calculates breakout points and flow directions within the study area.

The hydraulic model has been used to assess the impact of the project on flow paths, flood discharges, flood extents, depths and levels for the 1% and 0.1% Annual Exceedance Probability (AEP) design flood events for Smoky Creek and Billy's Gully.

TUFLOW hydraulic models were developed for three scenarios:

- Approved Conditions - which includes the previously approved IPE mine plans;
- Operational Conditions – which includes the changes to the floodplain under the proposed IPEE mine plans; and
- Post-mining Conditions – which includes the proposed final landform for the project.

The difference between the Approved Conditions and Operational Conditions provides the impact of the IPEE project on flood behaviour.

Descriptions of the development and calibration of the models and the design discharges are provided in Appendix B.

8.2 APPROVED CONDITIONS FLOODING

The Approved Conditions TUFLOW model was used to determine the 1% AEP and 0.1% AEP design flood levels, depth, extents and velocities for Smoky Creek and Billy's Gully, for the approved IPE footprint.

The Approved Conditions were used as a baseline for assessing the impact of the operational and post-mining landforms of the IPEE project. For comparison purposes, the maximum footprint of the approved IPE mining pit and overburden embankment and the proposed maximum footprint of the proposed IPEE mining pit and overburden embankment are also shown on the Approved Conditions figures.

8.2.1 Smoky Creek

Figure 8.1 and Figure 8.2 show the Approved Conditions extent and depth of flooding in Smoky Creek for the 1% and 0.1% AEP design events. The 1% and 0.1% AEP peak flood velocities are shown in Figure 8.3 and Figure 8.4. The following is of note with respect to the 1% AEP event:

- Flooding within Smoky Creek (and its tributary), in the vicinity of the IPE mining area, is generally confined within a narrow floodplain for most of its length.
- There is some interaction between the flood extent of Smoky Creek and its tributary immediately upstream of their confluence.

- Peak velocities within the Smoky Creek channel across the project reach up to 3.0 m/s.
- Overbank velocities are below 1.0 m/s.

The following is of note with respect to the 0.1% AEP event:

- Peak velocities within the Smoky Creek channel across the project reach up to 4.0 m/s.
- Overbank velocities are below 2.0 m/s.

8.2.2 Billy's Gully

Figure 8.5 and Figure 8.6 shows the Approved Conditions extent and depth of flooding in Billy's Gully for the 1% and 0.1% AEP design events. The 1% and 0.1% AEP peak flood velocities are shown in Figure 8.7 and Figure 8.8. The following is of note with respect to the 1% AEP event:

- Flooding within Billy's Gully, in the vicinity of the IPE mining area, is generally confined within a narrow floodplain for most of its length.
- Peak velocities within the Billy's Gully channel across the project reach up to 2.5 m/s.
- Overbank velocities are below 1.0 m/s.

The following is of note with respect to the 0.1% AEP event:

- Peak velocities within the Billy's Gully channel across the project reach up to 3.0 m/s.
- Overbank velocities are below 1.0 m/s.

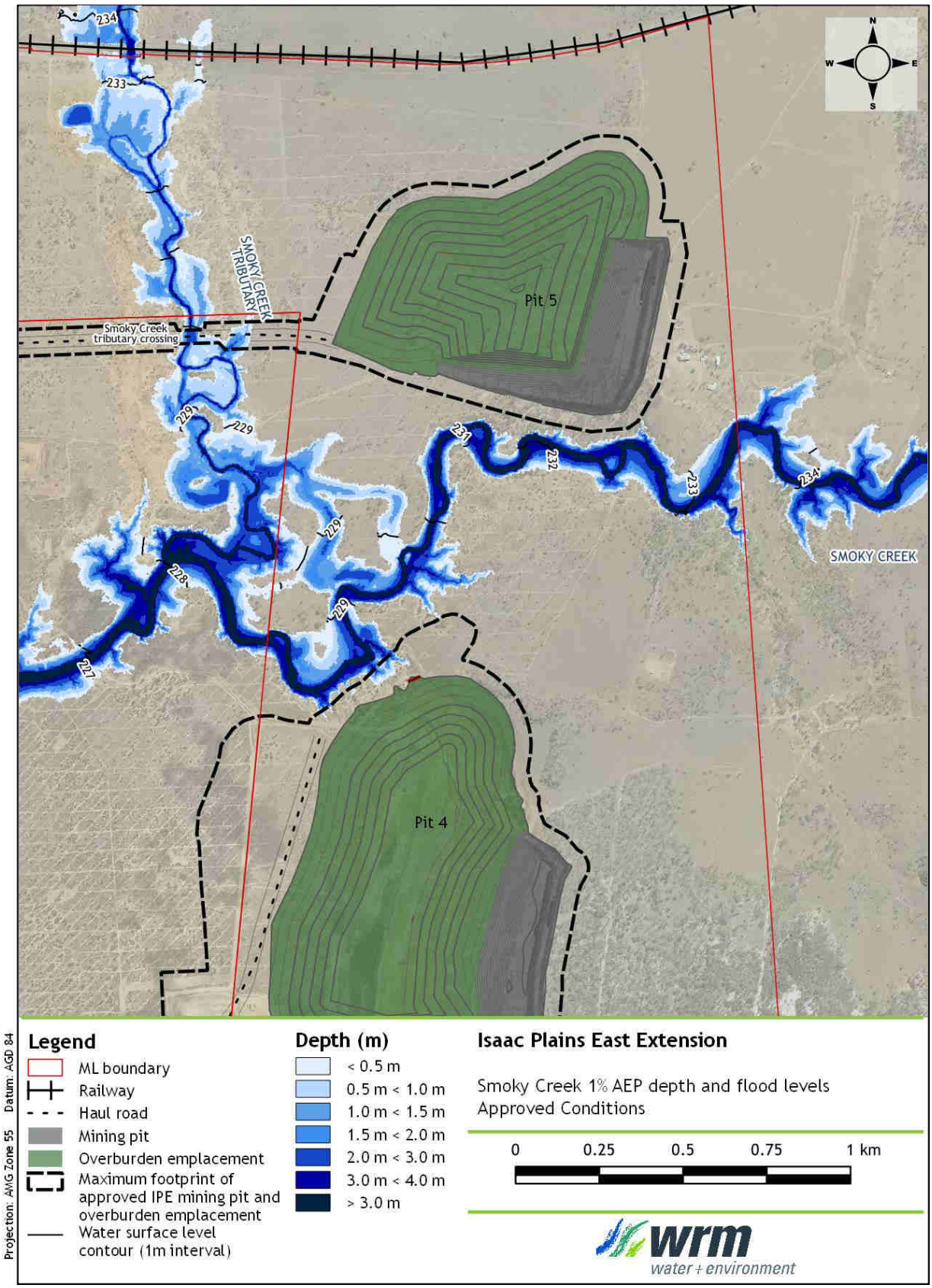

Figure 8.1 – 1% AEP peak depth and flood levels in Smoky Creek, Approved Conditions

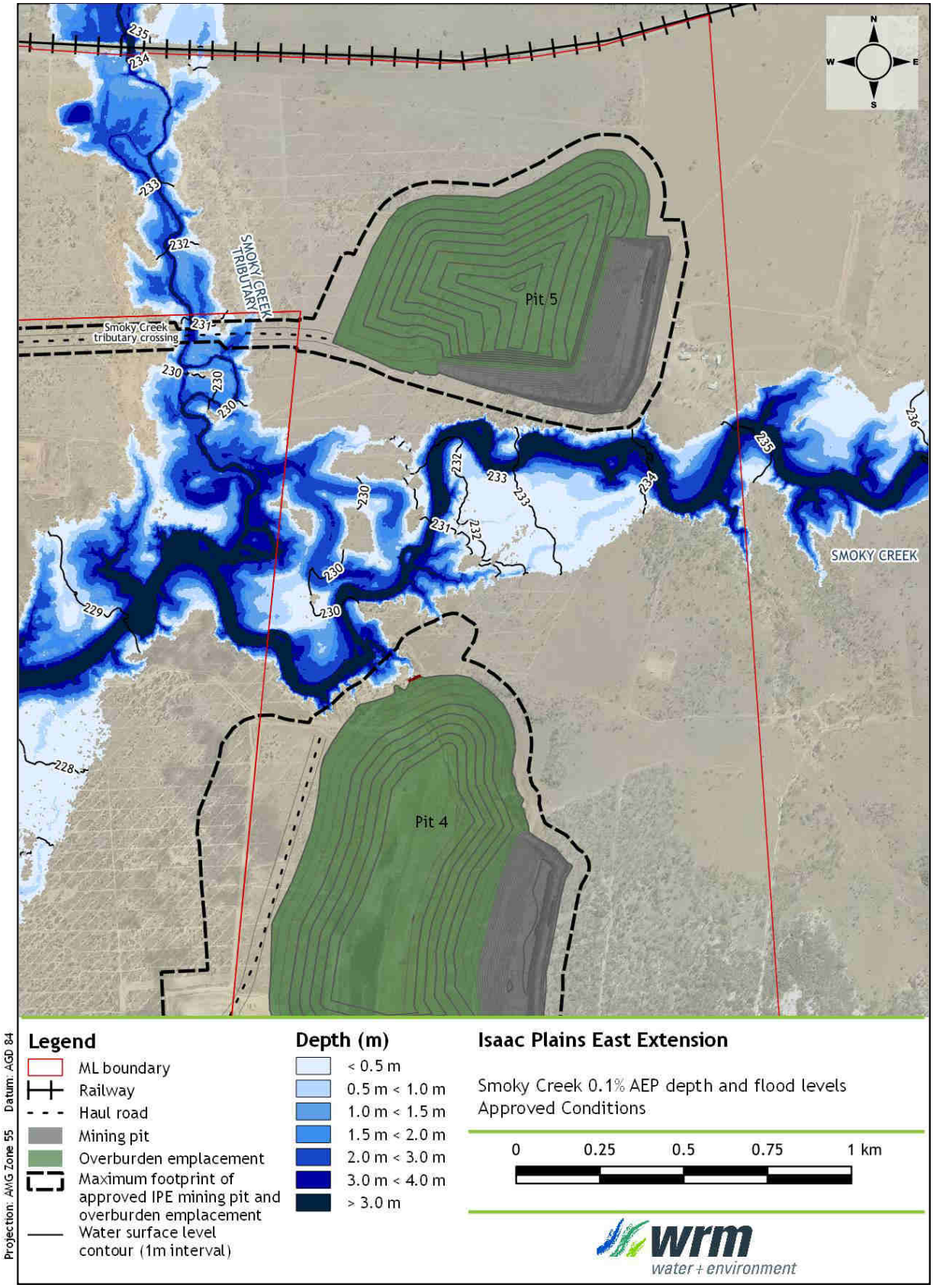

Figure 8.2 – 0.1% AEP peak depth and flood levels in Smoky Creek, Approved Conditions

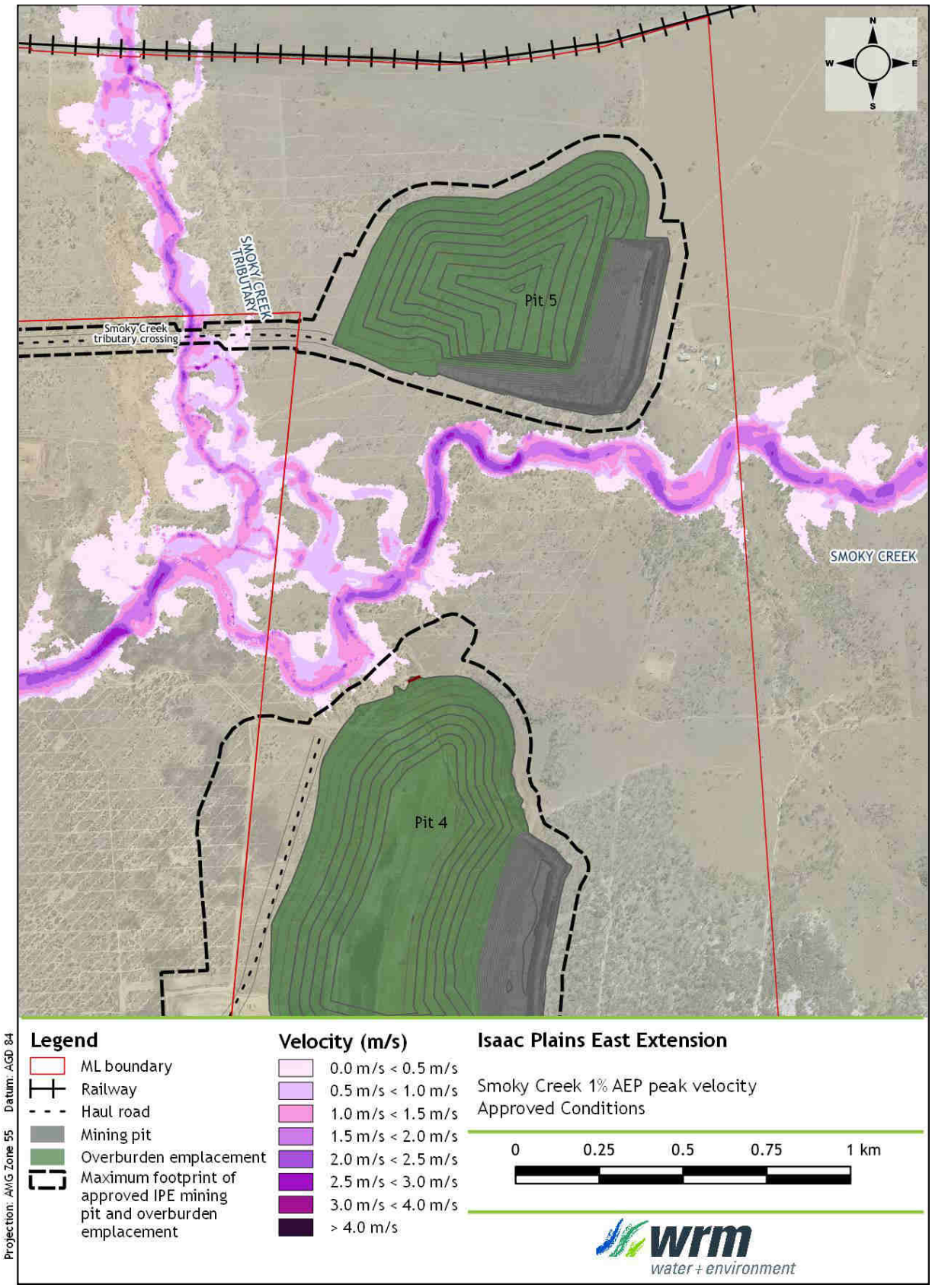

Figure 8.3 – 1% AEP peak velocities in Smoky Creek, Approved Conditions

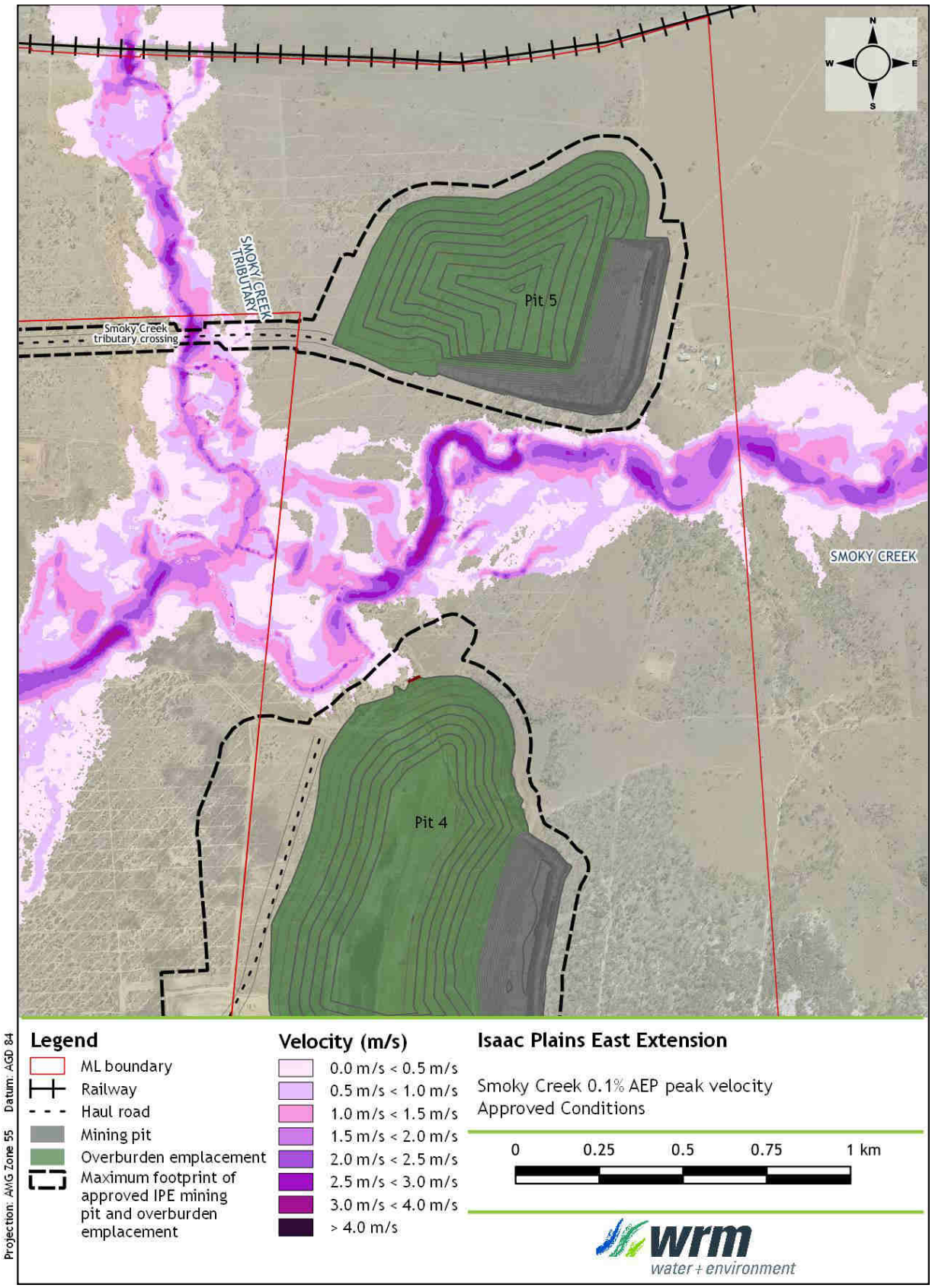

Figure 8.4 – 0.1% AEP peak velocities in Smoky Creek, Approved Conditions

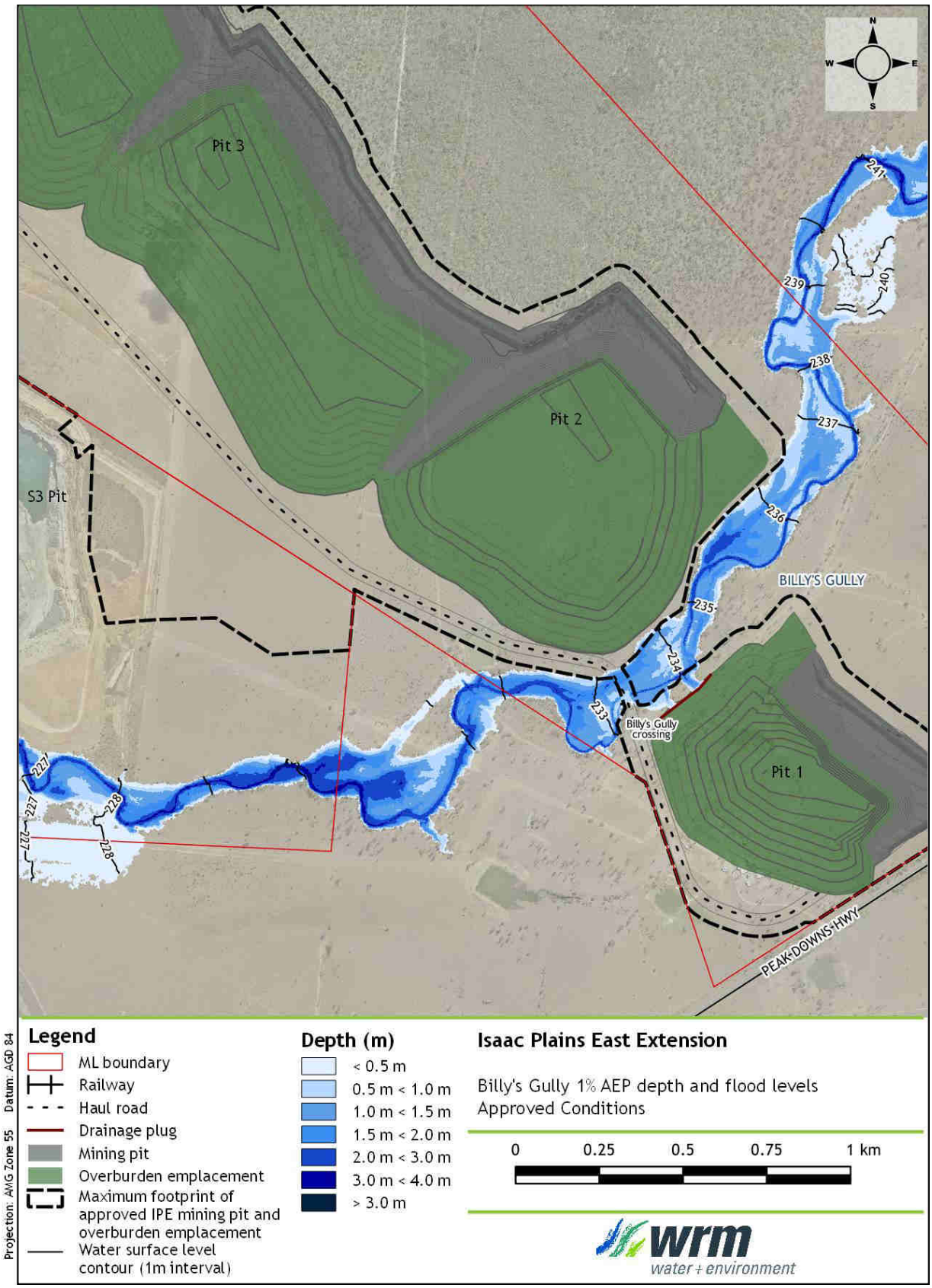

Figure 8.5 – 1% AEP peak depth and flood levels in Billy's Gully, Approved Conditions

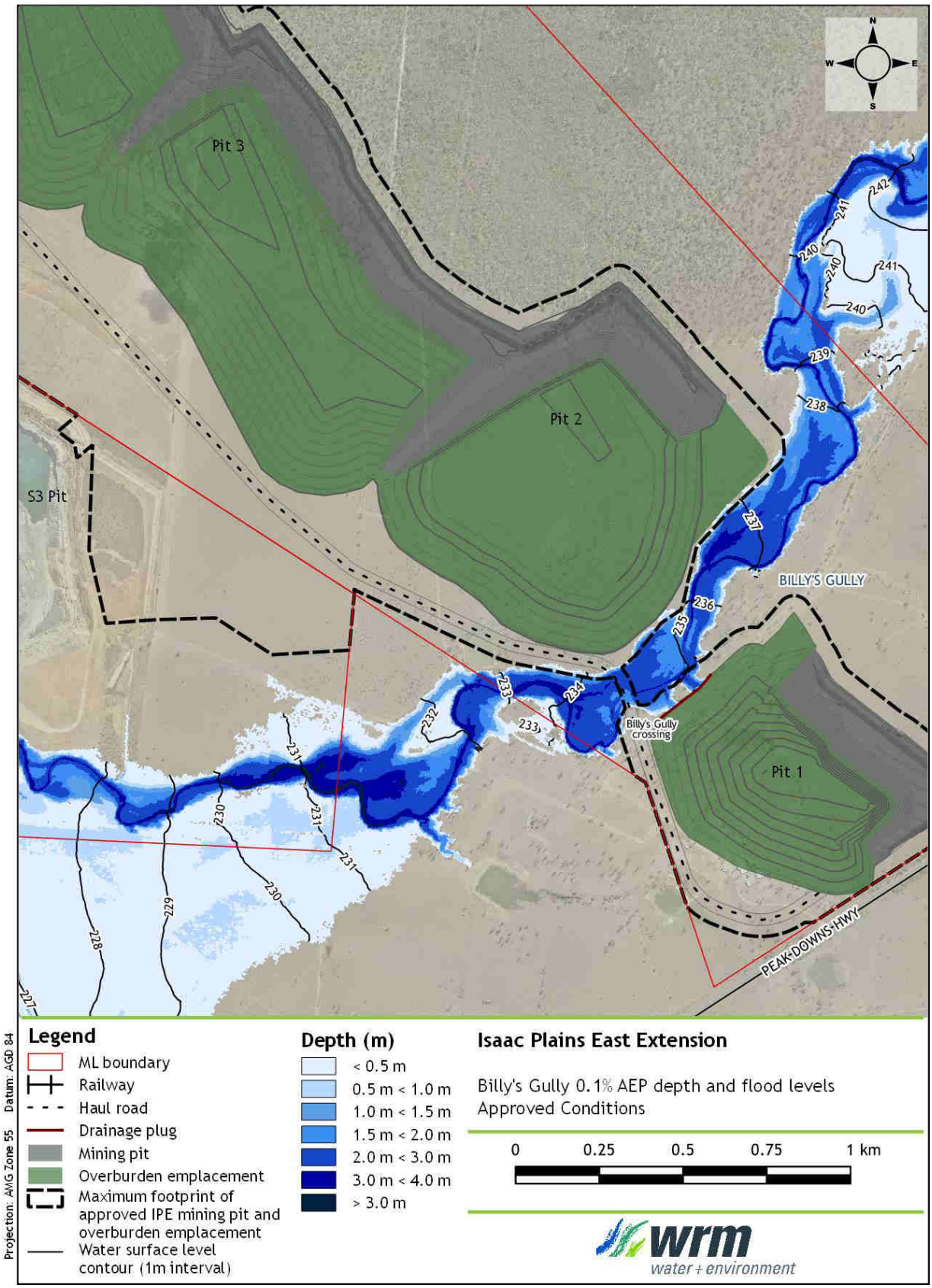

Figure 8.6 – 0.1% AEP peak depth and flood levels in Billy's Gully, Approved Conditions

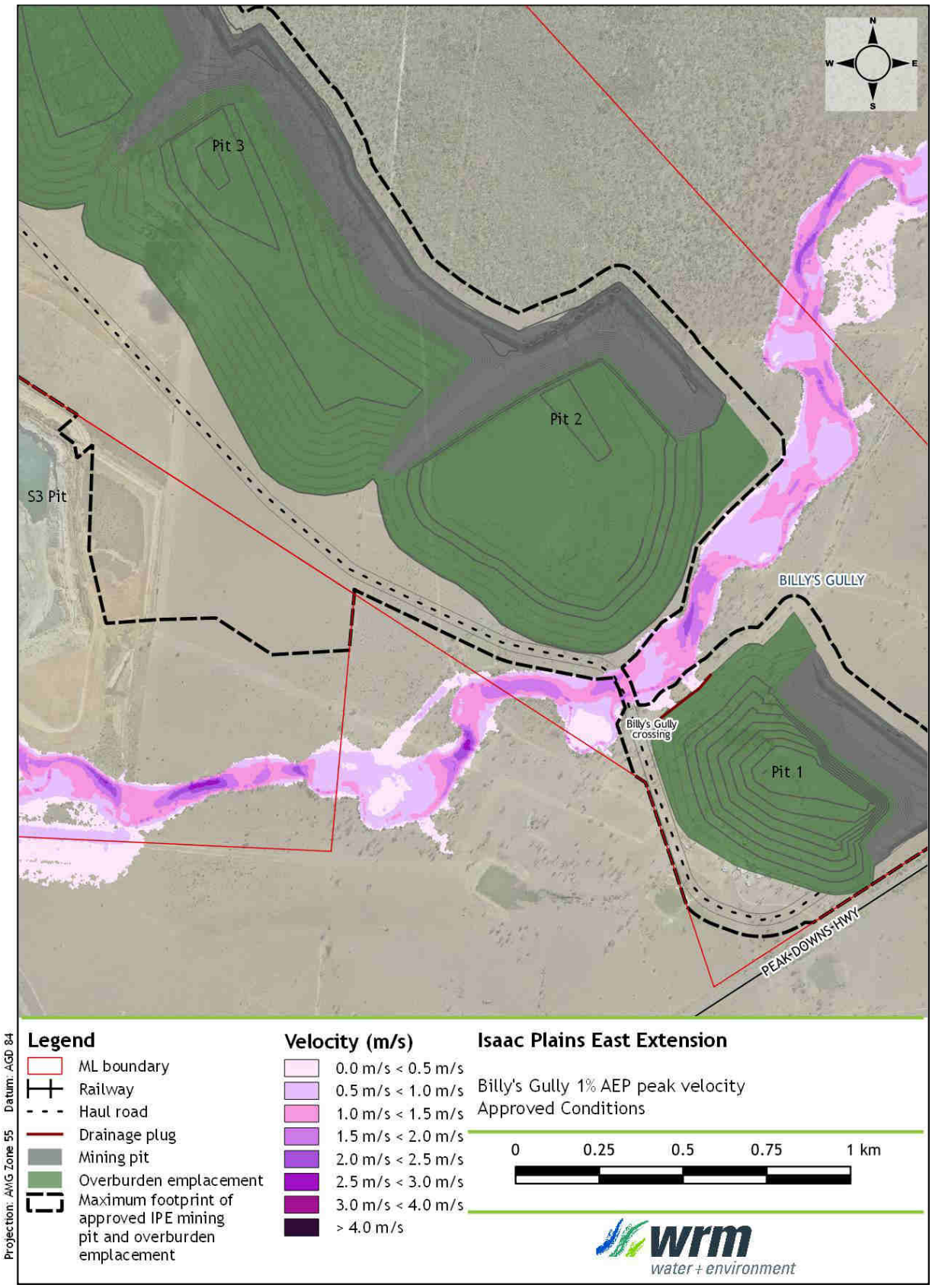

Figure 8.7 – 1% AEP peak velocities in Billy's Gully, Approved Conditions

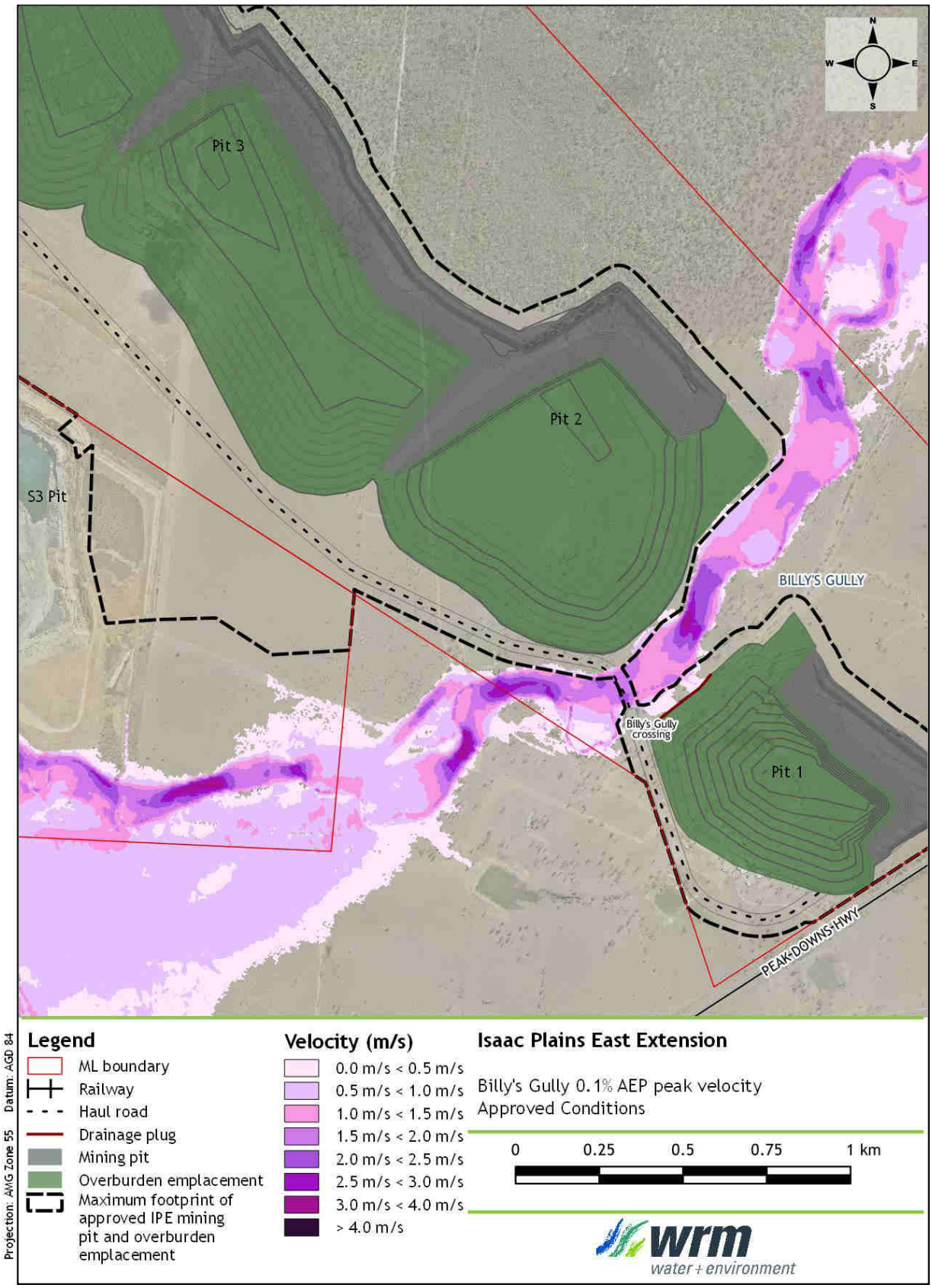

Figure 8.8 – 0.1% AEP peak velocities in Billy's Gully, Approved Conditions

8.3 OPERATIONAL CONDITIONS FLOODING

The Operational Conditions TUFLOW model was used to estimate peak flood levels and velocities in the vicinity of the project site during mining operations.

The proposed infrastructure changes from the Approved Conditions, with the potential to influence the hydrodynamic model, to the proposed Operational Conditions include:

- temporary flood protection levees along Pit 2 and Pit 4;
- haul road between Pit 4 and 5 with two culvert crossings. The concept arrangement of the additional culvert crossing is provided in Table 8.1;
- widening of the two approved haul road crossings over Billy's Gully and Smoky Creek tributary to 80 m. The upgraded haul road crossing concept arrangement is consistent with the previously approved crossing (refer to Appendix B, Section B2.2.5); and
- inclusion of an additional drainage plug at Pit 1.

Table 8.1 - Concept arrangement for additional culvert crossings

Crossing	Concept arrangement
Smoky Creek	3 x 1.2 m circular pipes with 0.3 m cover
Smoky Creek overflow path	1 x 0.6 m circular pipe with 0.3 m cover

8.3.1 Flood depths, extent and velocity

8.3.1.1 Smoky Creek

Figure 8.9 and Figure 8.10 show the Operational Conditions extent and depth of flooding in Smoky Creek for the 1% and 0.1% AEP design events. The 1% and 0.1% AEP peak flood velocities are shown in Figure 8.11 and Figure 8.12. The following is of note:

- The 1% and 0.1% AEP overbank flooding extents in Smoky Creek Tributary are generally similar between Approved and Operational Conditions.
- The 1% AEP overbank flooding extents in Smoky Creek are generally similar between Approved and Operational Conditions.
- The Pit 4 flood protection levee reduces the 0.1% AEP southern overbank flooding extent.
- The maximum 0.1% flood level along the Pit 4 flood protection levee is approximately 234.4 mAHD with a maximum 0.1% depth of 4.8 m.
- The Smoky Creek crossing is overtopped by approximately 4.6 m during the 1% AEP event and 5.80 m during the 0.1% AEP event.
- The Smoky Creek overflow crossing is overtopped by approximately 1.7 m during the 1% AEP event and 3.0 m during the 0.1% AEP event.
- The Smoky Creek Tributary crossing is overtopped by approximately 2.8 m during the 1% AEP event and 3.4 m during the 0.1% AEP event.
- The flood immunity of the crossings is low, however both the waterways are ephemeral, and only flow for short durations. This approach results in haul road crossings which minimise the obstruction of flow in the waterways.
- Scour protection will be installed at the three haul road crossings to control erosion caused by overtopping flows.

8.3.1.2 Billy's Gully

Figure 8.13 and Figure 8.14 show the Operational Conditions extent and depth of flooding in Billy's Gully for the 1% and 0.1% AEP design events. The 1% and 0.1% AEP peak flood velocities are shown in Figure 8.15 and Figure 8.16. The following is of note:

- Overbank flooding extents are generally similar between Approved and Operational Conditions.
- The Pit 2 flood protection levee reduces the 1% and 0.1% AEP northern overbank flooding extent.
- The maximum 0.1% flood level along the Pit 2 flood protection levee is approximately 238.4 mAHD, with a maximum 0.1% depth of 3.2 m.
- The additional Pit 1 drainage plug, located at the northeastern extent of the Pit 1 footprint, prevents a small overflow caused by the placement of the Pit 2 flood protection levee from entering Pit 1.
- The maximum 0.1% water depths at the Pit 1 drainage plugs (from northeast to southwest) are approximately 0.5 m, 2.3 m and 1.6 m.
- The Billy's Gully crossing is overtopped by approximately 1.9 m during the 1% AEP event and 2.9 m during the 0.1% AEP event.
- The flood immunity of the Billy's Gully crossing is low, however the waterway is ephemeral, and only flow for short durations. This approach results in haul road crossings which minimise the obstruction of flow in the waterway.
- Scour protection will be required at the Billy's Gully crossings to control erosion caused by overtopping flows.

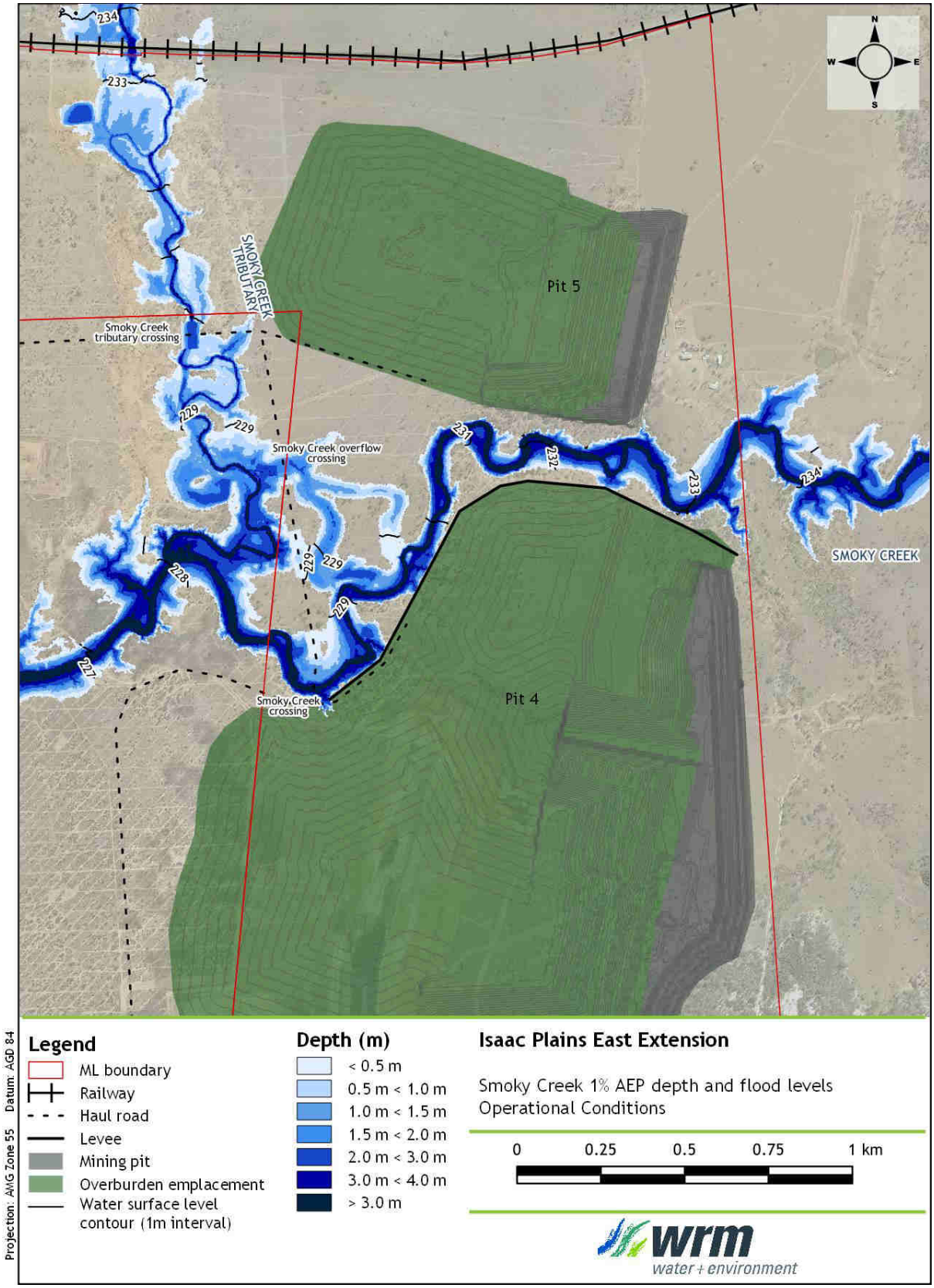

Figure 8.9 – 1% AEP peak depth and flood levels in Smoky Creek, Operational Conditions

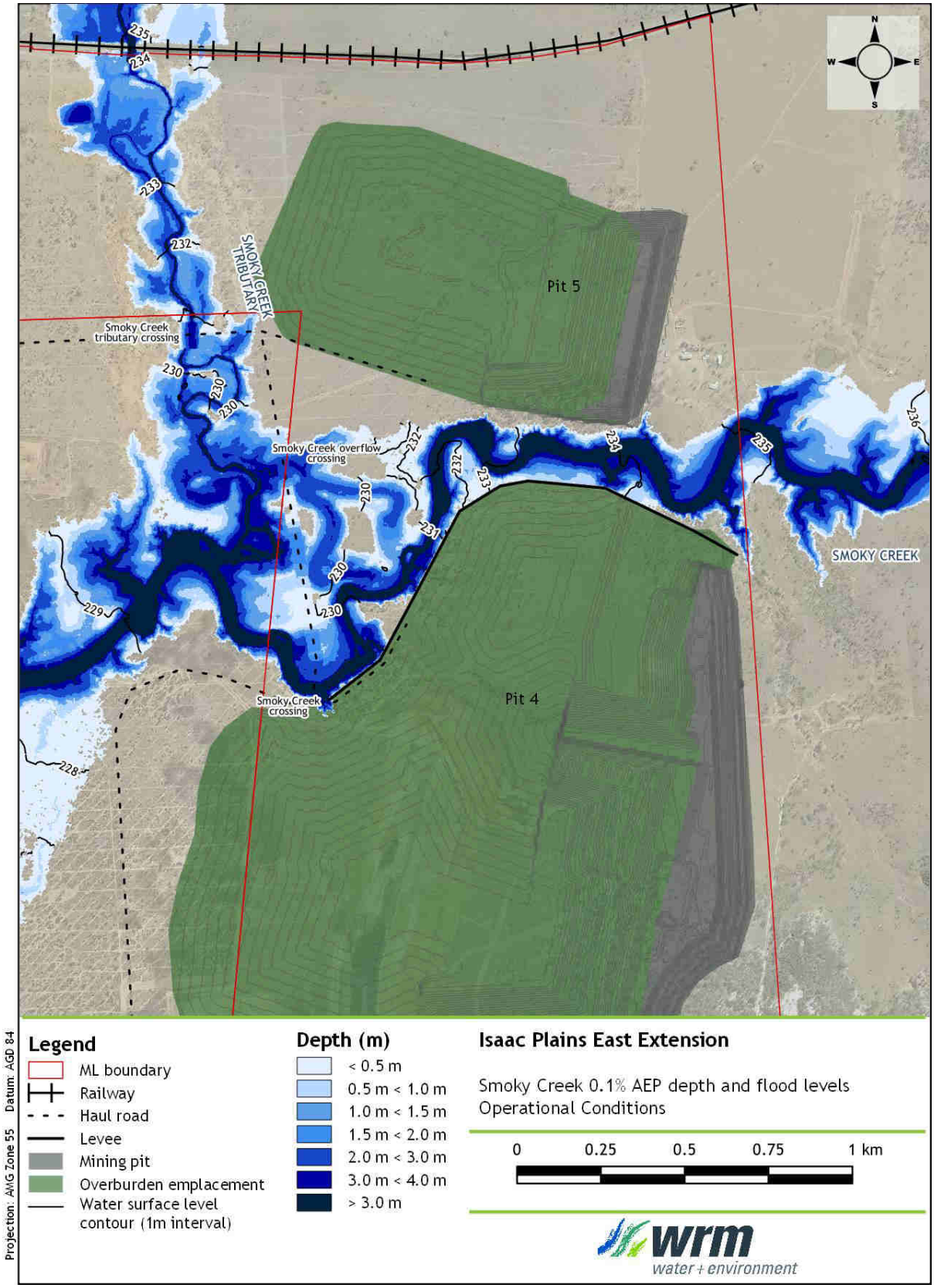

Figure 8.10 – 0.1% AEP peak depth and flood levels in Smoky Creek, Operational Conditions

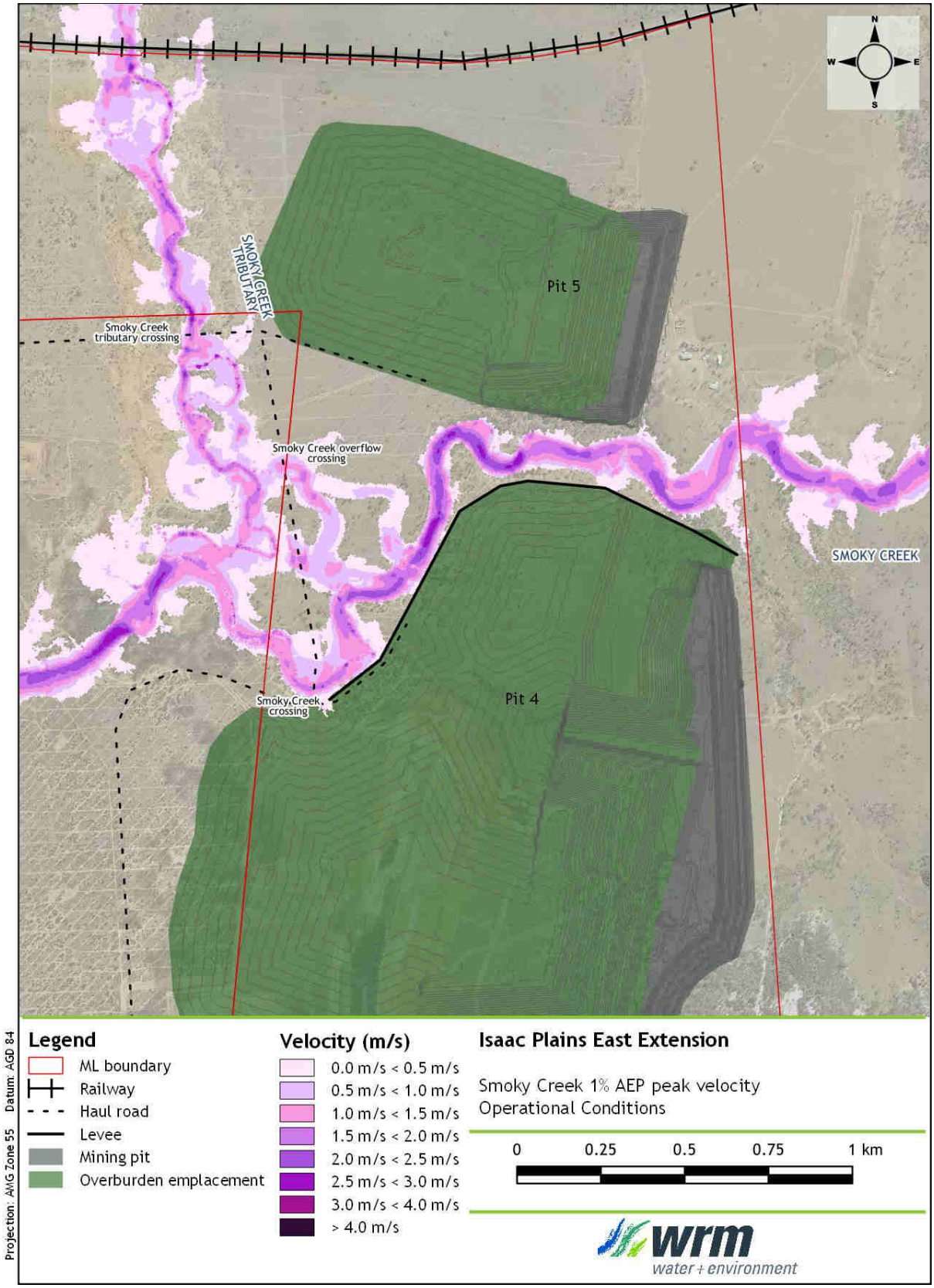

Figure 8.11 – 1% AEP peak velocities in Smoky Creek, Operational Conditions

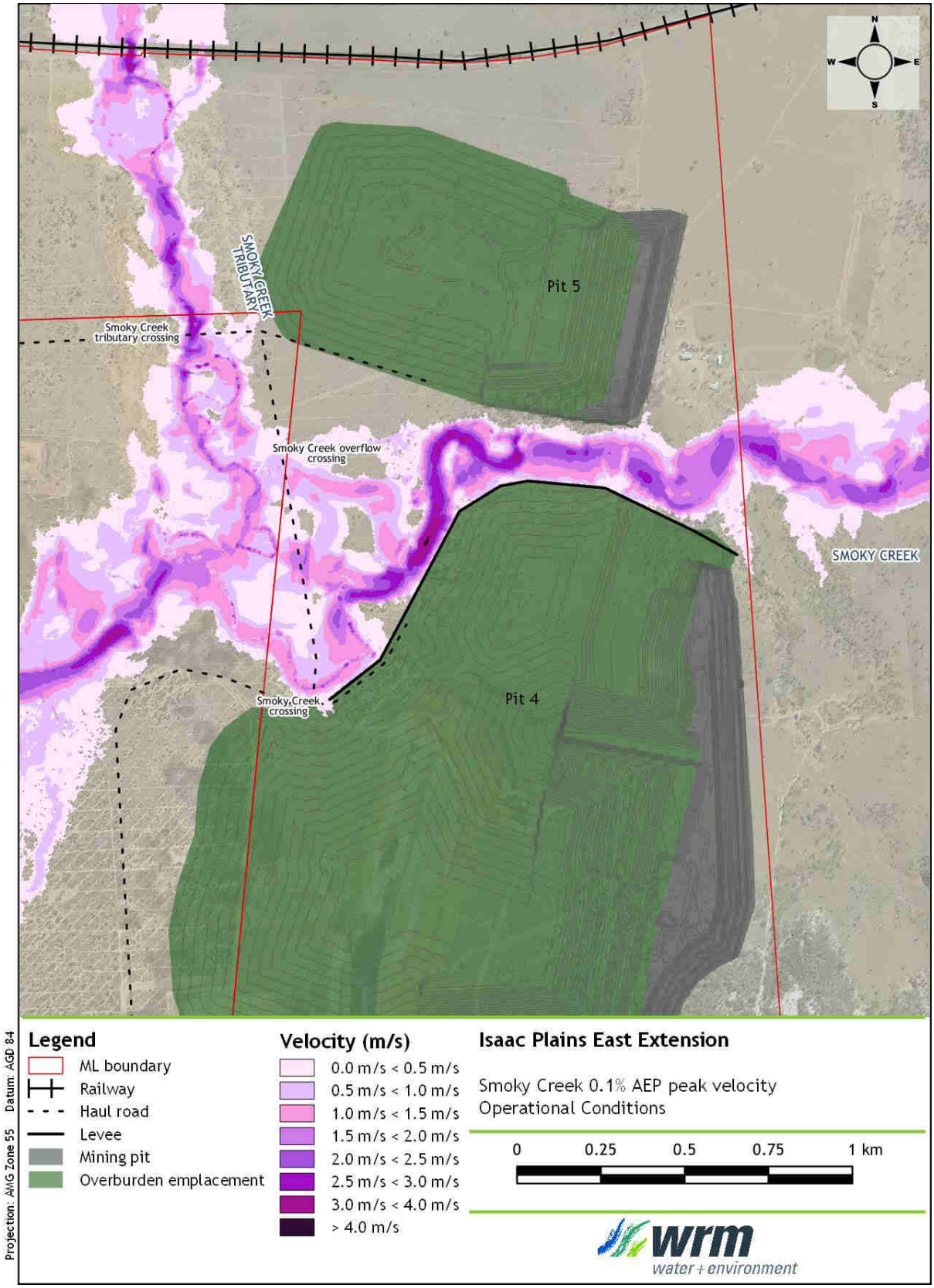

Figure 8.12 – 0.1% AEP peak velocities in Smoky Creek, Operational Conditions

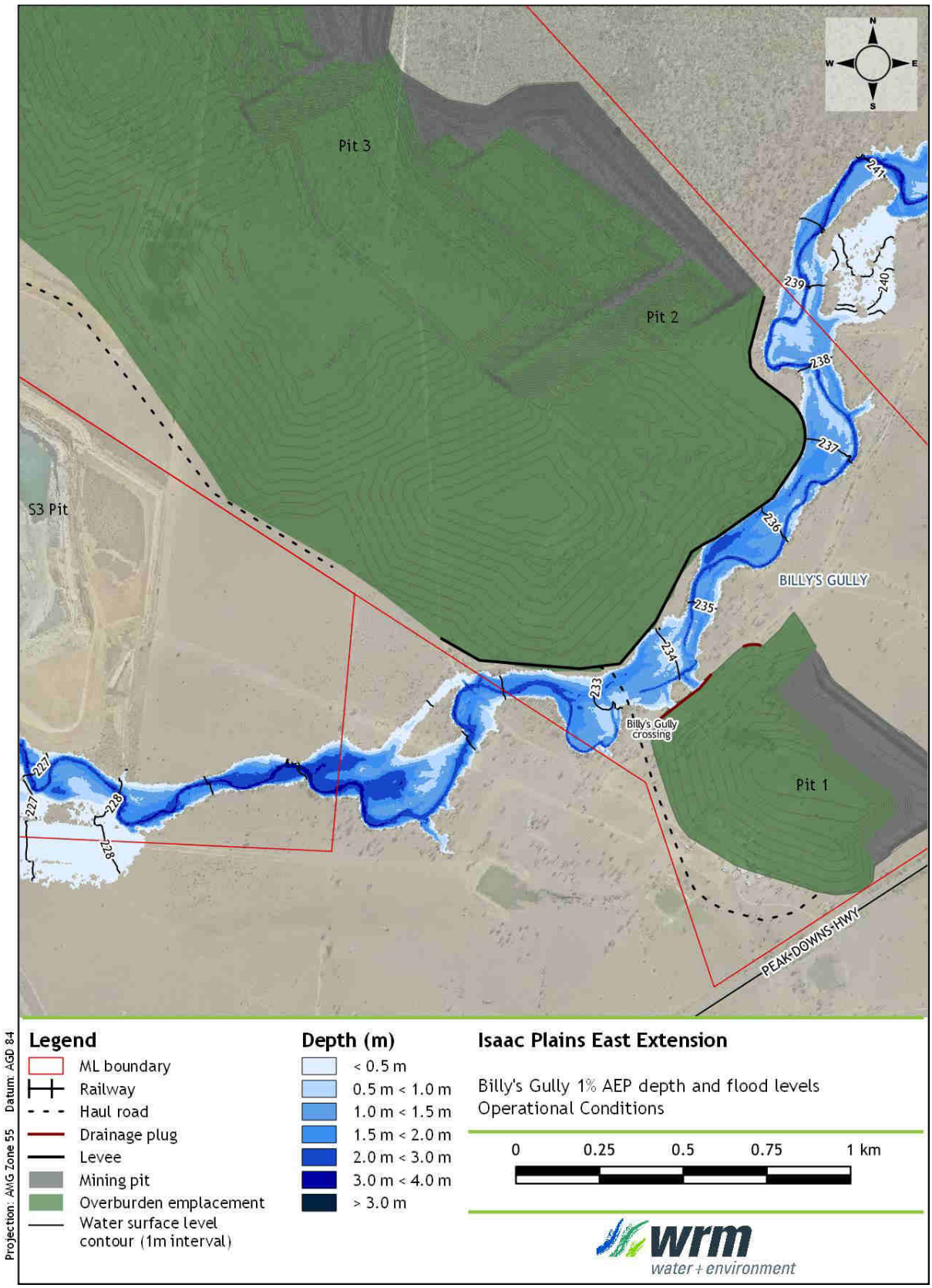

Figure 8.13 – 1% AEP peak depth and flood levels in Billy's Gully, Operational Conditions

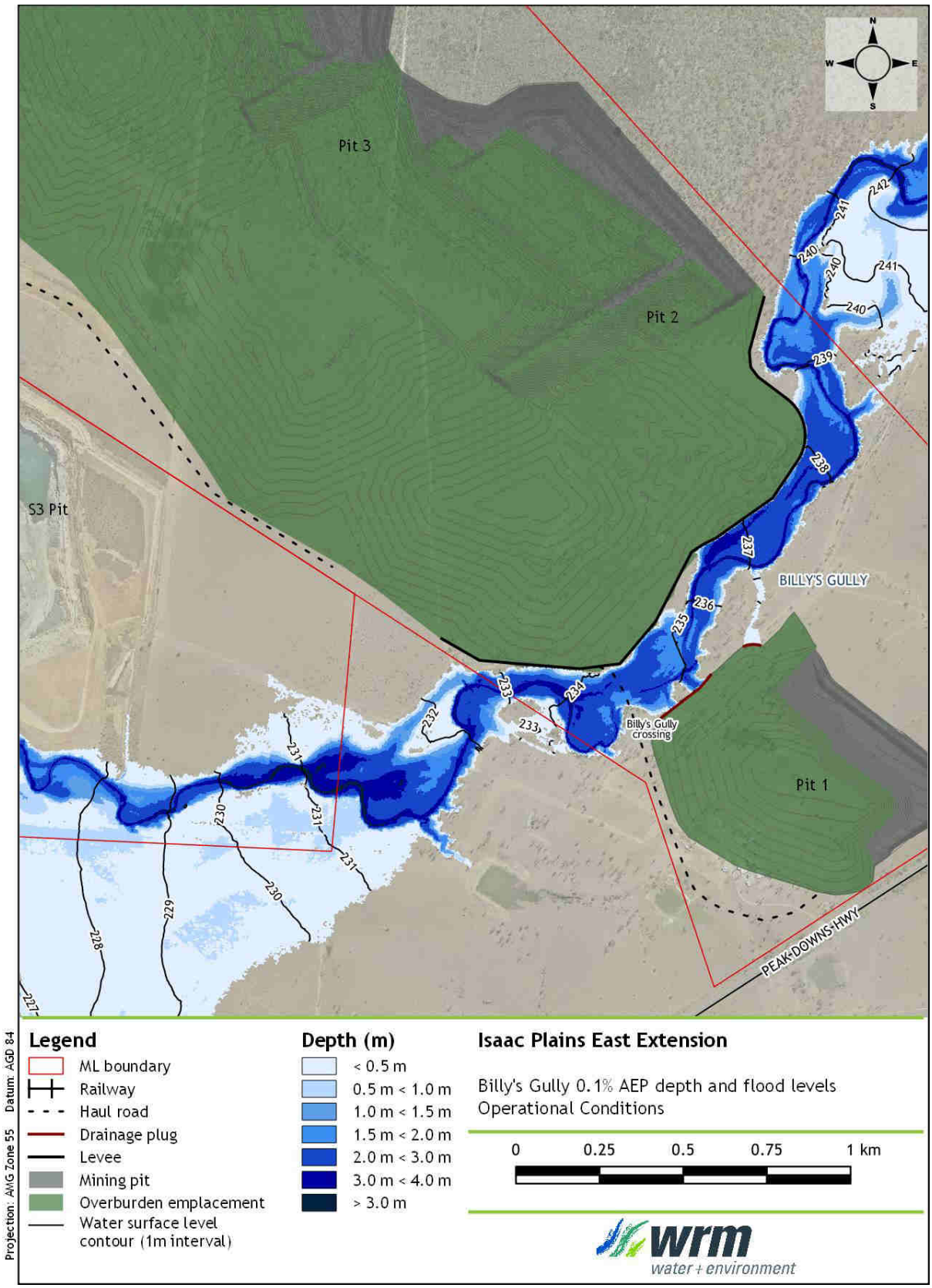

Figure 8.14 – 0.1% AEP peak depth and flood levels in Billy's Gully, Operational Conditions

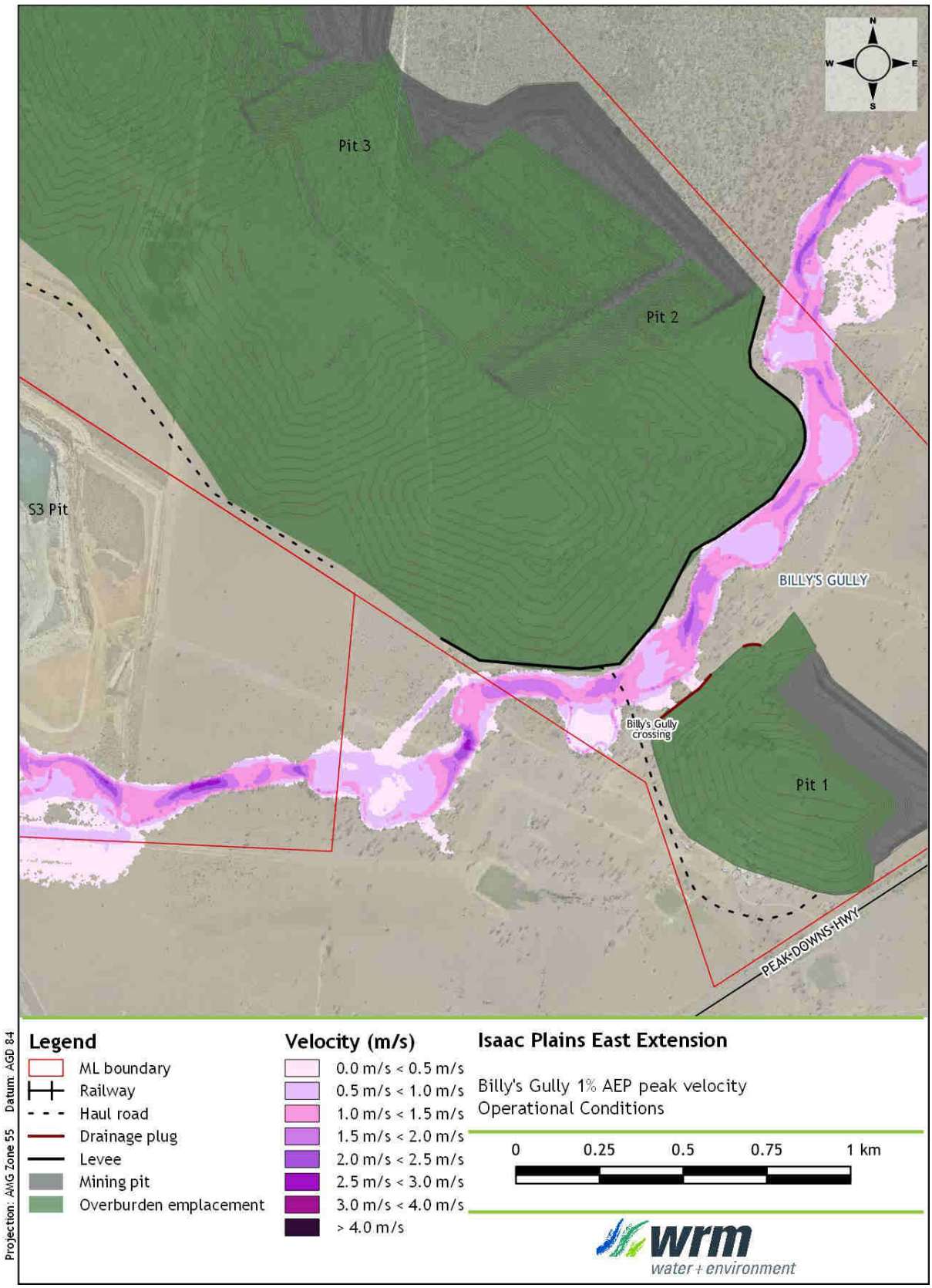

Figure 8.15 – 1% AEP peak velocities in Billy's Gully, Operational Conditions

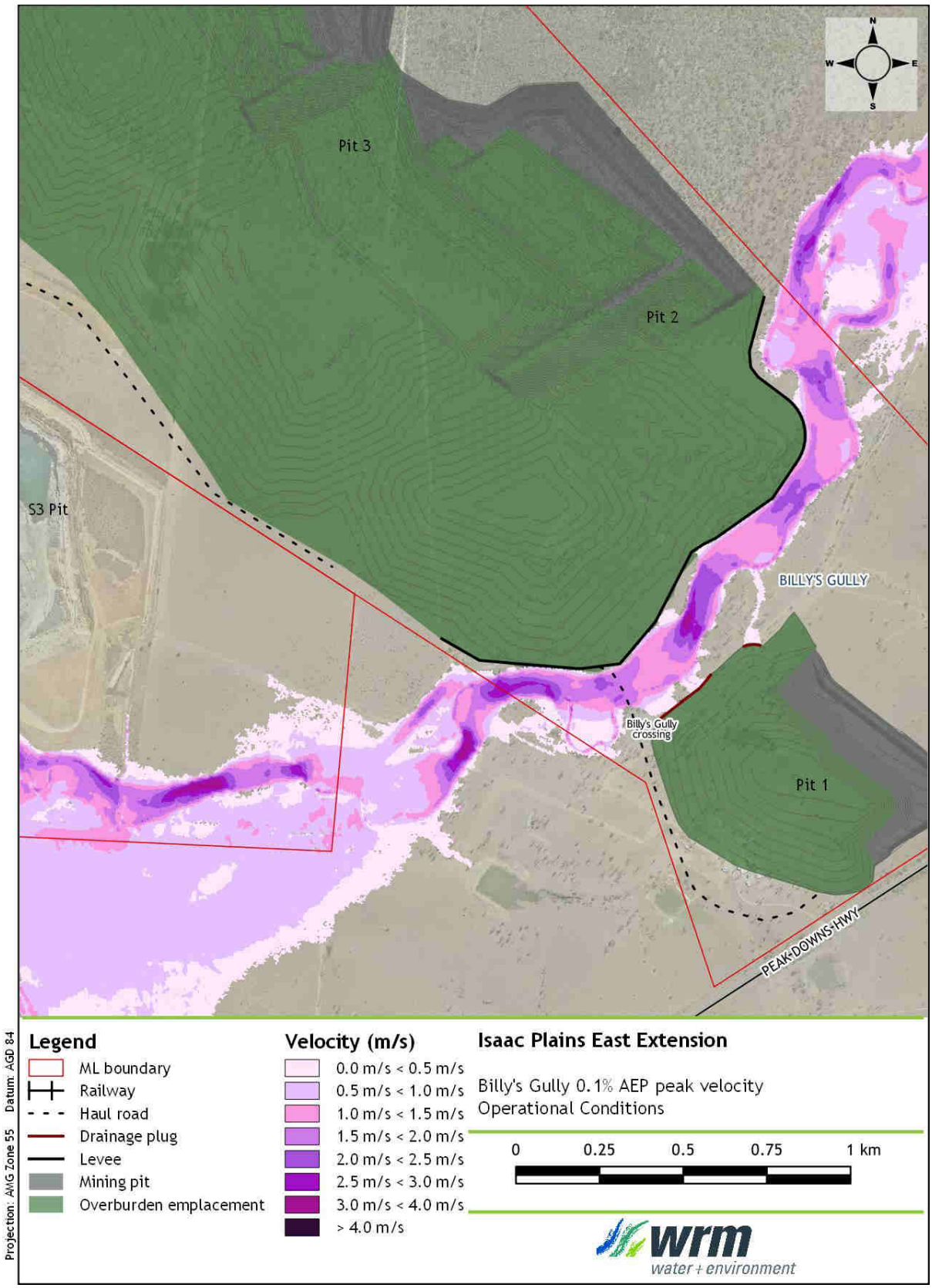

Figure 8.16 – 0.1% AEP peak velocities in Billy's Gully, Operational Conditions

8.3.2 Impact of the project on peak flood levels

Figure 8.17, Figure 8.18, Figure 8.19 and Figure 8.20 show the predicted changes in peak flood levels along Smoky Creek and Billy's Gully due to the proposed IPEE infrastructure changes during operations for the 1% AEP and 0.1% AEP events (i.e. the change between Operational Conditions and Approved Conditions). A summary of the impact of the project on peak flood levels is provided below.

Note that a water level afflux of ± 0.01 m is considered as being "no material impact".

8.3.2.1 Smoky Creek

The following is of note with respect to the change in peak flood levels during the 1% AEP event in Smoky Creek:

- The predicted change in flood levels in Smoky Creek Tributary is restricted to a small zone upstream and downstream of the Smoky Creek tributary haul road crossing. The impact zone does not extend more than 240 m upstream of the crossing and 100 m downstream. The maximum increase in flood level is around 0.21 m (at the crossing) and maximum decrease is around 0.30 m (upstream of the crossing).
- The Smoky Creek and Smoky Creek overflow haul road crossings do not cause a significant increase in peak flood levels during the 1% AEP event. The maximum decrease in peak water flood at both crossings is about 0.1 m.
- There is a maximum increase of about 0.2 m along the haul road between Smoky Creek and Smoky Creek overflow crossings. This is due to the proposed haul road affecting the interaction between the flood extent of Smoky Creek and its tributary. The increase in flood levels is restricted to a 95 m stretch over the haul road.
- There is a small increase of about 0.02 m in Smoky Creek about 500 m upstream of the Smoky Creek haul road crossing. This increase is due to the Pit 4 flood protection levee blocking a backflow area of Smoky Creek.

The following is of note with respect to the change in peak flood levels during the 0.1% AEP event in Smoky Creek:

- The predicted change in flood levels in Smoky Creek Tributary is restricted to a small zone upstream and downstream of the Smoky Creek tributary haul road crossing. The impact zone does not extend more than 400 m upstream of the crossing and 100 m downstream. The maximum increase in flood level is around 0.27 m (at the crossing) and maximum decrease is around 0.40 m (upstream of the crossing).
- The Smoky Creek and Smoky Creek overflow haul road crossings do not cause a significant increase in peak flood levels during the 0.1% AEP event. The maximum decrease in peak water level at both crossings is about 0.2 m.
- There is a maximum increase of about 0.14 m along the haul road between Smoky Creek and Smoky Creek overflow crossings. This is due to the proposed haul road affecting the interaction between the flood extent of Smoky Creek and its tributary. The increase in flood levels is restricted to a 80 m stretch over the haul road.
- The Pit 4 flood protection levee causes a maximum increase in flood levels of about 0.2 m in Smoky Creek. The impact zone extends approximately 480 m outside the ML boundary. The maximum increase in flood levels outside the ML boundary is 0.06 m.

8.3.2.2 Billy's Gully

The following is of note with respect to the change in peak flood levels during the 1% AEP event in Billy's Gully:

- The Billy's Gully haul road crossing causes an increase in peak flood levels of approximately 0.18 m. The impact zone does not extend more than 210 m upstream of the crossing and 100 m downstream.
- The Pit 2 flood protection levee causes an increase in peak flood levels of approximately 0.24 m. The increase impacts approximately 640 m of the Billy's Gully flow path and does not extend outside the ML boundary.

The following is of note with respect to the change in peak flood levels during the 0.1% AEP event in Billy's Gully:

- The Billy's Gully haul road crossing causes an increase in peak flood levels of approximately 0.12 m. The impact zone does not extend more than 280 m upstream of the crossing and 40 m downstream.
- The Pit 2 flood protection levee causes an increase in peak flood levels of approximately 0.47 m in Billy' Gully. The increase impacts approximately 970 m of the Billy's Gully flow path and extends approximately 155 m outside the ML boundary. The maximum increase in flood levels outside the ML boundary is 0.33 m, although the majority of the off-lease impact is less than 0.05 m.

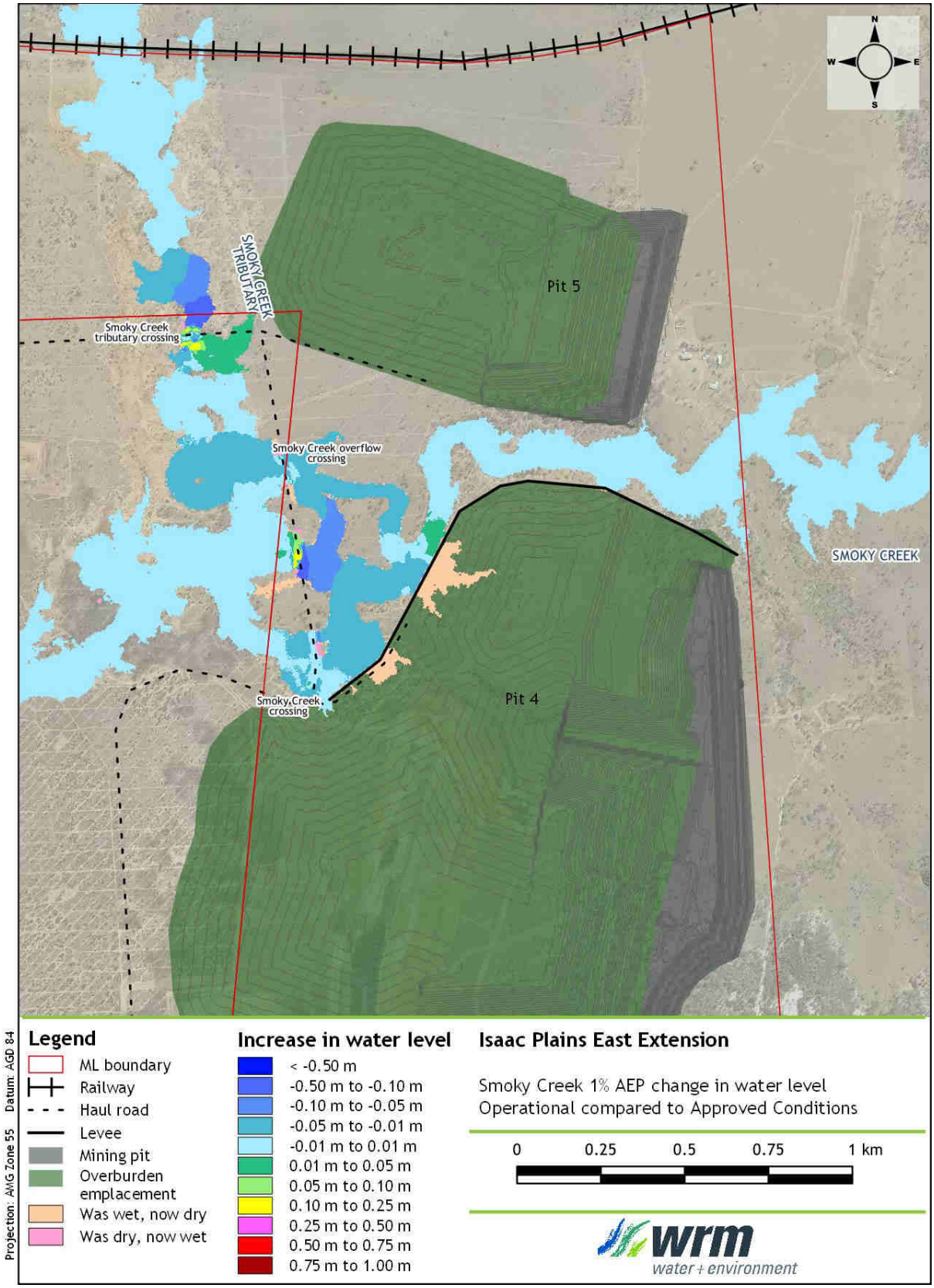

Figure 8.17 – Change in 1% AEP water levels in Smoky Creek, Operational Conditions compared to Approved Conditions

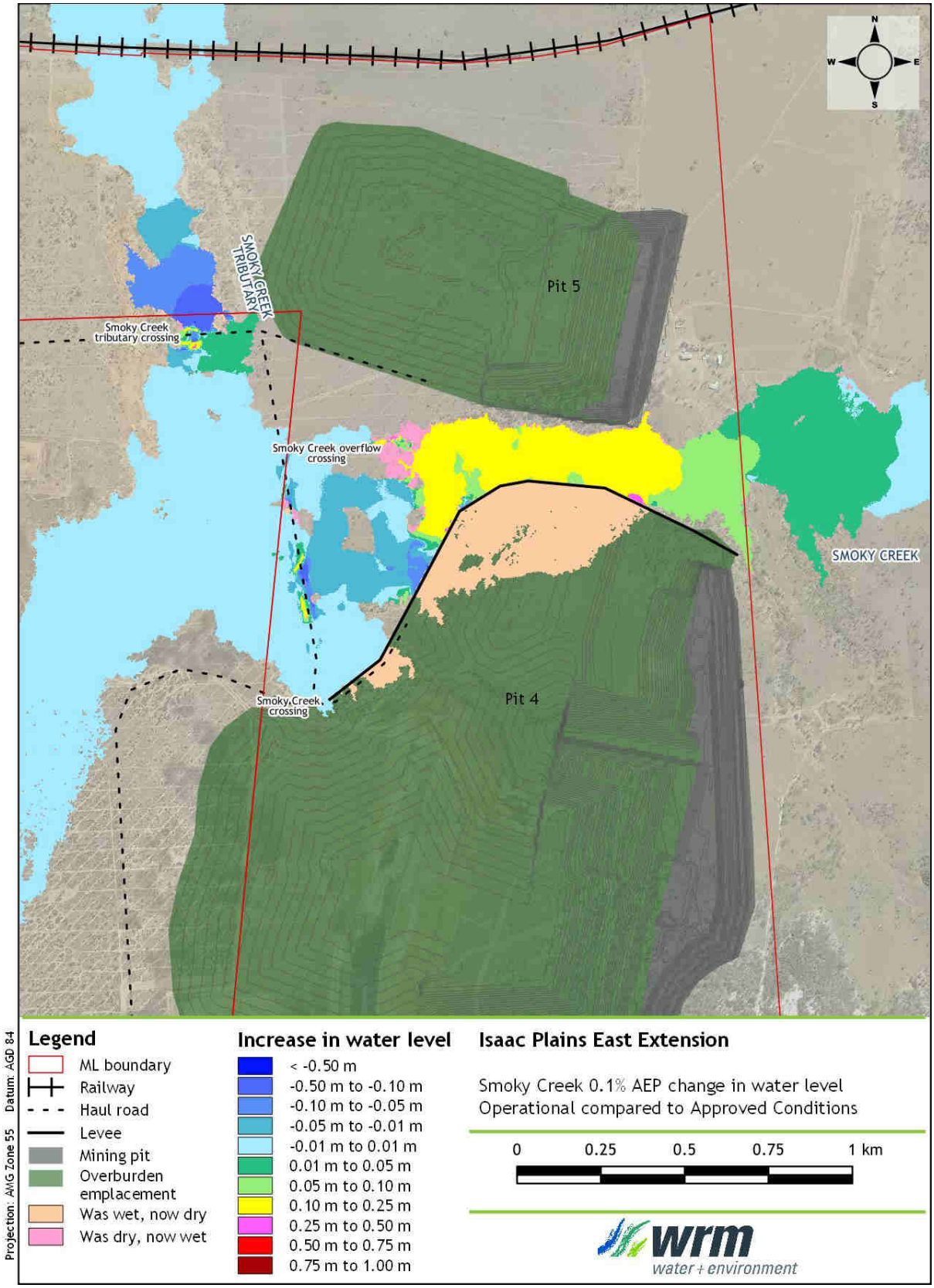

Figure 8.18 – Change in 0.1% AEP water levels in Smoky Creek, Operational Conditions compared to Approved Conditions

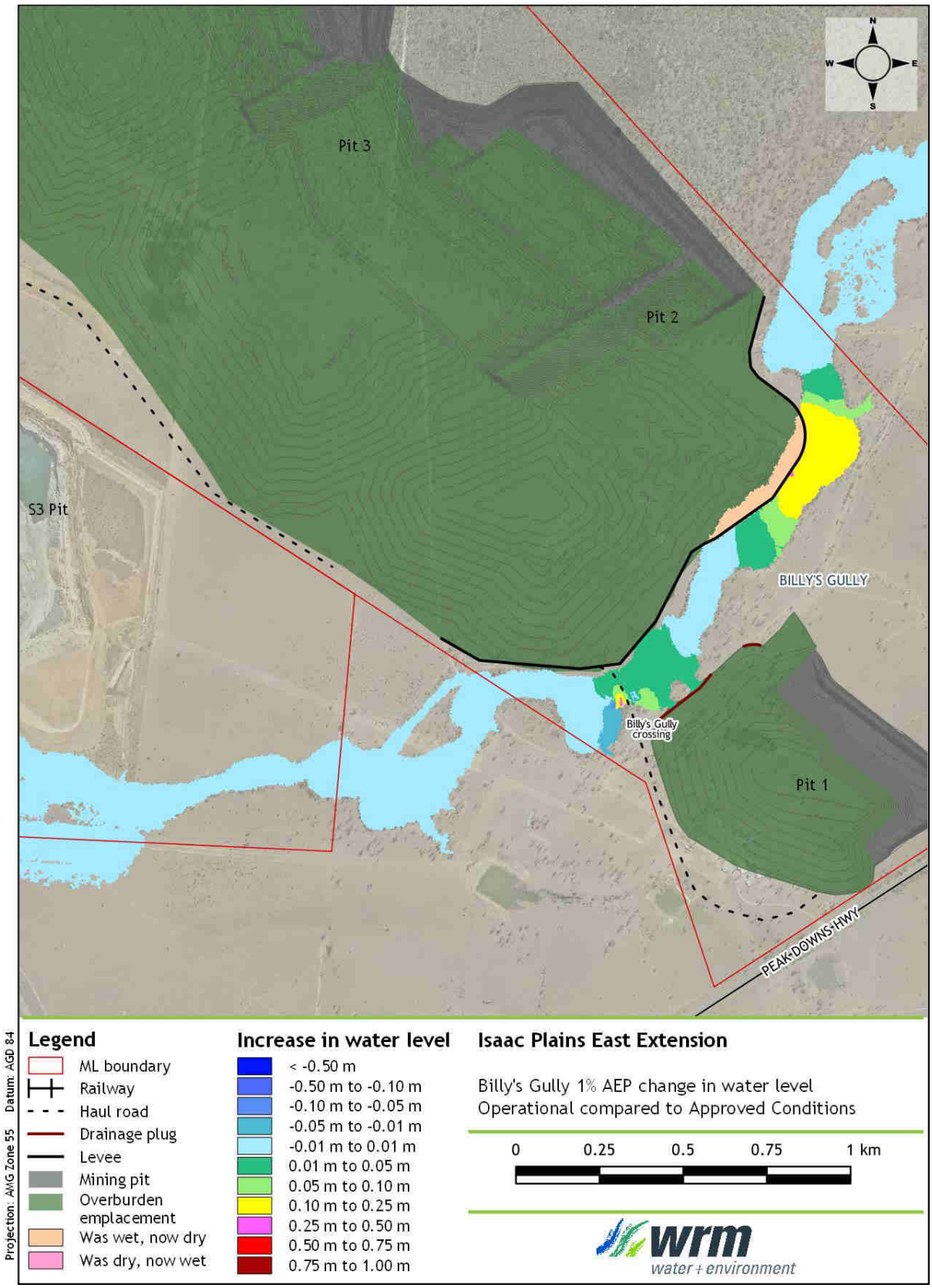

Figure 8.19 – Change in 1% AEP water levels in Billy's Gully, Operational Conditions compared to Approved Conditions

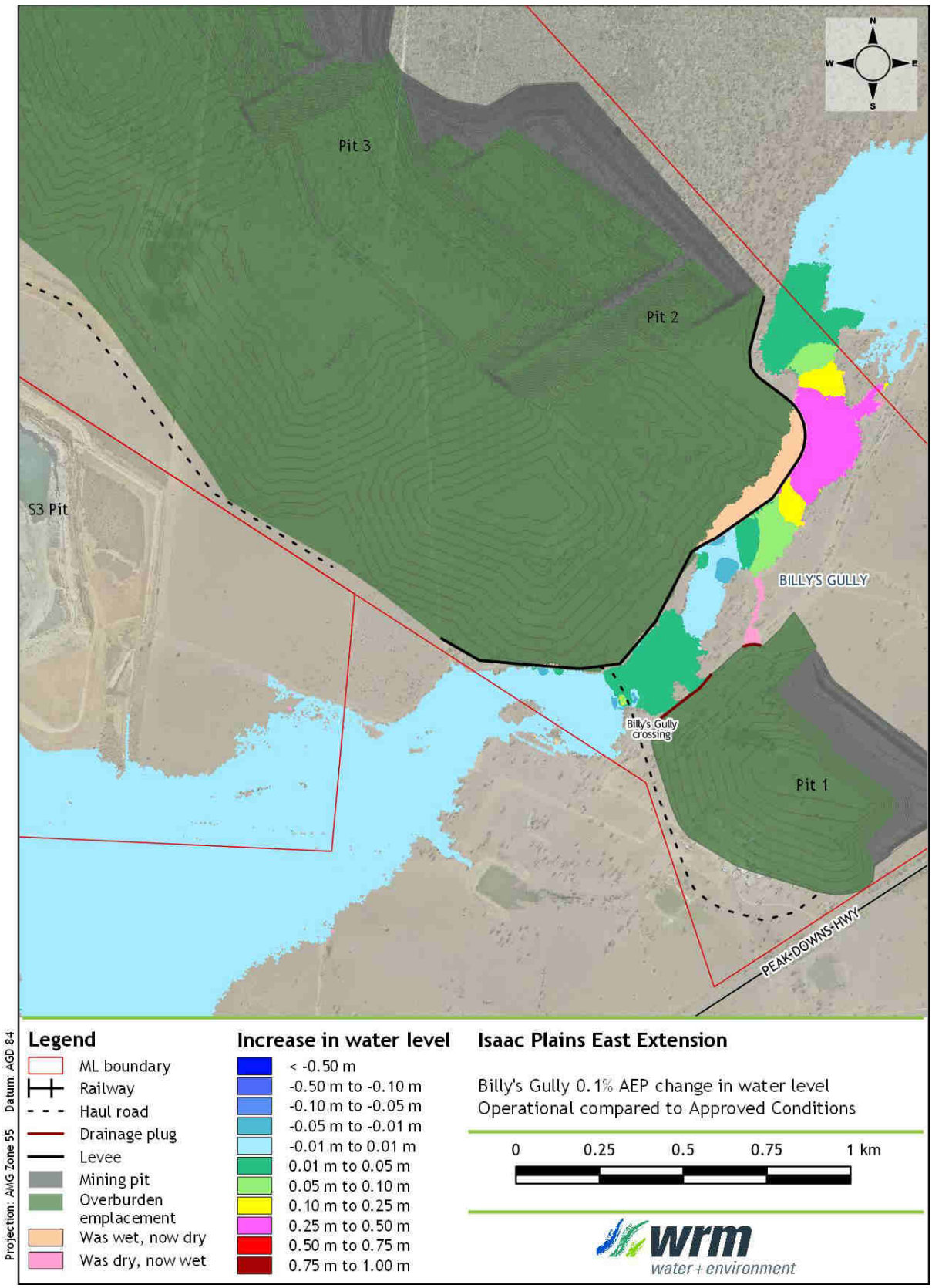

Figure 8.20 – Change in 0.1% AEP water levels in Billy's Gully, Operational Conditions compared to Approved Conditions

8.3.3 Impact of the project on peak flood velocities

Figure 8.21, Figure 8.22, Figure 8.23 and Figure 8.24 show the predicted changes in flood velocities along Smoky Creek and Billy's Gully due to the proposed infrastructure during operations for the 1% AEP and 0.1% AEP events (change between Operational Conditions and Approved Conditions). A summary of the impact of the project on peak flood velocities is provided below.

Note that a velocity change of ± 0.1 m/s is considered as being "no material impact".

8.3.3.1 Smoky Creek

The following is of note with respect to the change in peak velocities during the 1% AEP event in Smoky Creek:

- The predicted change in flood velocities in Smoky Creek Tributary is restricted to a small zone upstream and downstream of the Smoky Creek tributary haul road crossing. The impact zone does not extend more than 450 m upstream of the crossing and 320 m downstream. The maximum increase in velocity is around 0.49 m/s and maximum decrease is around 0.93 m/s. This local impact is associated with the change in channel geometry at the proposed haul road crossing.
- The predicted change in flood velocities in Smoky Creek is restricted to a 1.1 km zone upstream and downstream of the Smoky Creek haul road crossing. The impact zone does not extend more than 600 m upstream of the crossing and 500 m downstream. The maximum increase in velocity is around 0.5 m/s, and maximum decrease is around 0.63 m/s. This local impact is associated with the change in channel geometry at the proposed haul road crossing and the flood protection levee blocking flows into some backwater areas.

The following is of note with respect to the change in peak velocities during the 0.1% AEP event in Smoky Creek:

- The predicted change in flood velocities in Smoky Creek Tributary is restricted to a small zone upstream and downstream of the Smoky Creek tributary haul road crossing. The impact zone does not extend more than 280 m upstream of the crossing and 300 m downstream. The maximum increase in velocity is around 0.44 m/s and maximum decrease is around 0.85 m/s. This local impact is associated with the change in channel geometry at the proposed haul road crossing.
- The predicted change in flood velocities in Smoky Creek is restricted to a 2.1 km zone upstream and downstream of the Smoky Creek haul road crossing. The impact zone extends approximately 480 m outside of the ML boundary (upstream of the crossing) and approximately 400 m downstream of the haul road crossing. The maximum increase in velocity is around 0.59 m/s, and maximum decrease is around 0.73 m/s.

The impact of Smoky Creek haul road crossings on flow velocities will be taken into account during the detailed design of the crossings. Scour protection will be required at the haul road crossings, where necessary, to ensure that increased flow velocities do not cause erosion of the crossings.

8.3.3.2 Billy's Gully

The following is of note with respect to the change in peak velocities during the 1% AEP event in Billy's Gully:

- The predicted change in flood velocities at the Billy's Gully haul road crossing is restricted to a small zone upstream and downstream of the Smoky Creek tributary haul road crossing. The impact zone does not extend more than 240 m upstream of the crossing and 230 m downstream. The maximum increase in velocity is around 0.27 m/s and maximum decrease is around 0.25 m/s. This local impact is associated with the change in channel geometry at the proposed haul road crossing.

- The predicted change in flood velocities caused by the Pit 2 flood protection levee is restricted to an 800 m stretch of Billy's Gully adjacent to the levee. The impact zone does not extent outside the ML boundary and remains upstream of the haul road crossing. The maximum increase in velocity is around 0.65 m/s, and maximum decrease is around 0.32 m/s.

The following is of note with respect to the change in peak velocities during the 0.1% AEP event in Billy's Gully:

- The predicted change in flood velocities at the Billy's Gully haul road crossing is restricted to a small zone upstream and downstream of the Smoky Creek tributary haul road crossing. The impact zone does not extend more than 300 m upstream of the crossing and 300 m downstream. The maximum increase in velocity is around 0.29 m/s and maximum decrease is around 0.54 m/s. This local impact is associated with the change in channel geometry at the proposed haul road crossing.
- The predicted change in flood velocities caused by the Pit 2 flood protection levee is restricted to a 1.0 km stretch of Billy's Gully adjacent the levee. The impact zone extends approximately 150 m outside of the ML boundary, however this impact is a decrease of up to 0.07 m/s. The impact remains upstream of the haul road crossing. The maximum increase in velocity is around 0.30 m/s, and maximum decrease is around 0.78 m/s.

The impact of Billy's Gully haul road crossing on flow velocities will be taken into account during the detailed design of the crossings. Scour protection will be required at the haul road crossings, where necessary, to ensure that increased flow velocities do not cause erosion of the crossings.

8.3.4 Cumulative impacts with Isaac Plains Mine

The results from the hydraulic flood modelling show that any impacts associated with the project for the 1% AEP and 0.1% AEP are generally confined to small zones around the haul roads crossings and flood protection levees. These impacts dissipate well before reaching the Isaac Plains Mine area. On this basis, the existing mine and the project are not expected to have any cumulative impact on flood flows in Smoky Creek or Billy's Gully.

8.4 FLOOD PROTECTION LEVEE ASSESSMENT

The proposed flood protection levees will be regulated structures designed with a crest level above the 0.1% AEP design event. Each temporary flood protection levee would be installed progressively and in advance of the open cut mining operational areas it would protect.

The model results show that the proposed levee alignment and extent will prevent the inundation of the open cut pit throughout the life of the project to the required design standard. Detailed design plans of the proposed levee together with a consequence assessment and certification by a suitably qualified and experienced person(s) will be prepared prior to commencement of construction of the levee for assessment and approval by the administering authority.

During the detailed design phase, the model results will be used to identify potential locations of high flow velocity and scour potential. This information will be used to inform the appropriate level of scour protection along the proposed levees.

The proposed drainage plugs at Pit 1 are unlikely to be required to be regulated structures as there is no risk of water entering the pit. The maximum 0.1% water depths at the Pit 1 drainage plugs (from northeast to southwest) are approximately 0.5 m, 2.3 m and 1.6 m.

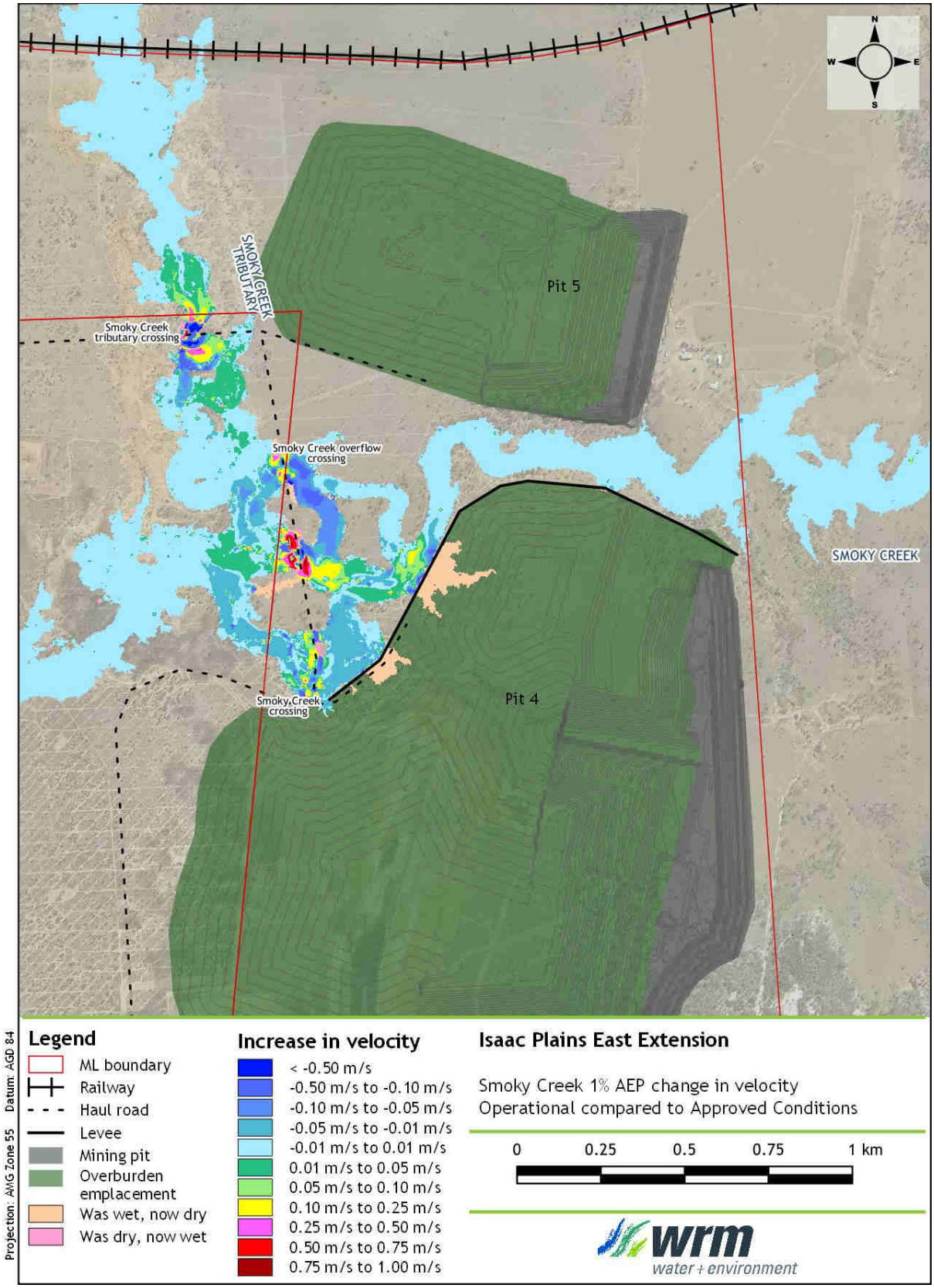

Figure 8.21 – Change in 1% AEP peak velocities in Smoky Creek, Operational Conditions compared to Approved Conditions

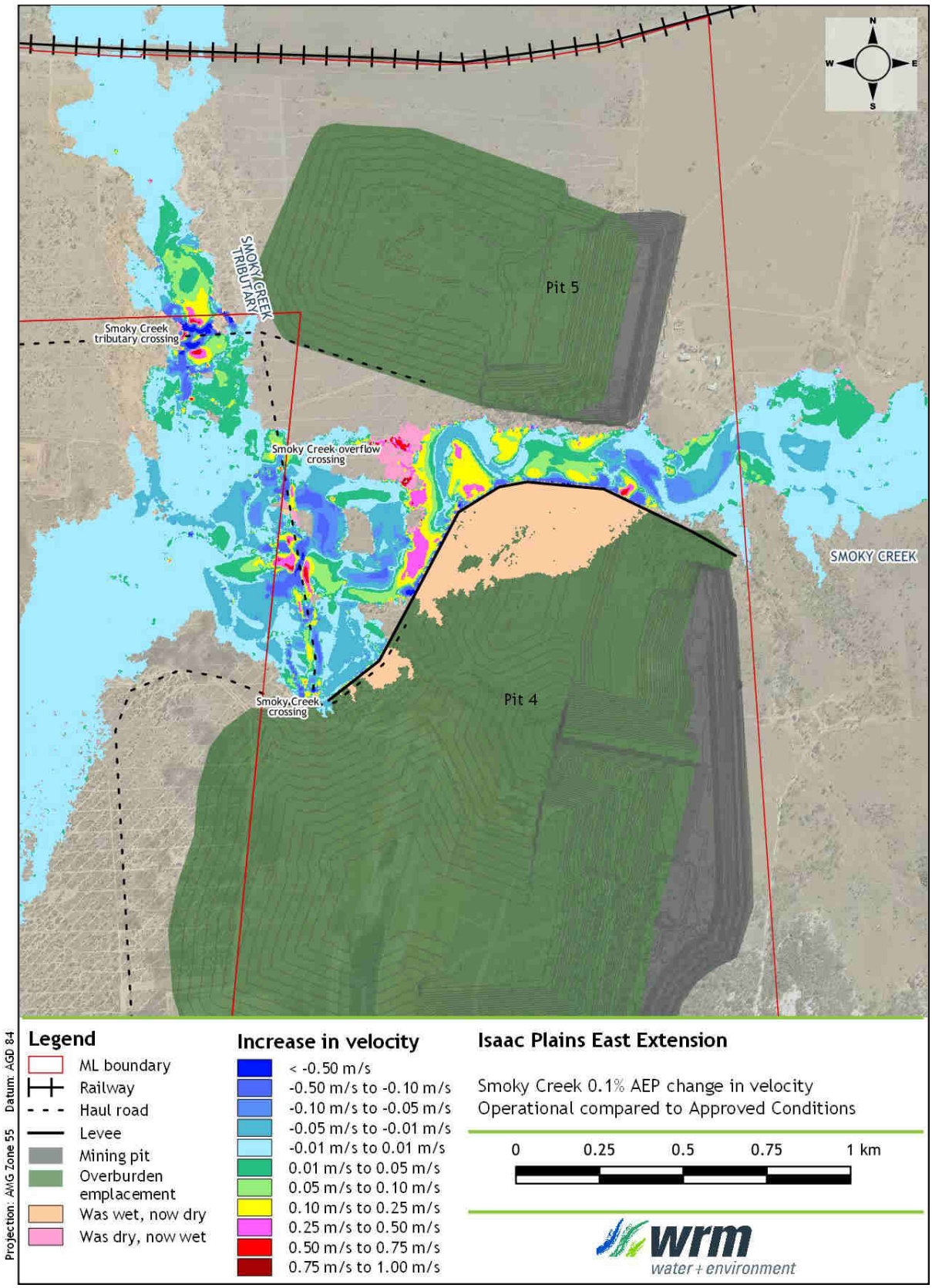

Figure 8.22 – Change in 0.1% AEP peak velocities in Smoky Creek, Operational Conditions compared to Approved Conditions

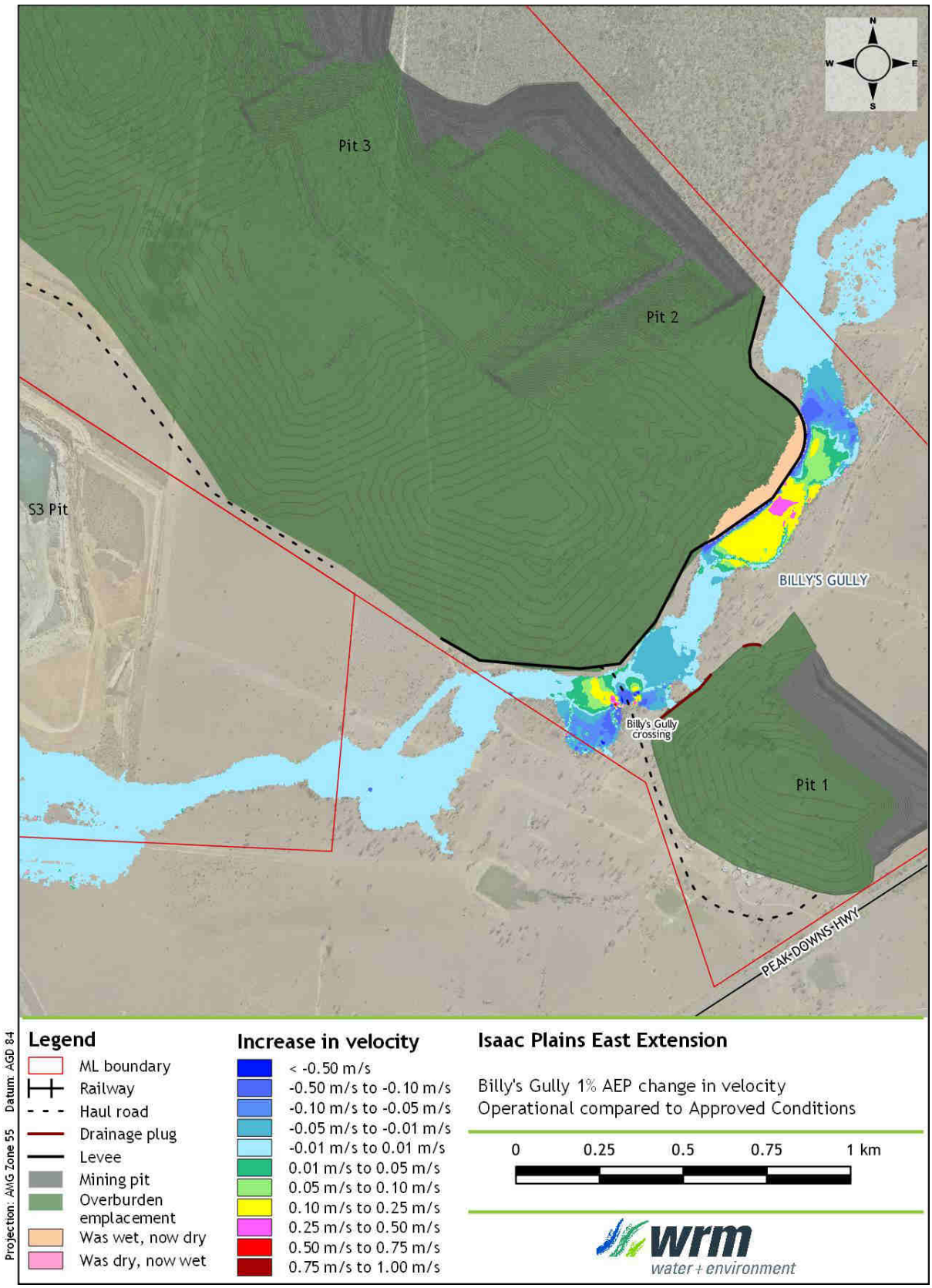

Figure 8.23 – Change in 1% AEP peak velocities in Billy's Gully, Operational Conditions compared to Approved Conditions

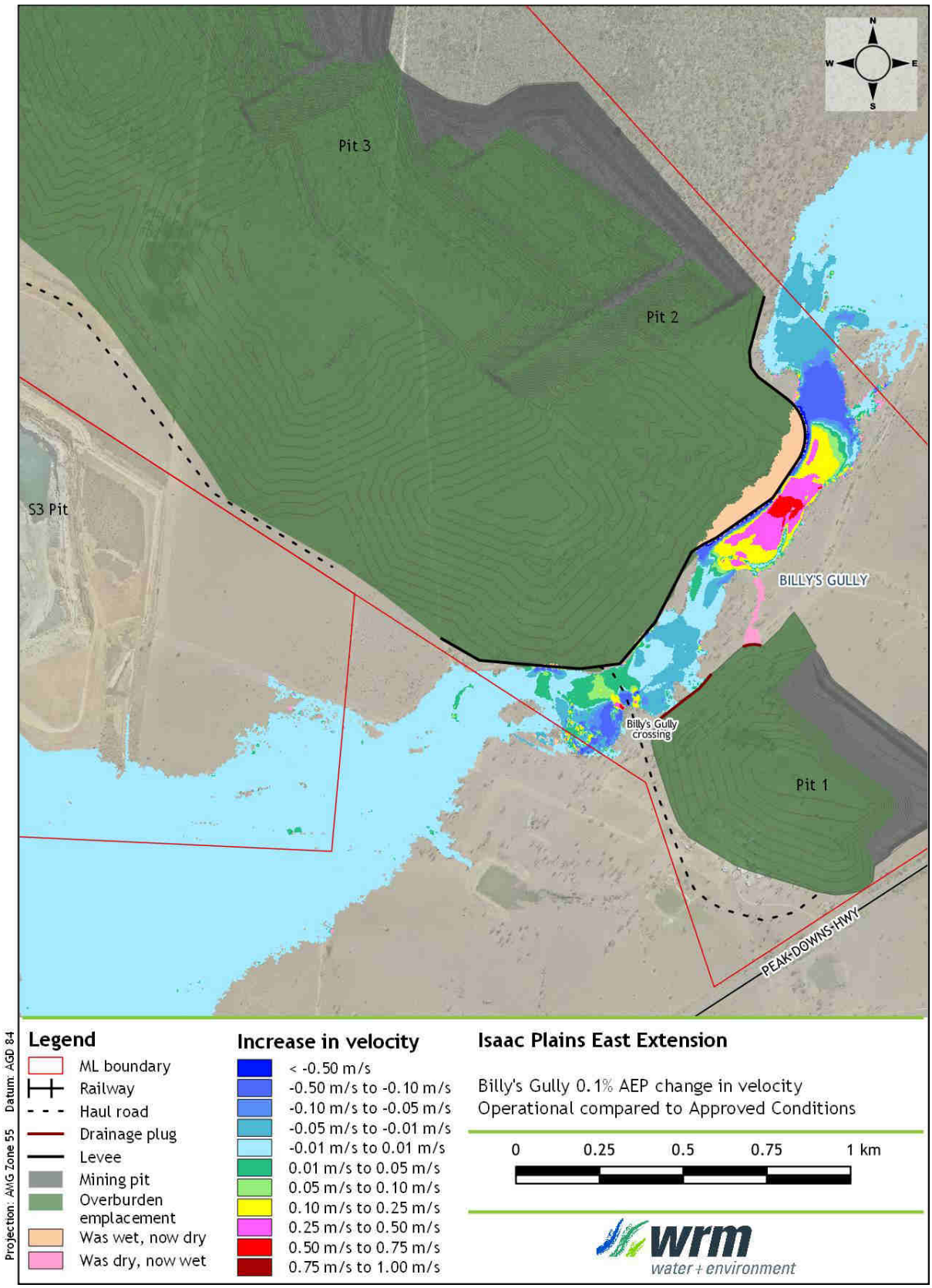

Figure 8.24 – Change in 0.1% AEP peak velocities in Billy's Gully, Operational Conditions compared to Approved Conditions

8.5 POST-MINING CONDITIONS FLOODING

The Smoky Creek, Smoky Creek Tributary and Billy's Gully haul road crossings will be removed and returned to pre-mining conditions as part of the final landform. Therefore, these structures have been removed from the Post-mining Conditions TUFLOW model. The flood protection levees have also been removed from the Post-mining Conditions TUFLOW model, as they will be integrated into the rehabilitated final landform of the overburden emplacement.

8.5.1 Flood depths, extent and velocity

Figure 8.25 and Figure 8.26 show the Post-mining Conditions extent and depth of flooding in Smoky Creek and Billy's Gully for the 0.1% AEP design event. The peak flood velocities are shown in Figure 8.27 and Figure 8.28. The following is of note with respect to the 0.1% AEP event:

- Smoky Creek (stream order 4)
  - The Smoky Creek 0.1% AEP inundation extent lies outside of the proposed Pit 4 and Pit 5 final voids.
- Billy's Gully (stream order 3)
  - The Billy's Gully 0.1% AEP inundation extent lies outside of the proposed Pit 2 final void.

The modelling results demonstrate the final voids would not be inundated in the post-mining phase.

Whilst the peak flood velocities are not considered excessive, appropriate scour protection measures will be considered as part of the final landform design process.

8.5.2 Impact of the final landform on peak flood levels and velocities

The Post-mining Conditions peak flood levels and velocities have been compared to the Approved Conditions predicted peak flood levels and velocities.

Figure 8.29 and Figure 8.30 show the predicted changes in peak flood levels along Smoky Creek and Billy's Gully due to the final landform for the 0.1% AEP events. Figure 8.31 and Figure 8.32 show the predicted changes in peak velocities. The following is of note:

- Smoky Creek
  - The impacts associated with the project's final landform are generally confined to small zones around the removed haul roads crossings (as the Approved Conditions included crossings at Smoky Creek Tributary) and around the Pit 4 landform. These impacts dissipate well before reaching the Isaac Plains Mine area and are not expected to have any cumulative impact on flood flows in Smoky Creek.
  - The increase in flood level in Smoky Creek from the Pit 4 landform, extend approximately 475 m outside the ML boundary. The maximum increase in flood level outside the ML boundary is approximately 0.06 m.
- Billy's Gully
  - The impacts associated with the project's final landform are generally confined to small zones around the removed haul roads crossings (as the Approved Conditions included a crossing on Billy's Gully) and around the Pit 2 landform. These impacts dissipate well before reaching the Isaac Plains Mine area and are not expected to have any cumulative impact on flood flows in Billy's Gully.
  - The increase in flood level extends from the Pit 2 landform approximately 20 m outside the ML boundary. The maximum increase in flood level outside the ML boundary is approximately 0.03 m.

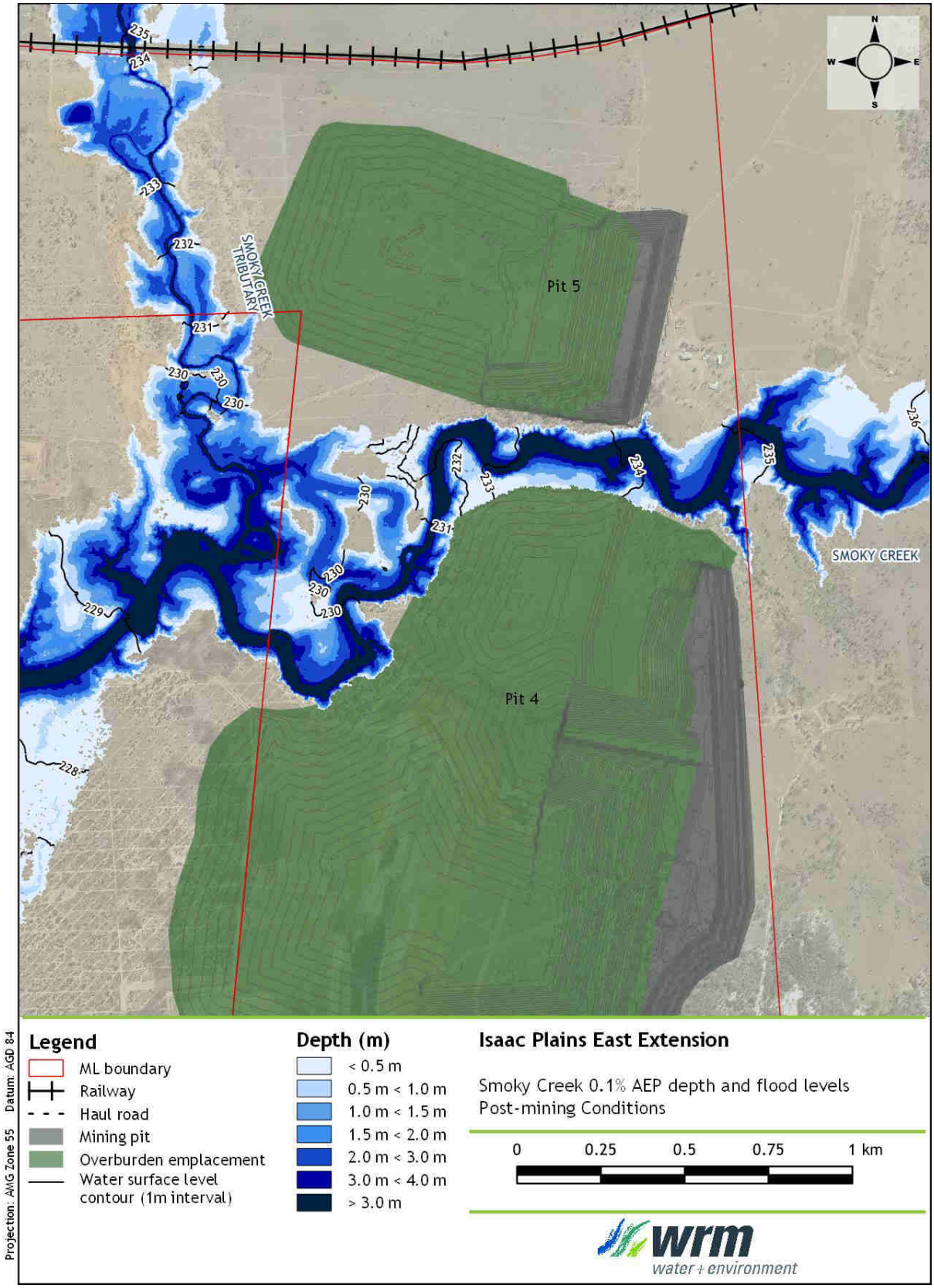

Figure 8.25 – 0.1% AEP peak depth and flood levels in Smoky Creek, Post-mining Conditions

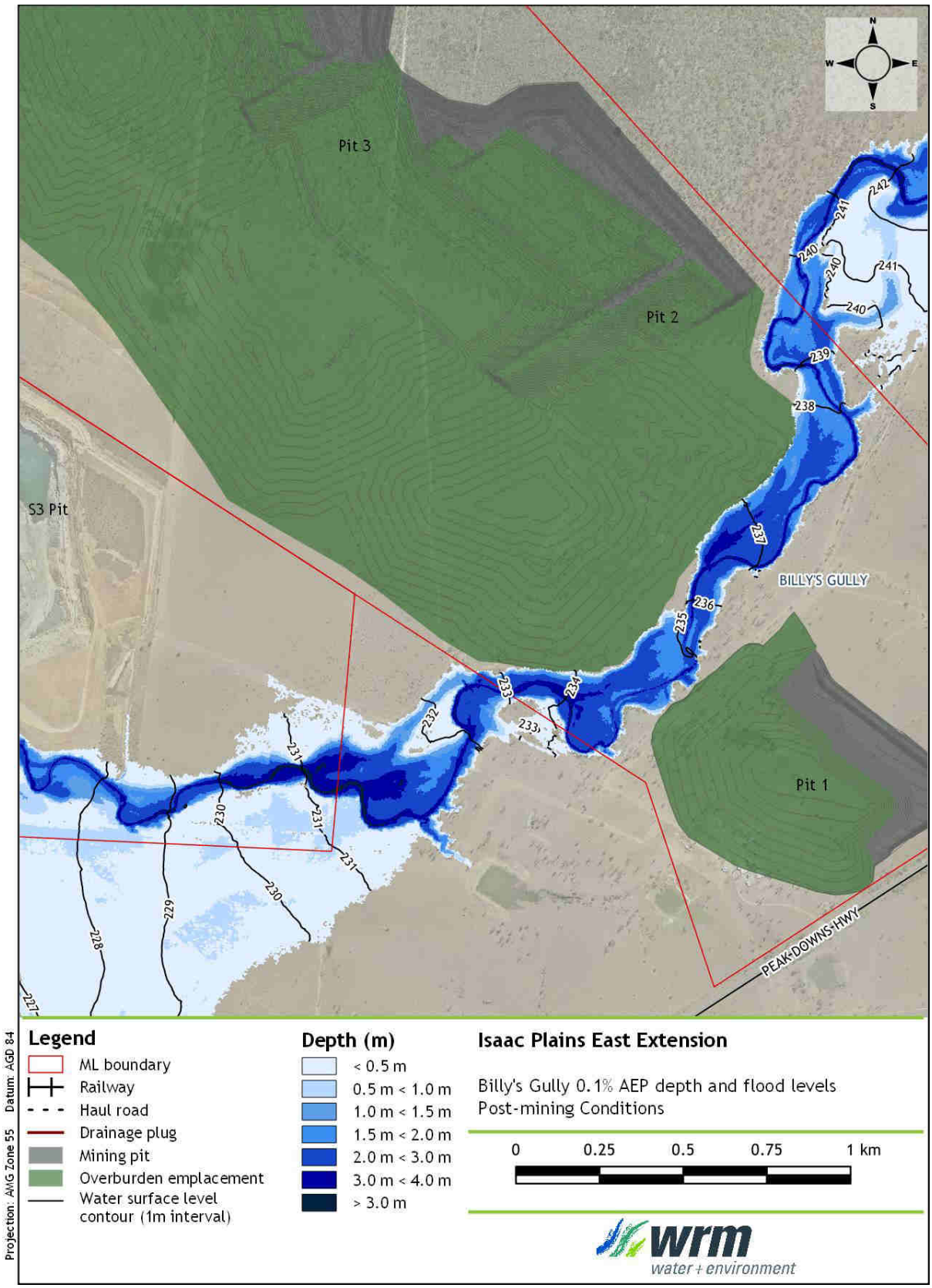

Figure 8.26 – 0.1% AEP peak depth and flood levels in Billy's Gully, Post-mining Conditions

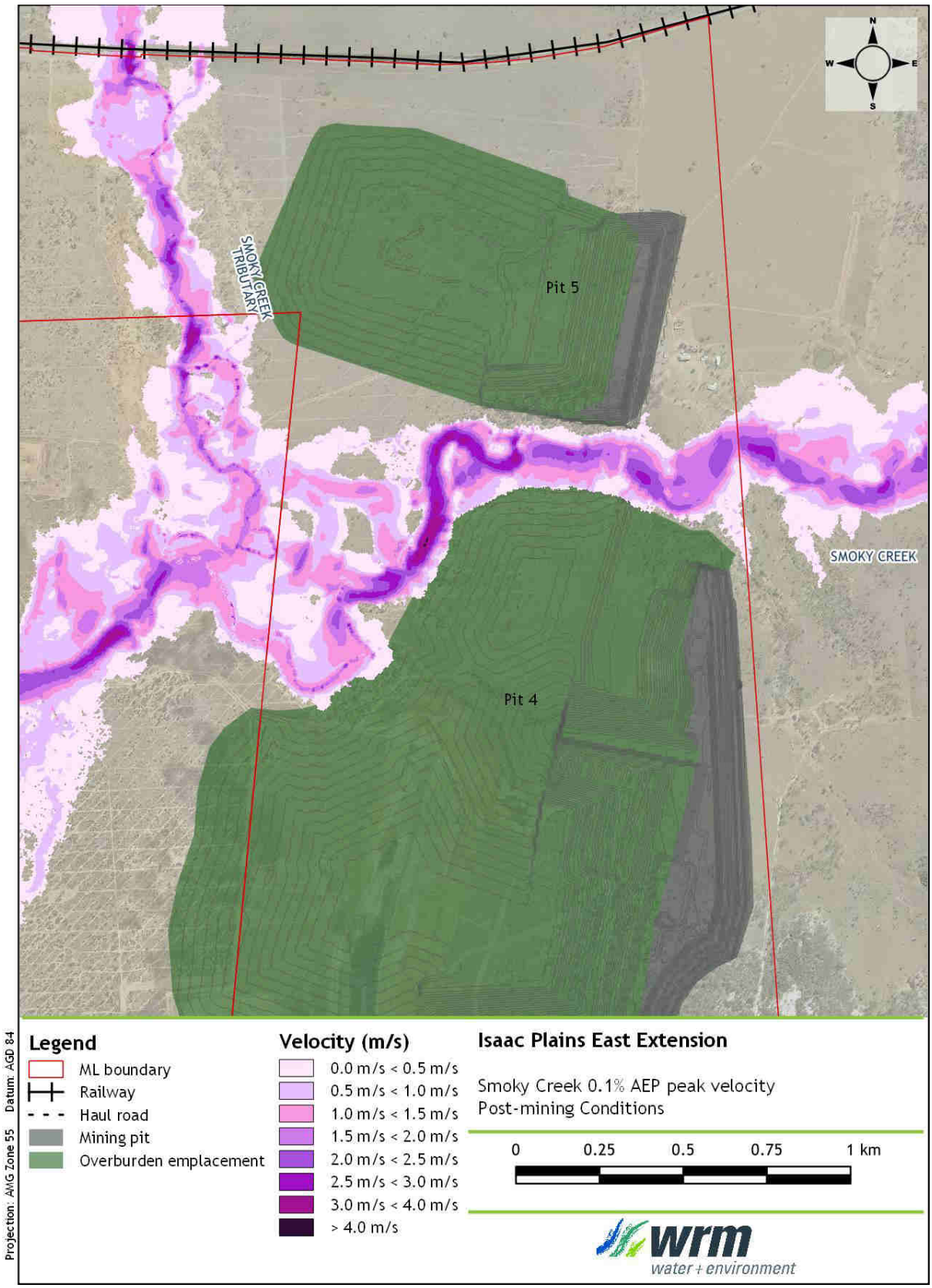

Figure 8.27 – 0.1% AEP peak velocities in Smoky Creek, Post-mining Conditions

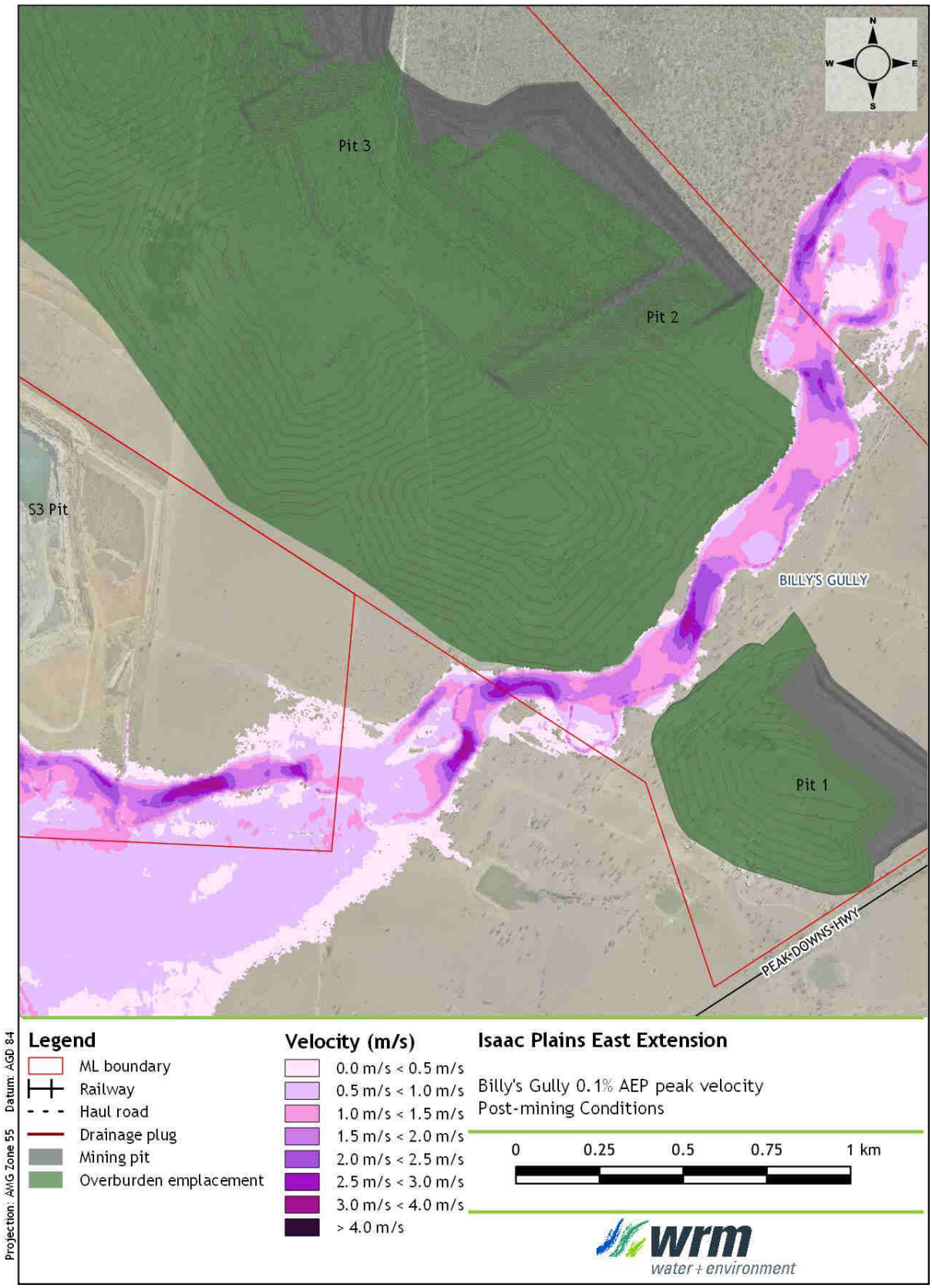

Figure 8.28 – 0.1% AEP peak velocities in Billy's Gully, Post-mining Conditions

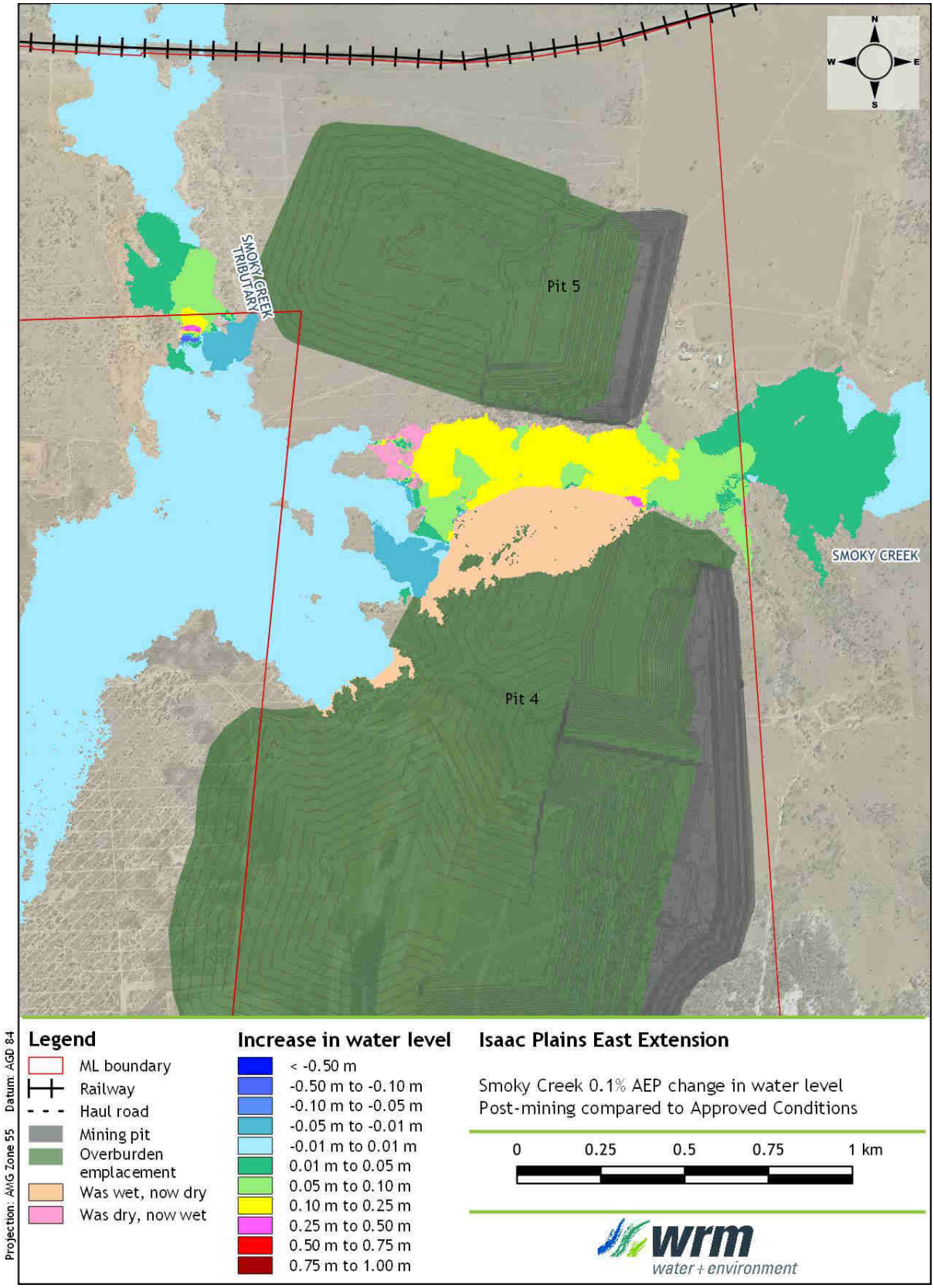

Figure 8.29 – Change in 0.1% AEP water levels in Smoky Creek, Post-mining Conditions compared to Approved Conditions

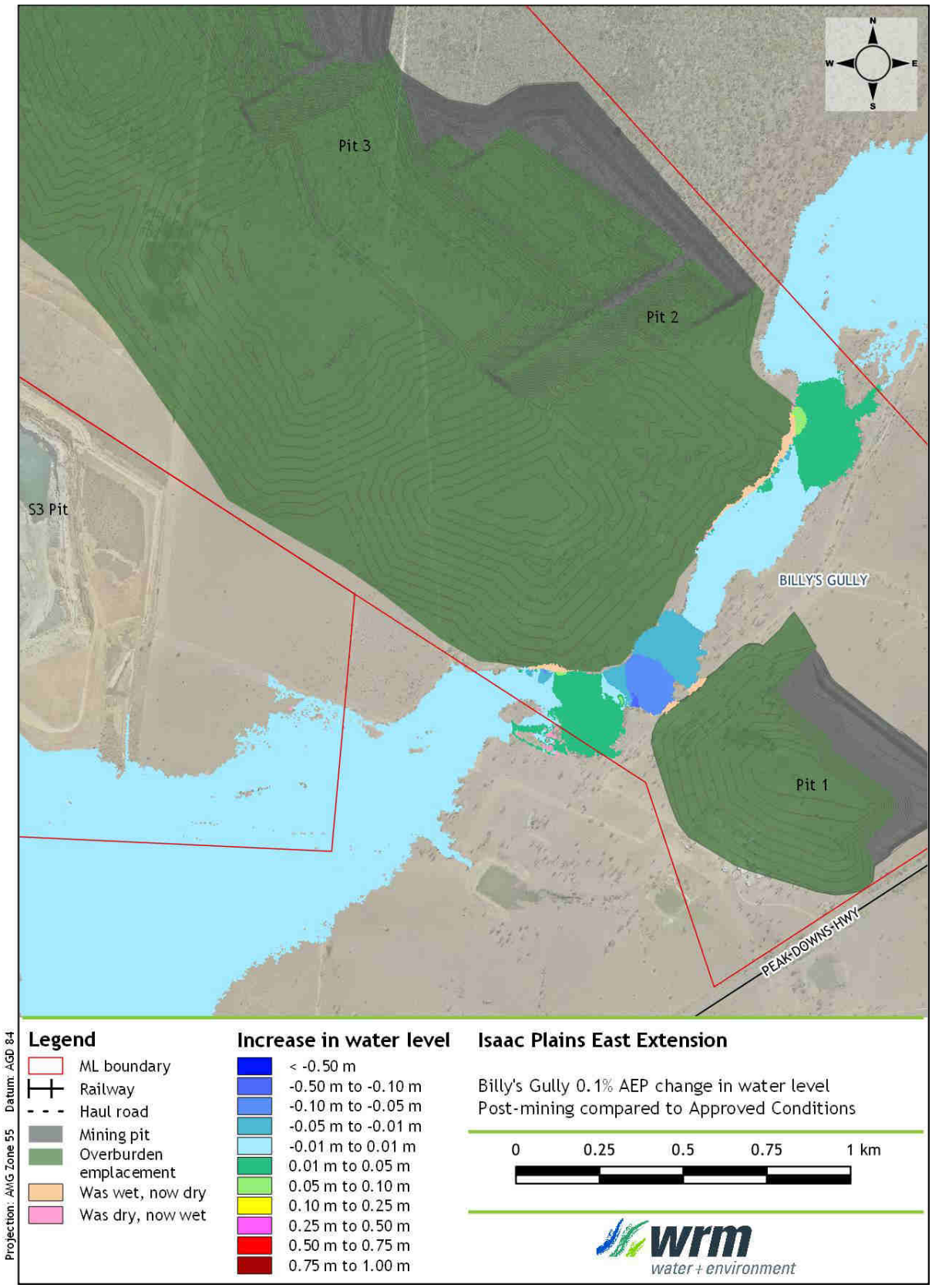

Figure 8.30 – Change in 0.1% AEP water levels in Billy's Gully, Post-mining Conditions compared to Approved Conditions

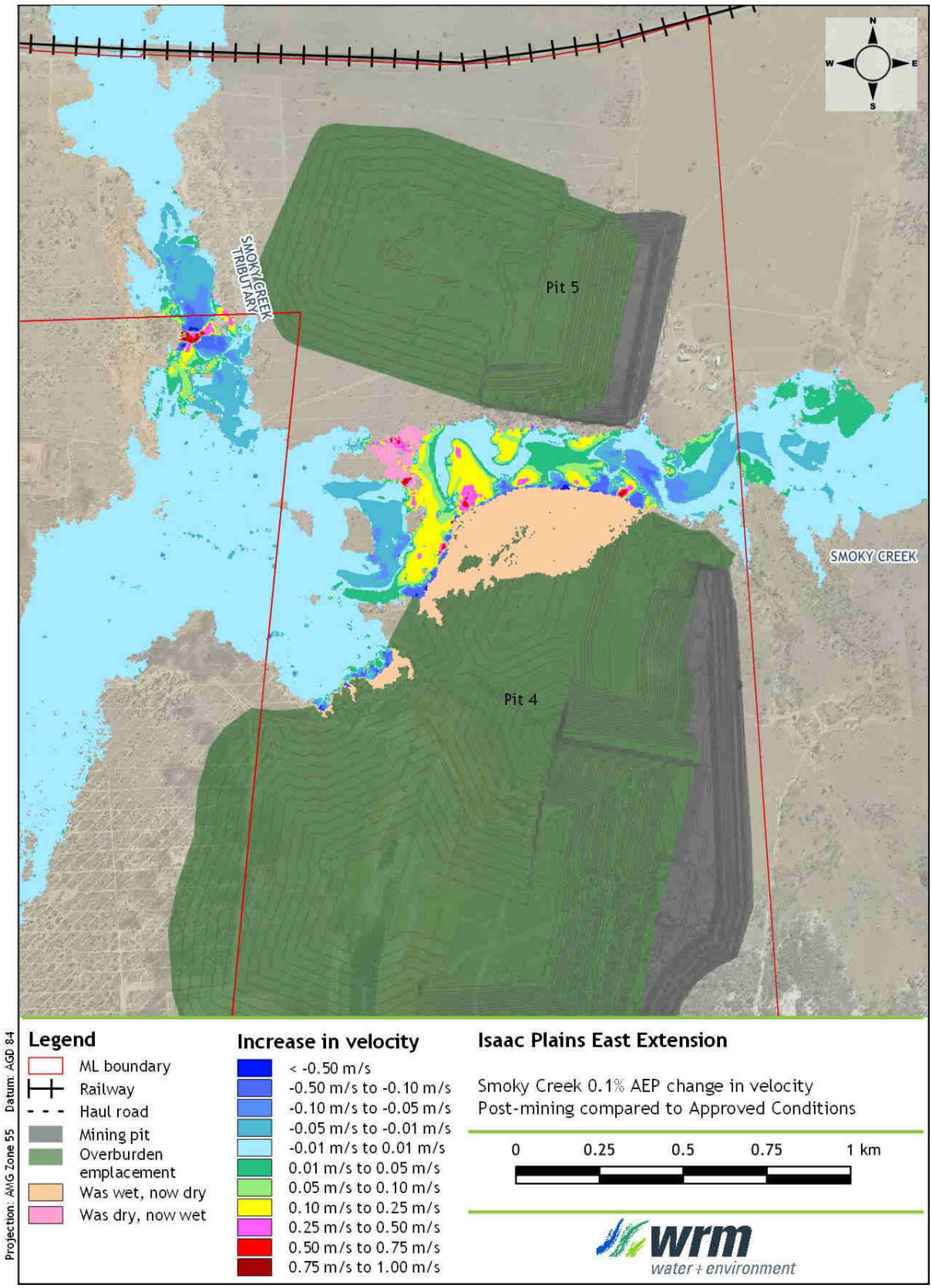

Figure 8.31 – Change in 0.1% AEP peak velocities in Smoky Creek, Post-mining Conditions compared to Approved Conditions

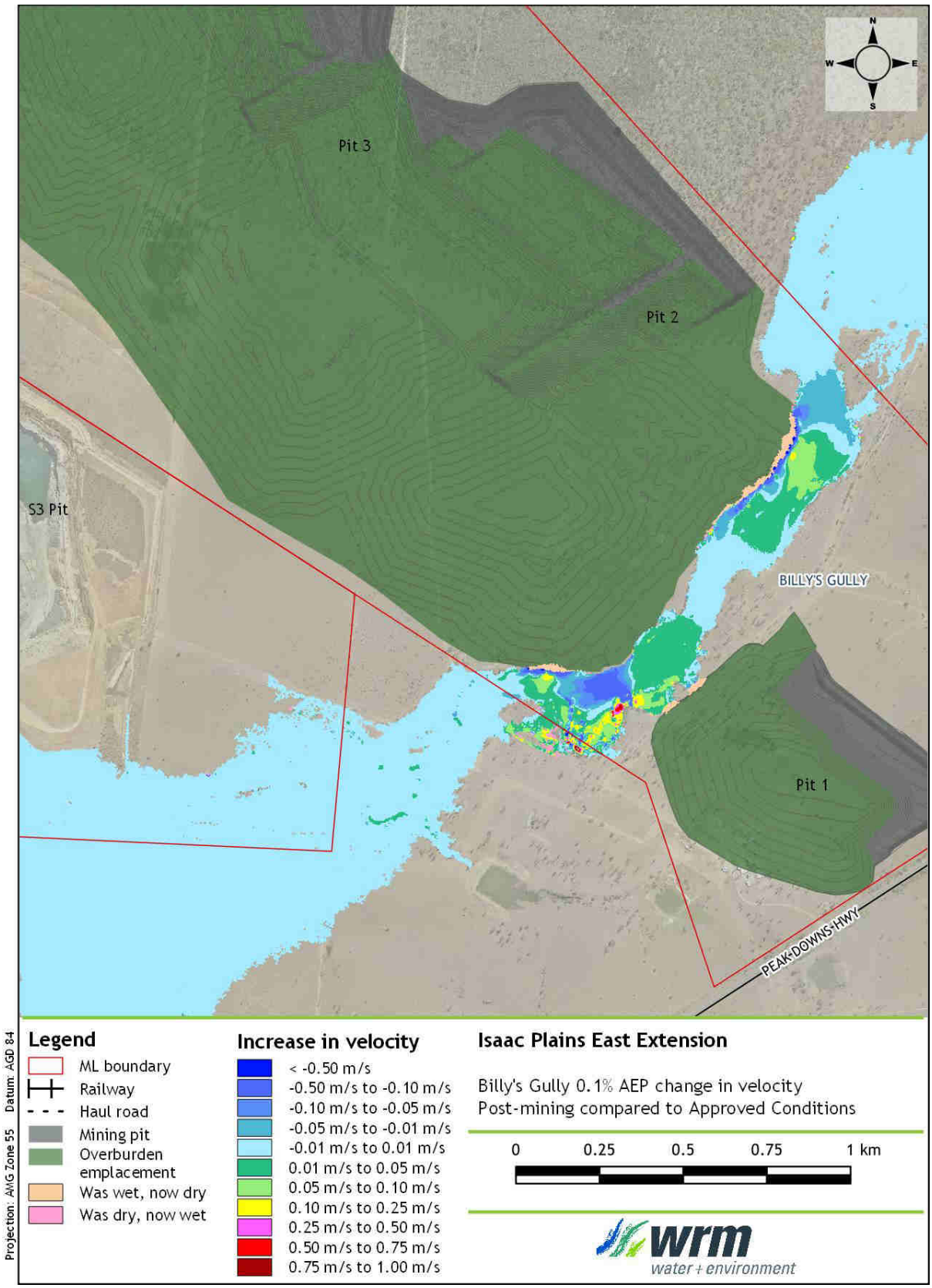

Figure 8.32 – Change in 0.1% AEP peak velocities in Billy's Gully, Post-mining Conditions compared to Approved Conditions

9 Final void behaviour

9.1 OVERVIEW

Water levels in the final voids will vary over time, depending on the prevailing climatic conditions, and the balance between evaporation losses and inflows from rainfall, surface runoff, and groundwater. A GOLDSIM model (separate to the OPSIM model used for the operational modelling) was used to assess the likely long-term water level behaviour of the final voids. The historical rainfall and evaporation sequences (130 years) were repeated 5 times to create an indicative long-term climate record.

The volume of water in the voids is calculated at each time step as the sum of direct rainfall to the water surface, catchment runoff and groundwater inflows, less evaporation losses.

A depth varying storage evaporation factor has been applied to each void to simulate the change in evaporation as void water levels increase. The storage evaporation factors are as follows:

- Bottom of void – 0.7
- Top of void – 1.0

9.2 FINAL VOID CONFIGURATION

The proposed final landform consists of three final voids at IPE and two final voids at IPM, with their associated rehabilitated overburden emplacement areas. Smoky Creek drains between Pit 4 and Pit 5 in the northern section of the project site. Billy's Gully drains to the south of Pit 2 in the southern section of the project site.

The final void configuration and contributing catchment areas are shown in Figure 9.1 and summarised in Table 9.1. The final catchment draining to the voids will be minimised using up-catchment diversions.

Table 9.1 – Contributing catchment to final voids

Final void	Contributing catchment area (ha)				Baseflow only catchment (ha)
	Mining pit	Rehabilitated landform	Unrehabilitated spoil	Total	
Pit 2 and 3	17.8	46.2	24.6	88.7	48.7
Pit 4	50.1	145.9	39.9	236.0	40.9
Pit 5	8.3	17.6	13.6	39.5	-
N1 Pit	54.4	200.4	50.4	305.3	38.8
S2 Pit	27.8	47.7	29.6	105.1	30.0

9.2.1 Stage-storage characteristic

The stage-storage curve for the final voids have been estimated from the final landform terrain model provided by Stanmore. Note that the volume in N1 Pit was decreased to provide volume for a tailing deposits cell of approximately 600 ML, plus a 2 m capping layer of the tailings.

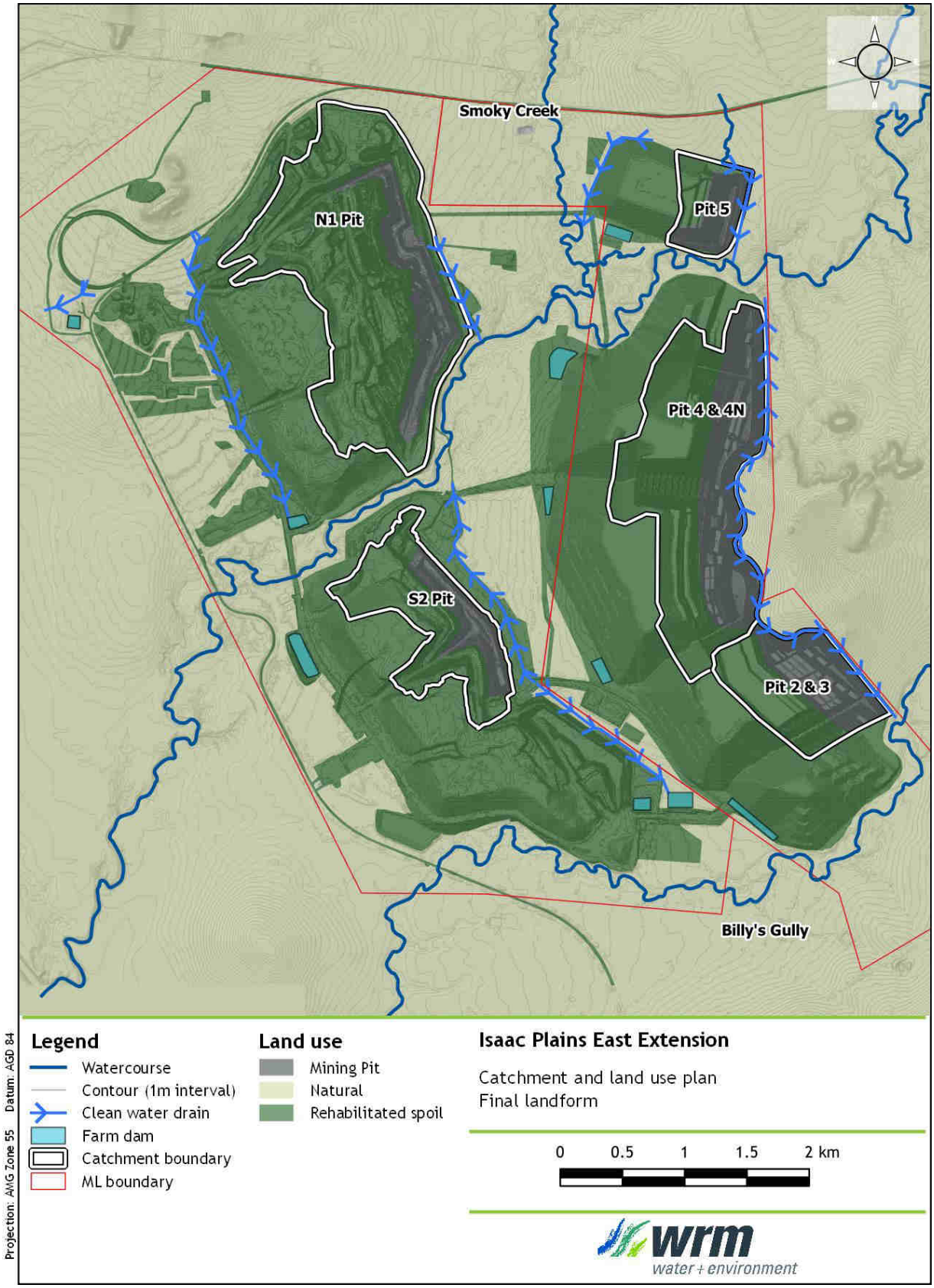

Figure 9.1 - Final void catchment plan

The geometries of the final voids are summarised in Table 9.2.

Table 9.2 - Modelled final void geometry

Final void	Depth (m)	Pit void overflow level/volume
Pit 2 and 3	95	237 mAHD / 17,353 ML
Pit 4	116	230 mAHD / 45,097 ML
Pit 5	76	231 mAHD / 6,634 ML
N1 Pit	76	225 mAHD / 22,577 ML
S2 Pit	77	227 mAHD / 15,582 ML

9.3 RUNOFF SALINITY

The adopted salinity concentrations for the final void catchment are as follows:

- Mining pit: 6,000 µs/cm;
- Unrehabilitated spoil: 1,000 µs/cm
- Rehabilitated landform (surface): 850 µs/cm
- Rehabilitated landform (baseflow): 15,000 µs/cm

The adopted runoff salinity for the final void assessment is applied at a fixed concentration and does not include any allowance for decay in runoff salinity over time.

9.4 GROUNDWATER INFLOW

Groundwater inflows to the final voids were provided by KCB from the groundwater impact assessment for the IPEE project. For N1 Pit and S2 Pit, the groundwater inflows been set to zero. This was based on based on recent site observations and advice from KCB that minimal groundwater inflow into the IPM pits would occur as the regional hydraulic gradient will be towards IPE pits.

Figure 9.2 shows the void water level versus groundwater inflow rates for the IPE final voids. The IPE groundwater inflows have been distributed between the IPE final voids according to their highwall length, as follows:

- Pit 2 and 3: 30%
- Pit 4: 56%
- Pit 5: 14%

The salinity of groundwater inflows has been set at 15,850 µs/cm based on information in the groundwater assessment (KCB, 2019) and advice from KCB (email 17/07/2019).

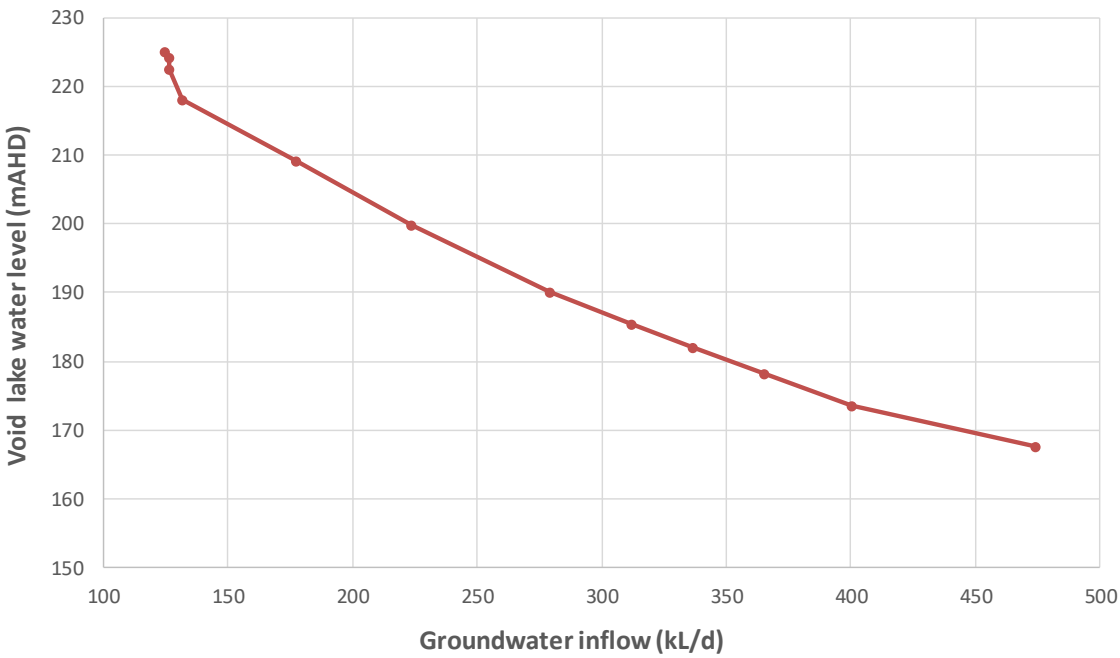

Figure 9.2 - IPE final voids - groundwater inflow recovery curve

9.5 GROUNDWATER SOURCE/SINK THRESHOLD LEVELS

For each void, there is a level that represents the point at which groundwater inflows would cease, and stored void water would potentially begin to leave the void and interact with the surrounding groundwater system. This has been referred to as the groundwater source/sink threshold level. These levels have been provided by KCB, and are as follows:

- N1 void: 215.0 mAHD
- S2 void: 214.1 mAHD
- Pit 2/3 void: 227.7 mAHD
- Pit 4 void: 225.6 mAHD
- Pit 5 void: 228.5 mAHD

9.6 MODELLED LONG-TERM WATER LEVELS

Figure 9.3 to Figure 9.7 show the simulated long-term water levels in the final voids, compared against the groundwater sink/source threshold levels and full supply levels

The model results show the following:

- Pit 2 & 3 (Figure 9.3):
  - The water level reaches equilibrium between 175 mAHD and 190 mAHD after 100 years and generally remains at these levels throughout the remainder of the simulation.
  - The maximum modelled water level is around 37 m below the source/sink threshold level (227.7 mAHD), and around 46 m below the full supply level (237 mAHD).
- Pit 4 (Figure 9.4):
  - The water level reaches equilibrium between 155 mAHD and 170 mAHD after 100 years and generally remains at these levels throughout the remainder of the simulation.

- The maximum modelled water level is around 48 m below the source/sink threshold level (225.6 mAHD), and around 52 m below the full supply level (230 mAHD).

- Pit 5 void (Figure 9.5):
  - The water level reaches equilibrium between 170 mAHD and 180 mAHD after 100 years and generally remains at these levels throughout the remainder of the simulation.
  - The maximum modelled water level is around 44 m below the source/sink threshold level (228.5 mAHD), and around 47 m below the full supply level (231 mAHD).
- N1 Pit void (Figure 9.6):
  - The water level reaches equilibrium between 170 mAHD and 185 mAHD after 100 years and generally remains at these levels throughout the remainder of the simulation.
  - The maximum modelled water level is around 13 m below the source/sink threshold level (215.0 mAHD), and around 23 m below the full supply level (225 mAHD).
- S2 Pit void (Figure 9.7):
  - The water level reaches equilibrium between 155 mAHD and 170 mAHD after 100 years and generally remains at these levels throughout the remainder of the simulation.
  - The maximum modelled water level is around 45 m below the source/sink threshold level (214.1 mAHD), and around 58 m below the full supply level (227 mAHD).

The final void water balance modelling results show that all five of the final voids at IPM and IPE will remain as groundwater sinks over the long term.

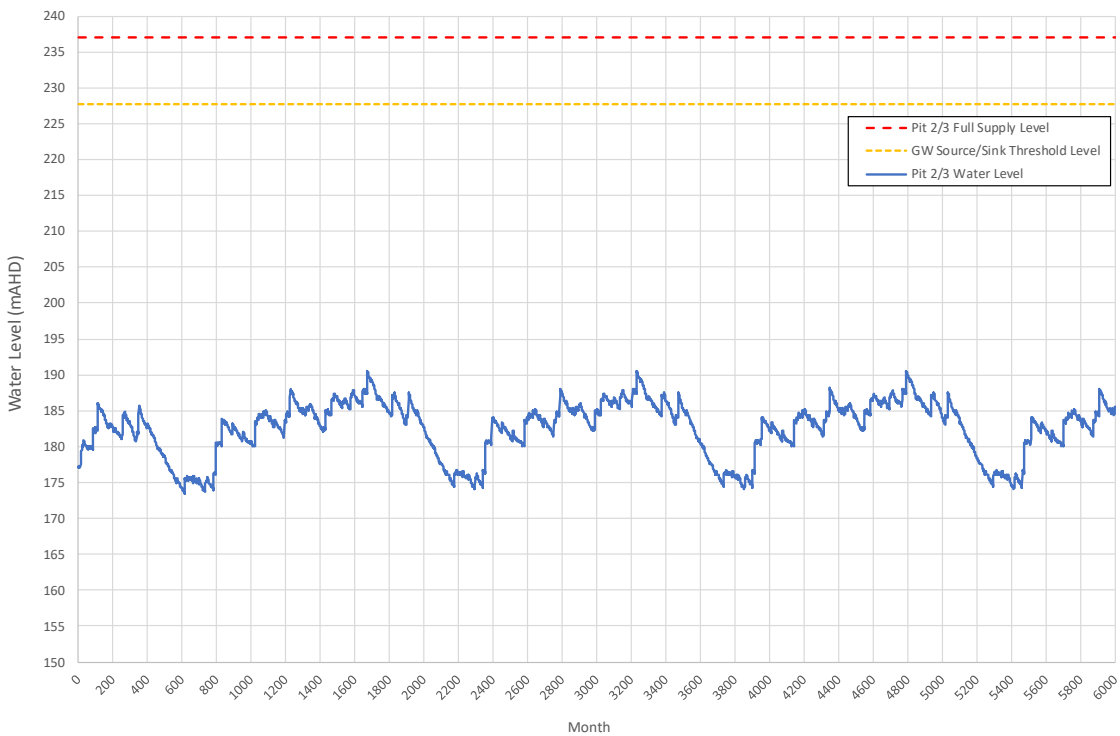

Figure 9.3 - Final void water levels, Pit 2 & 3

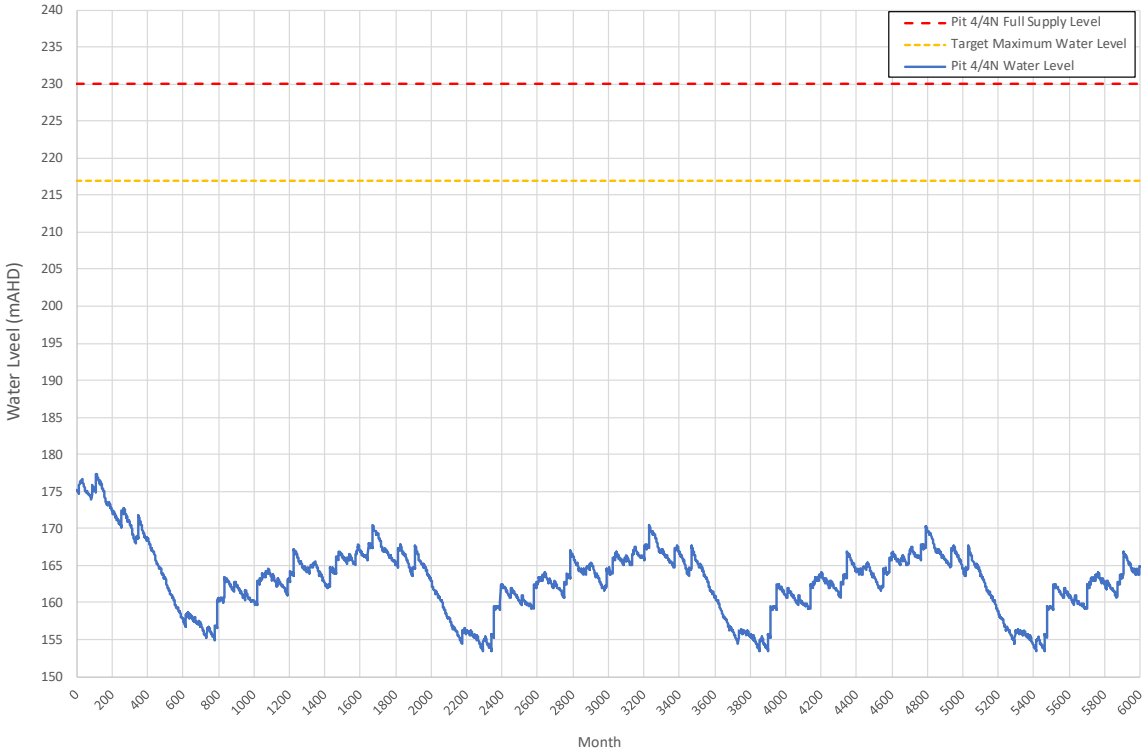

Figure 9.4 - Final void water levels, Pit 4

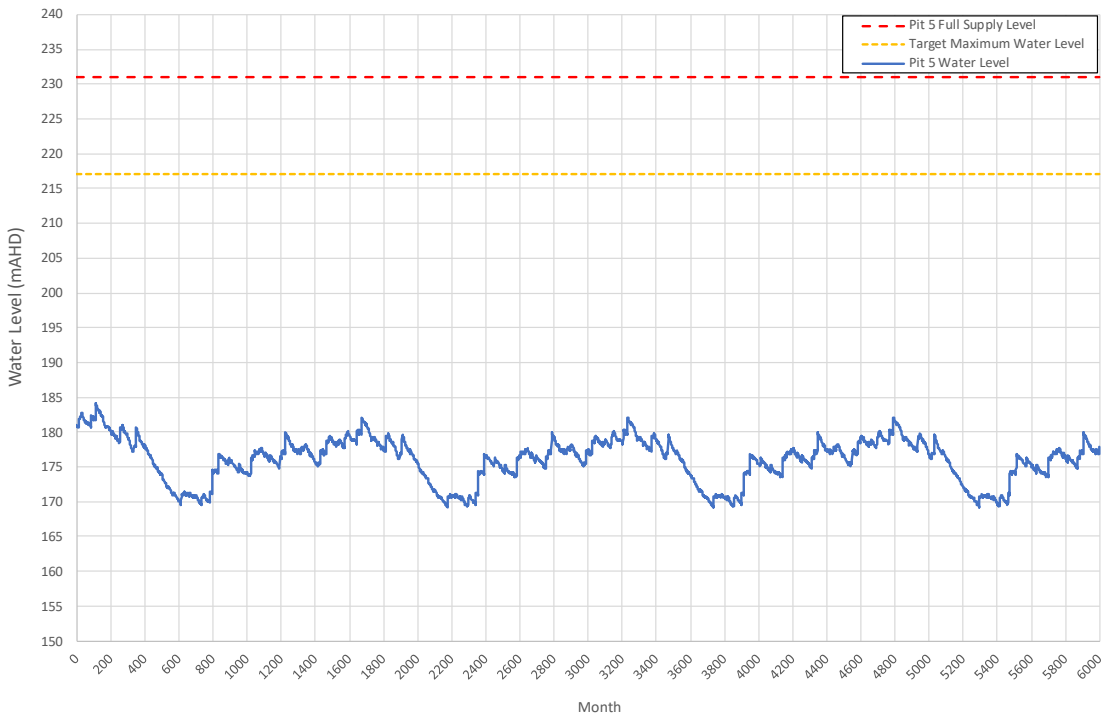

Figure 9.5 - Final void water levels, Pit 5

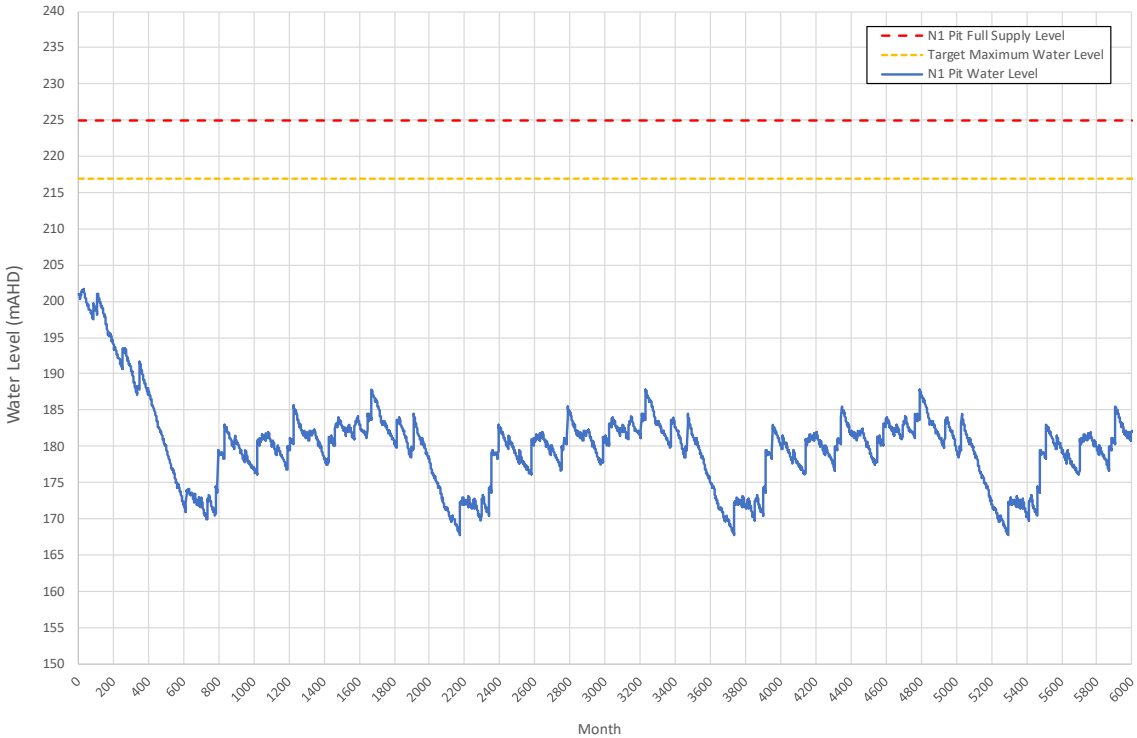

Figure 9.6 - Final void water levels, N1 Pit

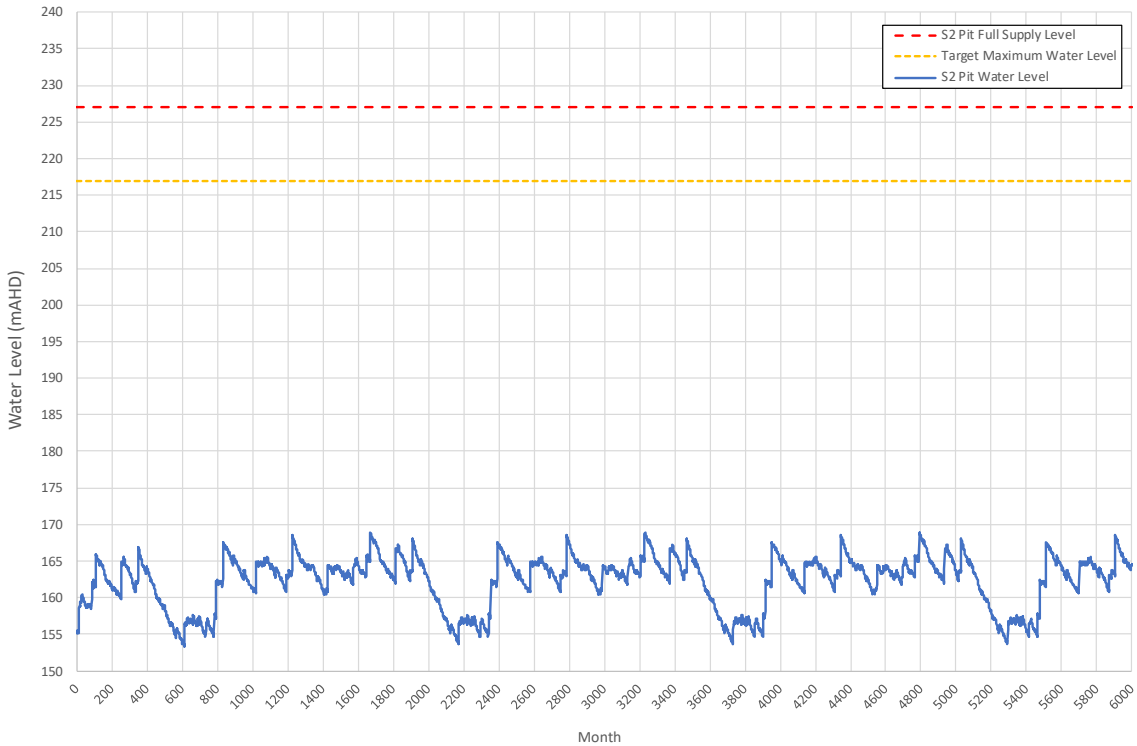

Figure 9.7 - Final void water levels, S2 Pit

9.7 MODELLED LONG-TERM SALINITY

Figure 9.8 to Figure 9.12 show the simulated long-term water salt load and concentrations in the final voids. The results have been modified to cap the maximum EC to 550,000 µs/cm, which is the maximum solubility of NaCl in water at 25 degrees Celsius.

The model results show the following:

- Pit 2 & 3 (Figure 9.8):
  - Salt accumulates within the Pit 2 & 3 void at an average rate of around 645 tonnes per year.
  - The void becomes hyper-saline (>53,850 µs/cm) after around 60 years of simulation.
- Pit 4 (Figure 9.9):
  - Salt accumulates within the Pit 4 void at an average rate of around 1,445 tonnes per year.
  - The void becomes hyper-saline (>53,850 µs/cm) after around 60 years of simulation.
- Pit 5 (Figure 9.10):
  - Salt accumulates within the Pit 5 void at an average rate of around 230 tonnes per year.
  - The void becomes hyper-saline (>53,850 µs/cm) after around 40 years of simulation.
- N1 Pit (Figure 9.11):
  - Salt accumulates within the N1 Pit void at an average rate of around 220 tonnes per year.
  - The void becomes hyper-saline (>53,850 µs/cm) after around 40 years of simulation.
- S2 Pit (Figure 9.12):
  - Salt accumulates within the S2 Pit void at an average rate of around 375 tonnes per year.
  - The void becomes hyper-saline (>53,850 µs/cm) after around 40 years of simulation.

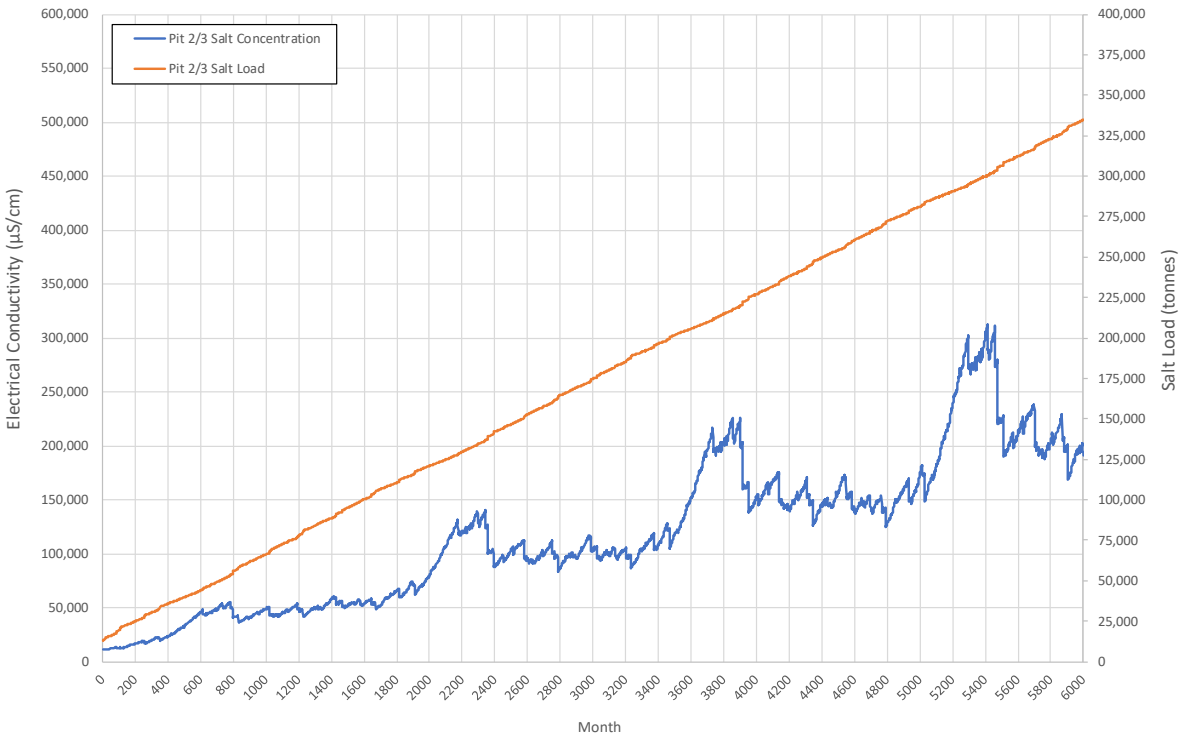

Figure 9.8 - Final void salt load and concentration, Pit 2 & 3

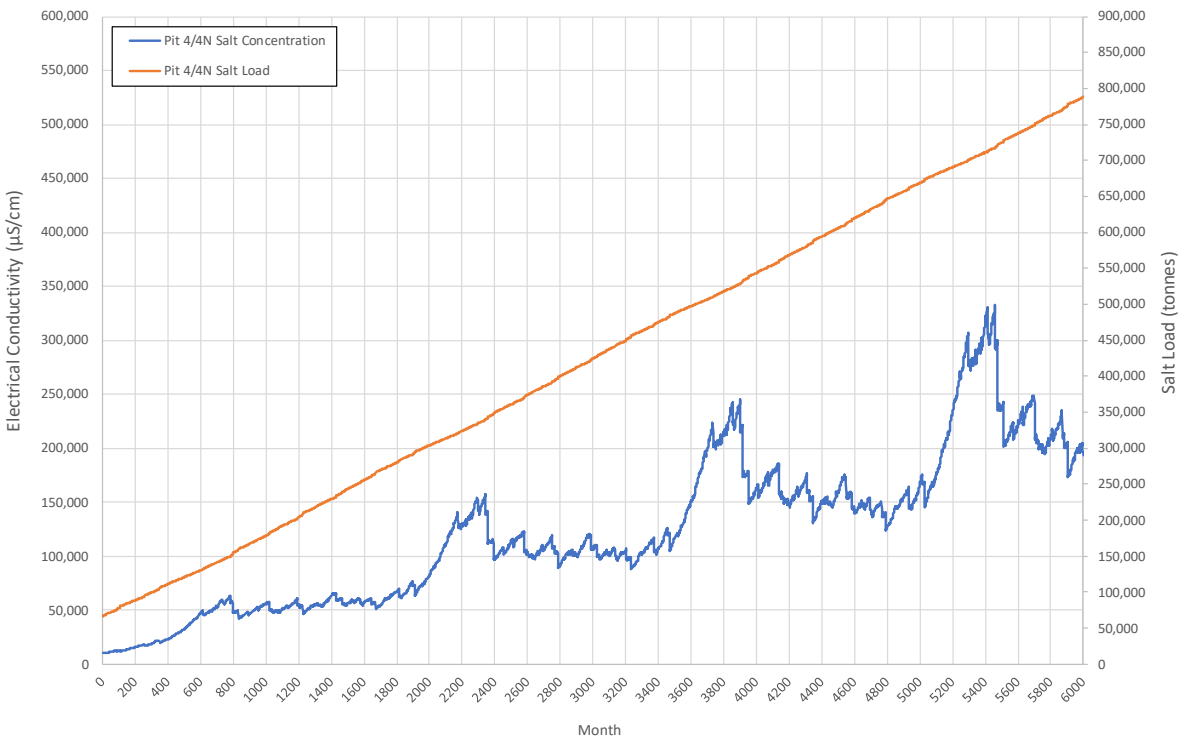

Figure 9.9 - Final void salt load and concentration, Pit 4

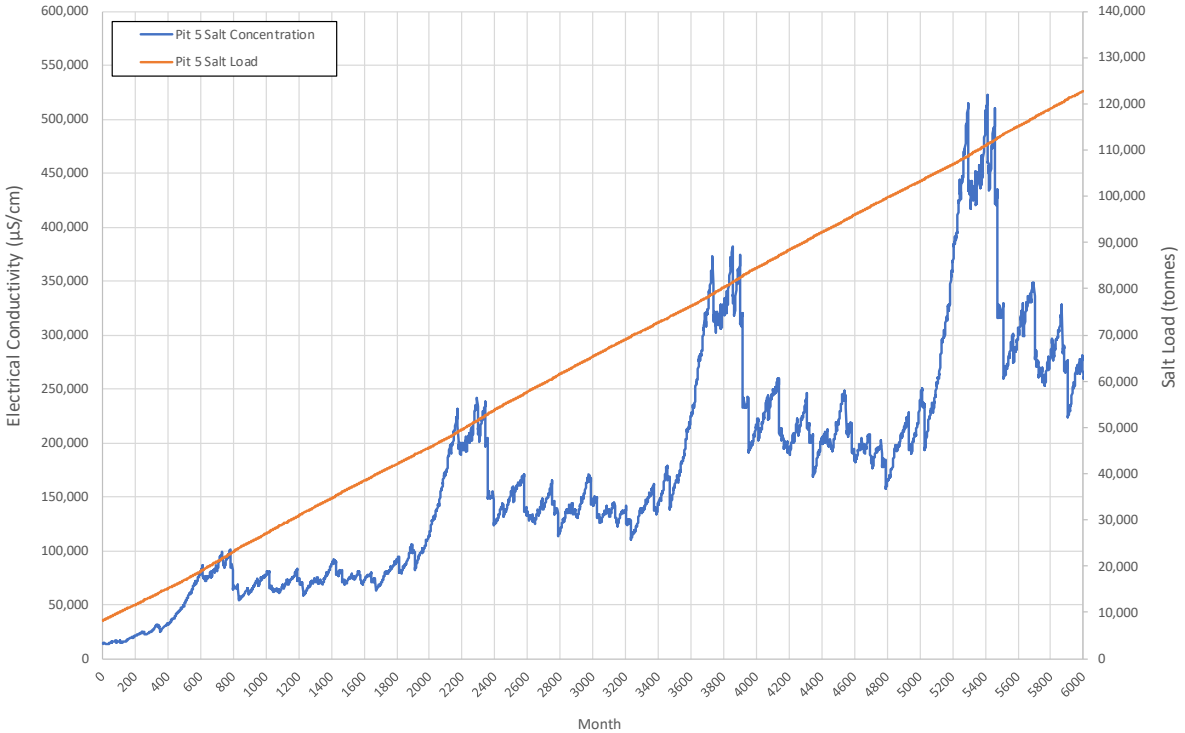

Figure 9.10 - Final void water levels, Pit 5

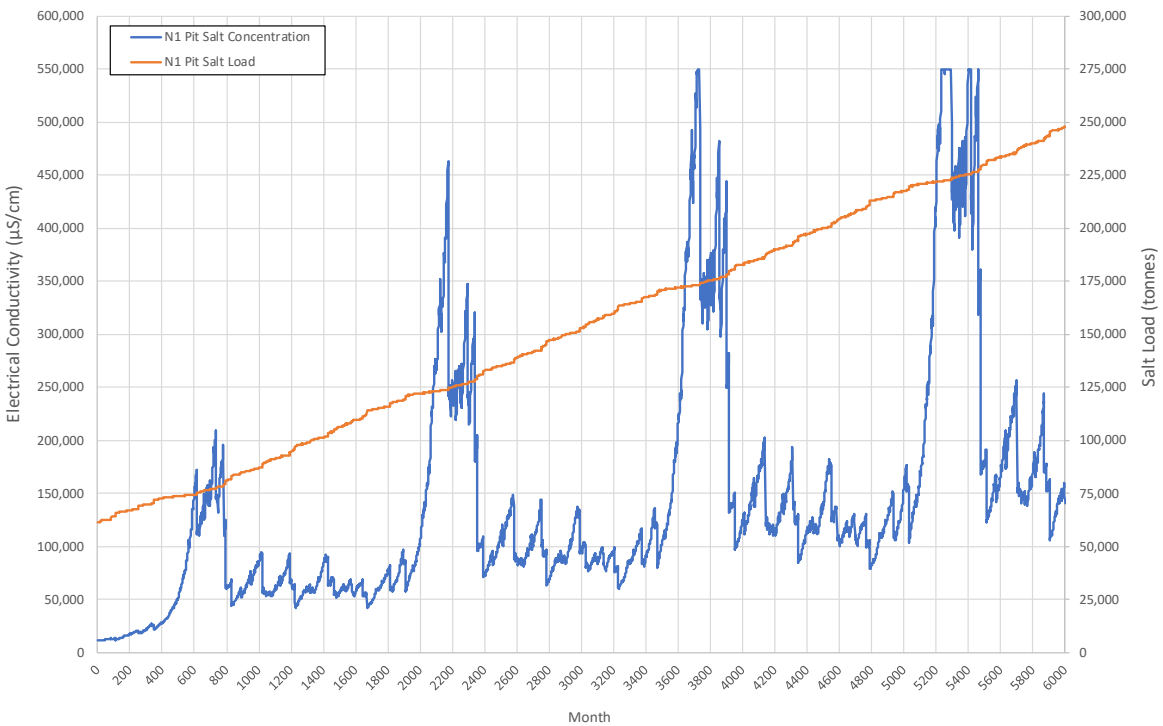

Figure 9.11 - Final void water levels and salt load, N1 Pit

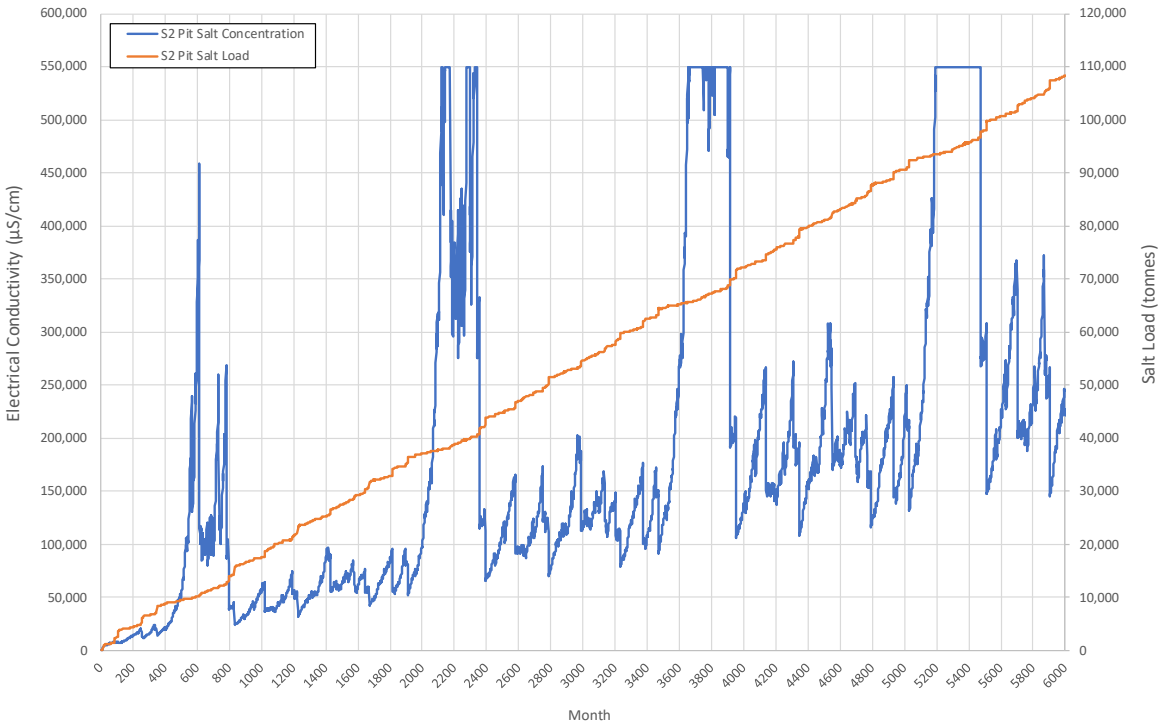

Figure 9.12 – Final void water levels and salt load, S2 Pit

10 Mitigation and management measures

10.1 POTENTIAL IMPACTS

The potential impacts of the IPEE project on surface water resources include:

- impacts on flows and the flooding regime in Smoky Creek, Billy's Gully and the Isaac River;
- impacts on regional water availability due to the potential need to obtain water from external water sources to meet the operational water requirements of mining operations;
- impacts on stream flows due to loss of catchment area draining to local drainage paths due to capture of runoff within onsite storages and the open cut pits;
- adverse impacts on the quality of surface runoff draining from the disturbance areas to the various receiving water surrounding the project;
- adverse impact on environmental values in Smoky Creek, Billy's Gully and the Isaac River associated with controlled releases from the mine water management system;
- cumulative impacts of all projects in the region on the environmental values of the receiving waters.

An assessment of each of these potential impacts of the IPEE project is provided in the following sections.

10.2 FLOODING IMPACTS

Potential impacts of the IPEE project on flood levels and flood velocities in Smoky Creek and Billy's Gully are addressed in Section 8.3 of this report. There are no significant impacts in comparison to the approved conditions for either the operational or final landform phases of the Project.

10.3 REGIONAL WATER AVAILABILITY IMPACTS

A significant proportion of mine site water requirements will be sourced from water collected on the site, including rainfall runoff and groundwater inflows to the open cut pits which will be stored in the mine affected water dams for recycling and reuse.

The results of the water balance modelling (see Section 7.3.4) show that the currently approved water licence allocation of 920 ML/a is more than adequate under all historical climate sequences. As such, the IPEE project will have no impact on regional water availability

10.4 STREAM FLOW IMPACTS

10.4.1 During active mining operations

10.4.1.1 Whole of mine

During active mining operations, the mine water management system will capture runoff from areas that would have previously flowed to the receiving waters of Smoky Creek, Billy's Gully and the Isaac River. The captured catchment area will change as the mine develops. A breakdown of the catchment areas reporting to the whole of mine water management system is provided in Table 10.1.

The total catchment areas of Smoky Creek and Billy's Gully to the downstream boundary of the IPC tenements are approximately 171 km^2 and 68 km^2, respectively. The catchment area of the Isaac River to the confluence of Billy's Gully is approximately 1,922 km^2.

The maximum captured catchment areas represent:

- Between 8.4% and 9.4% of the Smoky Creek catchment to the downstream boundary of the mine, depending on the Stage.
- Between 5.3% and 6.9% of the Billy's Gully catchment to the downstream boundary of the mine, depending on the Stage.
- The maximum area captured within the pits and mine affected dams occurs during Stage 4. This area (21.2 km^2) represents only 1.1% of the Isaac River to the Billy's Gully confluence.
- The remaining catchment drains off site through the sediment water management system.

Table 10.1 - Catchment area captured within the whole mine water management system

Catchment	Total catchment area (km^2)	Captured catchment area (km^2)					
		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
Smoky Creek	171	14.6	14.7	15.7	16.1	16.0	16.0
Billy's Gully	68	3.6	4.0	4.2	4.7	4.6	4.6
Isaac River	1,922	18.6	19.2	20.3	21.2	21.1	21.0

On this basis, the loss of catchment flows in Smoky Creek and Billy's Gully would be minimal. The potential impact on water quantity in the Isaac River due to the whole of mine is likely to be undetectable.

10.4.1.2 Project only

The IPEE project will result in changes to flows in Smoky Creek and Billy's Gully due to the progressive extension of open cut mining operations at IPE and associated subsequent capture and reuse of drainage from operational catchment areas.

The additional surface disturbance area associated with the project would excise a maximum of 2.9 km^2 during operations from the catchment area of Smoky Creek, and 2.2 km^2 from the catchment area of Billy's Gully. This represents approximately 1.7% of the total catchment area of Smoky Creek and approximately 3.2% of the total catchment area of Billy's Gully.

The maximum loss of catchment due to the project is only (5.2 km^2), which represents less than 0.3% of the Isaac River catchment downstream of the confluence with Billy's Gully. The loss of catchment flows in the Isaac River would be indiscernible, and as such the potential impact on water quantity in the Isaac River due to the IPEE project is considered negligible.

10.4.2 Final landform

At the completion of mining, permanent drainage of waste rock emplacement areas will be installed to minimise capture of surface runoff into the final voids in general accordance with the configuration shown in Figure 9.1. The majority of the disturbed area at the site will be rehabilitated and allowed to drain back to Smoky Creek and Billy's Gully. A residual area of approximately 9.2 km^2 will continue to drain to the final voids.

The net change in catchment area draining from the site is summarised in Table 10.2. The changed topography as a result of the final landform will have the following impacts on catchment area:

- The catchment draining to Smoky Creek (to the downstream of site) will reduce by around 7.0 km^2 (compared to pre-mining conditions), a decrease of less than 4.1%.
- The catchment draining to Billy's Gully (to the downstream of site) will reduce by around 2.1 km^2 (compared to pre-mining conditions), a decrease of less than 3.1%.
- The catchment draining to Isaac River (to downstream of the Billy's Gully confluence) will reduce by around 9.1 km^2 (compared to pre-mining conditions), a decrease of less than 0.5%.
- The loss of catchment flows in Smoky Creek, Billy's Gully and the Isaac River would be indiscernible, and as such the potential impact on water quantity in these waterways due to the final landform is considered negligible.

Table 10.2 - Final landform - captured catchment areas

Catchment	Pre-mining catchment area (km^2)	Post-mining catchment area (km^2)	Post-mining captured catchment area (km^2)
Smoky Creek (to d/s of IPC)	171	163	7.0
Billy's Gully (to d/s of IPC)	68	66	2.1
Isaac River (to the Smoky Creek confluence)	1,922	1,913	9.1

10.5 REGIONAL WATER QUALITY AND ENVIRONMENTAL VALUES

10.5.1 Overview

Section 5 describes the objectives and principles of the water management system, which have been previously established as part of IPM and IPE approvals, to protect water quality and the environmental values of the waterways potentially affected by the mining operations at IPC. The approved release contaminant trigger investigation levels in the IPC EA have been established to meet the relevant WQO's.

No changes are proposed to these objectives and principles as part of the IPEE project and the water management system and infrastructure remains mostly generally unchanged (with the exception of additional sediment dams associated with IPEE).

The general principles of the water management system, are as follows:

- A diverted water management system that separates clean water from mine affected and sediment water wherever possible. Details of the proposed upstream catchment diversions and flood protection levees are provided in Section 5.7.
- An sediment water management system that contains runoff that potentially has high sediment concentrations in sediment dams. Water collected in the sediment dams will be managed in accordance with the ESCP and used for dust suppression or will overflow to receiving watercourses after a period of settling. Details of the sediment water management system are provided in Section 5.6.
- A mine affected water management system that contains potentially saline runoff from the pit and infrastructure areas (including ROM coal stockpile) in mine affected water dams. Mine affected water will be used as a priority in meeting makeup demand in the CHPP and for road watering. Water from the mine affected water management system may only be released to the downstream environment in compliance with the EA conditions. Details of the existing and proposed mine affected water management system and its expected performance are provided in Section 5.5 and Section 7.

- A reject and tailings disposal system that contains and dewaters the tailings and allows for maximum recycle of water to the CHPP. Details of the tailings and rejects circuit are provided in Section 5.4.

10.5.2 Performance of the water management system

10.5.2.1 Mine affected water management system

An assessment of the mine affected water management system is given in Section 7.3.6.1. The results of the water balance modelling indicate that, under the current model assumptions and configuration:

- There is a 1% probability of an uncontrolled releases occurring from RD1, in any one year; and
- There is a 1% probability of an uncontrolled releases occurring from S2 SD, in any one year.

Uncontrolled releases from these two storages are only predicted to occur during periods of extreme rainfall. The water balance model predicts that, during these rare releases, the salinity of the overflow would be low, at around 630 to 6,000 µs/cm. In addition, the modelling indicates that there would be significant flows in the receiving waters occurring concurrently with the releases, with dilution ratios of around 100 to 1,500.

Therefore, it is highly unlikely that any uncontrolled releases from these two mine affected water storages would have a measurable impact on receiving water quality. They would also be highly unlikely to exceed the receiving water contaminant trigger levels for salinity (1,000 µs/cm) in the currently approved IPC EA.

10.5.2.2 Sediment water management system

An assessment of the mine affected water management system is given in Section 7.3.6.2. The model results show that some overflow of water from sediment dams may occur during wet periods that exceed the design standard of the sediment control system (Section 5.6).

Available water quality monitoring data indicates that the runoff draining to the sediment dams has low salinity. Overflows would only occur during significant rainfall events which will also generate runoff from surrounding undisturbed catchments. Hence it is unlikely that sediment dam overflows will have a measurable impact on receiving water quality or environmental values.

The additional disturbance footprint associated with the project will increase the volume of stormwater to be contained and managed on the mine site. Notwithstanding, the sediment water management system will remain generally unchanged (i.e. continued collection of runoff from the overburden dumps) for the IPEE project with augmentations as necessary.

10.5.3 Controlled releases

There are no proposed changes to the current release conditions as prescribed in Conditions C5-C16 of the currently approved EA.

Figure 10.1 shows a ranked plot of modelled EC in Smoky Creek downstream of the controlled release point on days when there is a controlled release opportunity (i.e. when the Isaac River flow exceeds the minimum flow criteria and there is water available for release). The plot shows the modelled EC in Smoky Creek both with controlled releases (from 111 model realisations).

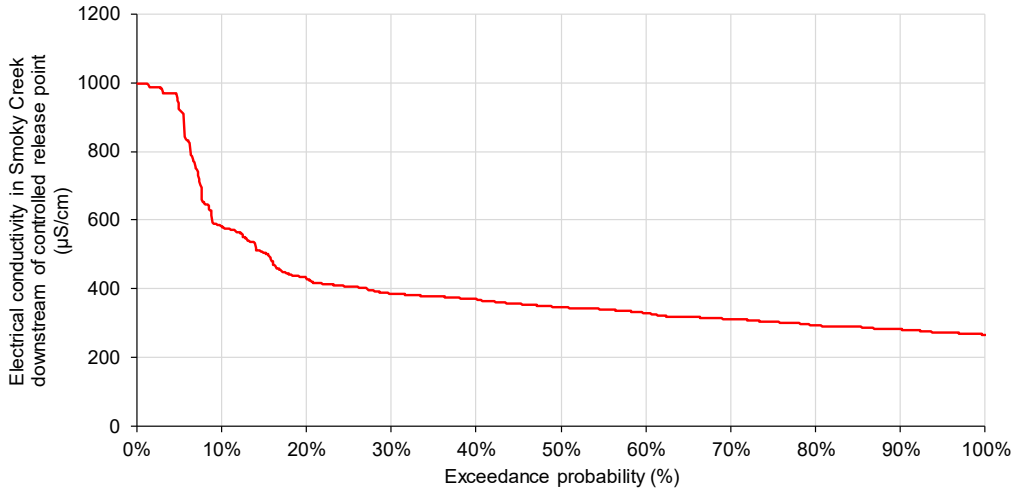

Figure 10.1 - Electrical conductivity in Smoky Creek, downstream of the controlled release point

The results show that:

- The minimum EC in Smoky Creek on a controlled release day is around 282 µs/cm, which is around 32 µs/cm higher than the modelled background salinity;
- There is a 50% chance that the downstream Smoky Creek EC will be greater than 347 µs/cm during a controlled release (97 µs/cm above modelled background salinity);
- There is a 10% chance that the downstream Smoky Creek EC will be greater than 583 µs/cm during a controlled release (333 µs/cm above modelled background salinity);
- The EC in Smoky Creek is below the receiving water contaminant trigger level of 1,000 µs/cm on all release days.

The model predicts that controlled releases would only occur on 0.2% of all Smoky Creek flow days over the simulation period.

On this basis, the modelling demonstrates that the implementation of the water management system and currently approved release conditions would mitigate any impacts of the site as a whole (including the project) on downstream water quality.

10.5.4 Monitoring and maintenance

It will be necessary to manage each of these systems to ensure that they are operating as designed.

- Continual monitoring of water quality and storage volumes in the mine affected storages will be undertaken to ensure that uncontrolled spills do not occur and cause a downstream impact.
- The pit and dam pumps will be inspected and operated regularly to ensure they will operate when required.
- Sediment dams will be cleaned out on a regular basis to maintain the available sediment storage volume.
- Diversion drains will be monitored regularly to ensure they are operating as designed and do not allow mixing of clean and dirty water.
- Contaminated water sumps and interceptors are to be inspected and cleaned out regularly.

- Continual monitoring of potable water quality to ensure it meets potable water standards.

10.6 CUMULATIVE IMPACTS – SURFACE WATER

10.6.1 Overview

The objective of a cumulative impact assessment is to identify the potential for the project to have compounding interactions with similar impacts from other projects, including activities proposed, under development or already in operation within a suitable region of influence of the project.

There are three levels at which cumulative impacts may be relevant:

- Localised cumulative impacts – These are the impacts that may result from multiple existing or proposed mining operations in the immediate vicinity of the project. Localised cumulative impacts include the effect from concurrent operations that are close enough to potentially cause additive effect on the receiving environment. For the purposes of this assessment, we have included all existing and proposed projects located within the Isaac River catchment to the Deverill flow gauge.
- Regional cumulative impacts – These include the project's contribution to impacts that are caused by mining operations throughout the Bowen Basin region or at a catchment level. Each coal mining operations in itself may not represent a substantial impact at a regional level; however, the cumulative effect on the receiving environment may warrant consideration.
- Global cumulative impacts – These includes impacts that the project might contribute to at a global scale. The only potential global scale impact for the project is greenhouse gas (GHG) emissions, and as such has not been addressed in this assessment.

10.6.2 Existing projects

Projects which are currently operating within the Isaac River catchment upstream of the Deverill gauging station and have been included in the cumulative impacts assessment for the project are listed in Table 10.3.

10.6.3 New or Developing Projects

Relevant projects that have been considered include:

- Projects within the predicted sphere of influence of the project, as listed on the Department of State Development, Manufacturing, Infrastructure and Planning (DSDMIP) website that are undergoing assessment under the State Development and Public Works Organisation Act 1971 (SDPWO Act) for which an Initial Advice Statement (IAS) or an EIS are available; and
- Projects within the predicted sphere of influence of the project, which are listed on the website of the Department of Environment and Science (DES) that are undergoing assessment under the Environmental Protection Act 1994 (EP Act) for which an IAS or an EIS are available.
- Projects within the predicted sphere of influence of the project, which are listed on the website of the Department of Infrastructure, Local Government and Planning (DILGP) that are undergoing assessment under the Regional Planning Interests Act 2014 (RPI Act) for which an Assessment Application is available.

Projects currently undergoing assessment or having recently completed assessment under these processes and included in the cumulative impact assessment for the project are listed in Table 10.4.

10.6.4 Cumulative impacts – surface water resources

10.6.4.1 Water quality

The project is located in the Isaac River catchment, which is a major tributary within the Fitzroy basin. The Fitzroy basin is the largest catchment in Queensland draining into the Pacific Ocean and also the largest catchment that drains to the Great Barrier Reef, although it does not contribute significant freshwater flows to the coastal environment when compared to river systems further north.

In 2008, the Queensland Government undertook an investigation into the cumulative effects of coal mining in the Fitzroy River basin on water quality (EPA, 2009). The investigation found that:

- There were inconsistencies in discharge quality limits and operating requirements for coal mine water discharges as imposed through environmental authorities.
- In some cases, discharge limits and operating conditions of coal mines were not adequately protecting downstream environmental values.

These conclusions led to a number of inter-related actions by Queensland Government and other stakeholders:

- Water quality objectives were developed for the Fitzroy Basin and added to Schedule 1 of the Environmental Protection (Water) Policy 2009 (EPP (Water)) in October 2011.
- Model water conditions were developed for coal mines in the Fitzroy basin (DERM February 2012). These model water conditions are designed to manage water discharges to meet the water quality objectives set out in the EPP (Water) and to provide consistency between mining operations in the Fitzroy basin.
- Environmental authorities for a number of mining operations were amended to introduce conditions consistent with the model water conditions. This includes the Isaac Plains Mine.
- A number of mining operations entered into Transitional Environmental Programs (TEP) under the EP Act. These TEPs were focussed on actions that would allow mines to achieve compliance with new environmental authority conditions and upgrade operating conditions.

With these measures in place, a strong strategic and policy framework is now in place for management of cumulative water quality impacts from mining activities. This framework allows for management of individual mining activities in such a way that overarching water quality objectives can be achieved.

Mine affected water from the proposed project will be managed through a mine water management system which is designed to operate in accordance with currently approved EA conditions. Stanmore are not proposing any changes to the currently approved discharge conditions and in-stream trigger levels that already apply at IPC, and which were developed in accordance with the Model water conditions for coal mines in the Fitzroy basin.

The water quality assessment undertaken for the project has identified that sediment inputs can be controlled through drainage, erosion and sediment control measures. On this basis, the proposed project is not expected to make any significant contribution to cumulative sediment loads in the Fitzroy River Basin.

Given that the proposed project mine affected water releases will be managed within an existing overarching strategic framework for management of cumulative impacts of mining activities, the proposed management approach for mine water from the project is expected to have negligible cumulative impact on surface water quality and associated environmental values.

Table 10.3 - Existing projects considered in the cumulative impact assessment

Project - Proponent	Description	Operational status	Relationship to the Project Mining Lease	
			Timing	Location
Burton Mine - Peabody Energy Australia	Open cut coal mine	Ceased production indefinitely	May have overlapping operational phases with the construction and operations of the project, although unlikely given the current operational status.	Located 25 km to the northwest of the project area. Located within the Isaac River catchment (upstream).
Eaglefield Mine - Peabody Energy Australia	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 37 km to the northwest of the project area. Located within the Isaac River catchment (upstream).
North Goonyella Mine - Peabody Energy Australia	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 37 km to the northwest of the project area. Located within the Isaac River catchment (upstream).
Goonyella Riverside Mine - BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 24 km to the northwest of the project area. Located within the Isaac River catchment (upstream).
Moranbah North Mine - Anglo American	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 15 km to the northwest of the project area. Located within the Isaac River catchment (upstream).
Grosvenor Mine - Anglo American	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 9.6 km to the east of the project area. Located within the Isaac River catchment (upstream).
Broadlea Mine - Fitzroy Australia Resources	Open cut coal mine	Care and maintenance	May have overlapping operational phases with the construction and operations of the project.	Located 8.7 km to the northeast of the project area. Located within the headwaters of Smoky Creek, within the Isaac River catchment.
Carborough Downs Mine - Fitzroy Australia Resources	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 13 km to the east of the project area. Located within the headwaters of Billy's Gully, within the Isaac River catchment.
Millennium Mine - Peabody Energy Australia	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 13 km to the southeast of the project area. Located within the Isaac River catchment (downstream).
Daunia Mine - BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 22 km to the southeast of the project area. Located within the Isaac River catchment (downstream).
Poitrel Mine - BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 18 km to the southeast of the project area. Located within the Isaac River catchment (downstream).

Caval Ridge Mine - BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 29 km to the south of the project area. Located within the Isaac River catchment (downstream).
Peak Downs Mine - BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 30 km to the south of the project area. Located within the Isaac River catchment (downstream).
Moorvale Mine – Peabody Energy Australia	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 25 km to the east of the project area. Located within the headwaters of North Creek, within the Isaac River catchment.
Saraji Mine – BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 50 km to the south of the project area. Located within the Isaac River catchment (downstream).
Norwich Park Mine – BMA	Open cut coal mine	Ceased production indefinitely	May have overlapping operational phases with the construction and operations of the project, although unlikely given the current operational status.	Located 64 km to the southwest of the project area. Located within the Isaac River catchment (downstream).
Lake Vermont Mine – Jellinbah Group	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 80 km to the south of the project area. Located within the Isaac River catchment (downstream).

Table 10.4 – Proposed projects considered in the cumulative impact assessment

Project - Proponent	Description	Project status	Relationship to the Project Mining Lease	
			Timing	Location
Isaac Downs Project – Stanmore IP South Pty Ltd	Open cut coal mine	Public notification of draft TOR	May have overlapping operational phases with the construction and operations of the project.	Located 12 km to the south of the project area. Located within the Isaac River catchment (downstream).
Moranbah South Project – Anglo American	Underground coal mine	Approved project	May have overlapping operational phases with the construction and operations of the project.	Located 5 - 10 km to the west of the project area. Located within the Isaac River catchment (downstream).
Moorvale South Project – Peabody Energy Australia	Open cut coal mine	Approved project	May have overlapping operational phases with the construction and operations of the project.	Located 26 km to the southeast of the project area. Located within the Isaac River catchment (downstream).
Eagle Downs Mine – Bowen Central Coal Joint Venture	Underground coal mine	Construction on hold – site on care and maintenance	May have overlapping operational phases with the construction and operations of the project.	Located 27 km to the south of the project area. Located within the Isaac River catchment (downstream).

Winchester South Project – Whitehaven Coal	Open cut coal mine	EIS active	May have overlapping operational phases with the construction and operations of the project.	Located 30 km to the southeast of the project area. Located within the Isaac River catchment (downstream).
Olive Downs Coking Coal Project – Pembroke Olive Downs Pty Ltd	Open cut coal mine	Approved with conditions	May have overlapping operational phases with the construction and operations of the project.	Located 35-55 km to the southeast of the project area. Located within the Isaac River catchment (downstream).
Saraji East Mine - BMA	Open cut coal mine	EIS active	May have overlapping operational phases with the construction and operations of the project.	Located 54 km to the south of the project area. Located within the Isaac River catchment (downstream).
Dysart East Coal Mine – Bengal Coal	Underground coal mine	ML granted	May have overlapping operational phases with the construction and operations of the project.	Located 72 km to the southeast of the project area. Located within the Isaac River catchment (downstream).

10.6.4.2 Loss of Catchment and Stream Flows in the Isaac River

As detailed in Section 10.4, the project will result in a loss of catchment to the Isaac River during operations and post-mining. The surface runoff volume lost from the catchment will generally be in proportion to the loss of catchment area. The project area is less than 0.3% of the catchment area of the Isaac River to the confluence of Phillips Creek. Of this, around 43% of this area is managed through the ESCP and then released to the downstream environment following treatment.

There are approximately 17 existing coal mines in the vicinity the Project that also capture runoff from the Isaac River catchment, as shown in Figure 10.2. The total estimated captured area of all these projects (including IPC and the project) combined represents around of 7.3% of the Isaac River catchment to the Phillips Creek confluence. If the same percentage of ESCP for the Project is applied to the other mines, then the estimated captured catchment areas reduce to around 57% of the total area (around 4.1% of the Isaac River catchment to the Phillips Creek confluence).

In addition, these mines have discharge licences which return captured surface water, as well as groundwater collected in underground workings, to the Isaac River catchment. Site discharges would reduce the impact on surface water volumes. There is limited information available on actual discharge volumes from the 17 mines to the Isaac River.

A comparison of the captured catchment areas of the existing mining projects considered in the cumulative impact assessment with the Isaac River catchment to the Phillips Creek confluence is provided in Table 10.5, which indicates the following:

- The combined total catchment area of the existing mines (including the project) represents around 7.3% of the total catchment area of the Isaac River to the Phillips Creek confluence.
- The combined mine affected catchment area (estimated) represents less than 4.1% of the total Isaac River catchment area to the Philips Creek confluence.

When taking into account potential discharges from the operating mines in accordance with their current release rules, the overall loss of catchment area and associated stream flow is relatively small.

Table 10.5 - Catchment area of existing projects considered in the cumulative impact assessment

Catchment	Total catchment area (km^2)	Estimated mine affected catchment area (km^2)
IPC + the project	21.2	12.1
Other mines	541	309
Combined	562	320
Isaac River (to the Phillips Creek confluence)	7,731	7,731

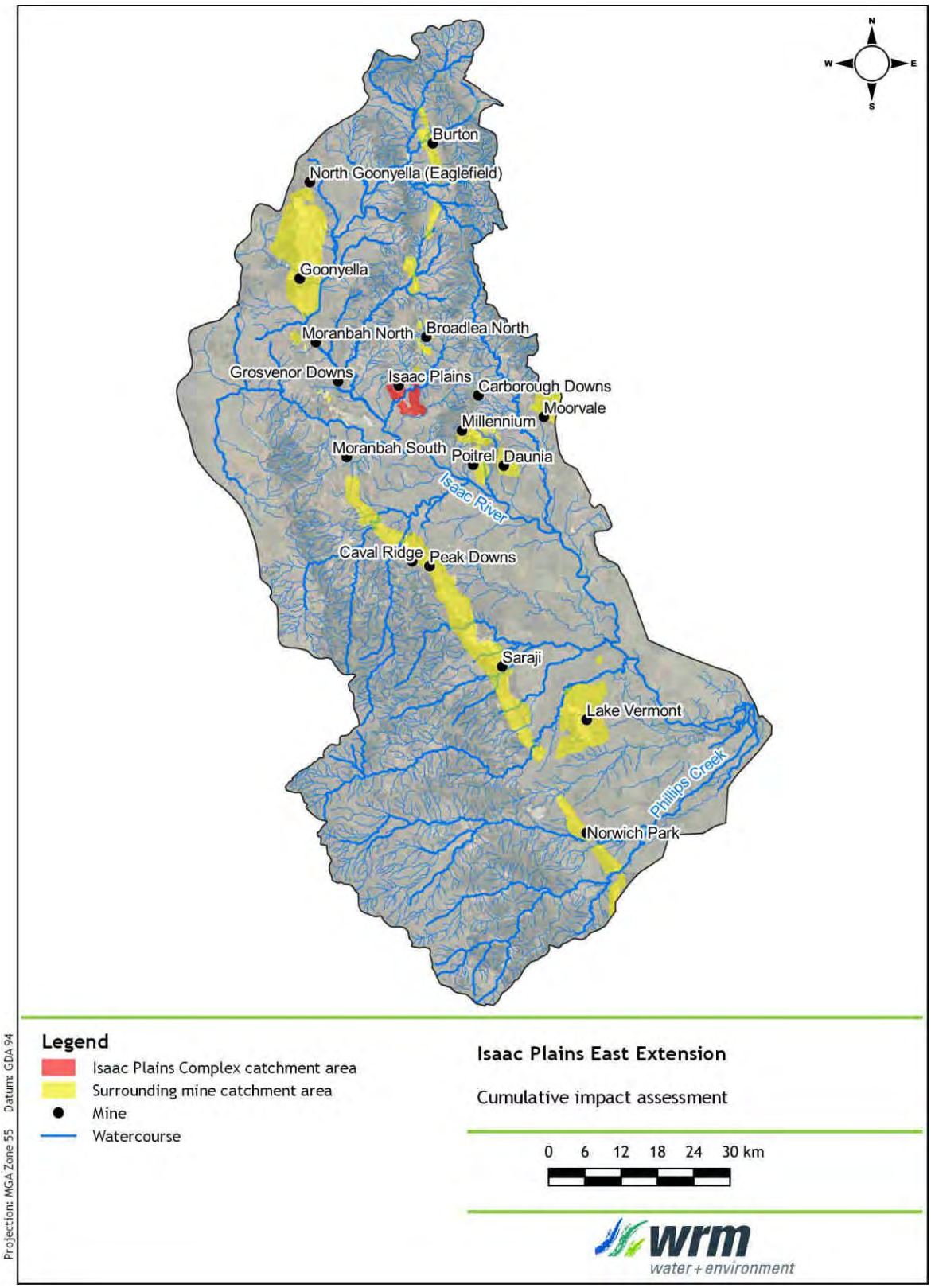

Figure 10.2 – Cumulative impact assessment – location of existing mines upstream of the Isaac River confluence with Phillips Creek

10.7 PROPOSED EA AMENDMENTS – SURFACE WATER

10.7.1 Authorised releases

The following changes to EA Tables 1 and 5 of the approved EA are proposed:

- Remove RP3 (S1 Pit) from EA Tables 1 and 5 as it is now backfilled.
- Add a new release point (RP6) at N1 Pit in Table 1.
- Add a new monitoring point at N1 Pit in EA Table 5.

The proposed updated tables are provided in Table 10.6 and Table 10.7. Once S3 Pit is backfilled, RP5 can be removed from EA Tables 1 and 5

Table 10.6 – Proposed mine affected water release points (EA table 1)

Release point	Easting	Northing	Mine affected water source and location	Monitoring point	Receiving waters
RP 1	614974	7569713	RD1	Spillway	Smoky Creek
RP 2	616695	7567301	RD2	Spillway	Billy's Gully
RP 4	615114	7569350	S2 SD	Pump intake (via bleed-off valve)	Smoky Creek
RP 5	617929	7567111	S3 pit	Pump intake (via bleed-off valve)	Billy's Gully
RP 6	tbc	tbc	N1 pit	Pump intake (via bleed-off valve)	Smoky Creek

Table 10.7 – Proposed water storage monitoring (EA table 5)

Water storage description	Easting	Northing	Monitoring point	Frequency of monitoring
RD1	614974	7569713	Spillway	Quarterly
RD2	616695	7567301	Spillway	Quarterly
S2 SD	615114	7569350	Pump intake (via bleed-off valve)	Quarterly
S3 pit	617929	7567111	Pump intake (via bleed-off valve)	Quarterly
N1 pit	tbc	tbc	Pump intake (via bleed-off valve)	Quarterly

The additional sediment dams will be managed under the ESCP and therefore require no changes to the EA.

10.7.2 Mine affected water release limits and trigger levels

There are no proposed changes to the mine affected water release limits, release contaminant trigger investigations levels or mine affected water release conditions in Table 2, 3 and 4 of the approved EA.

10.7.3 Mine affected water release events

There are no additional stream gauges proposed as part of the project. The existing stream gauges are adequate to define the trigger release conditions from the existing mine water release points.

10.7.4 Receiving environment monitoring

There are no proposed changes to the receiving water contaminant trigger level in EA Table 7.

The upstream water quality monitoring locations currently identified in EA Table 8 should now reflect the new monitoring locations upstream of IPEE. The proposed updated EA Table 8 is provided in Table 10.8.

Table 10.8 – Receiving water upstream background sites and downstream monitoring points

Monitoring points	Receiving water location description	Easting (CGD94 - Zone 55)	Northing (CGD94 - Zone 55)
Upstream background monitoring points			
Monitoring point 1	W6 – Smoky Creek u/s	619082	7571899
Monitoring point 2	W7 – Billy's Gully u/s	620330	7568146
Downstream monitoring points			
Monitoring point 3	W2 – Isaac River d/s of Peak Downs highway	616690	7561249
Monitoring point 4	W4 – Billys Gully d/s	616415	7566527
Monitoring point 5	W5 – Smoky Creek d/s	614925	7569302

10.7.5 Location of regulated structures

There are no new regulated dams proposed as part of the project. The proposed levees associated with the IPEE project will likely be regulated structures.

The details of these levees will be confirmed as part of the detailed design process. Once complete, the Register of Regulated Structures will be updated with the appropriate information.

10.8 UPDATE OF EXISTING WATER MANAGEMENT DOCUMENTS

The approved IPC water management system is currently operated in accordance with the sites WMP, ESCP and REMP Design Document, and a register of regulated structures is maintained. These documents will be updated to incorporate the proposed changes to the water management system associated with the IPEE project.

In addition, the performance of the water management system is continually reviewed through the following mechanisms:

- Annual water management plan review and water balance update.
- Annual REMP assessment report.
- Annual inspection of dams and levees

Stanmore will continue to monitor the performance of the water management system through these existing review mechanisms.

11 Assessment of significance of impacts relating to MNES

The surface water components of the proposed IPEE project has been assessed against the *Significant impact guidelines 1.3: Coal seam gas and large coal mining developments - impacts on water resource* (DoE, 2013).

11.1 DESCRIPTION – SURFACE WATER

The IPEE project is located within the Isaac River catchment, which forms part of the Isaac northern tributaries region of the Isaac River Sub-Basin, within the greater Fitzroy Basin.

There are two waterways located within the proposed project area. Smoky Creek, an ephemeral fourth order stream, drains through the project area between the proposed Pit 4/4N and Pit 5 mining areas. Billy's Gully, an ephemeral third order stream, drains through the project area southeast of the proposed Pit 2 mining area. Both of these waterways drain through the existing approved IPC mining areas, before discharging downstream of the mine into the Isaac River.

Water quality in the vicinity of the IPC mining areas is considered to be slightly alkaline, with low to moderate variable EC and elevated nutrient levels in the upstream reaches. The concentrations of some metals are also elevated above the WQO's for the area, however observed spikes in concentrations are within the range typically experienced at background sites. (C&R, 2018a).

11.2 NATURE AND EXTENT OF LIKELY IMPACT

A WMP for IPC (WRM, 2018) has been prepared in accordance with the EA conditions. The WMP includes a study of potential contaminants, a water balance model, a description of the site water management system, measures to manage and prevent saline and acid rock drainage, contingency procedures for emergencies and a monitoring and review program for the effectiveness of the WMP. The WMP will be revised to incorporate the IPEE project. Mine affected water is managed in accordance with the requirements of the environmental authority and WMP. Water with potential sediment is managed in accordance with the IPC ESCP.

An extensive surface monitoring network has been established at IPC which includes upstream and downstream monitoring points on all licensed discharge points. Stanmore will continue to monitor surface water in accordance with the WMP and EA.

With the monitoring, management and mitigation measures detailed above, the water balance model predicts that water discharging from site would continue to comply with approved and proposed EA conditions. The monitoring and reporting requirements detailed in the WMP will continue to be implemented to monitor compliance with the EA and allow early identification of potential issues with the site water management systems.

11.3 CONCLUSION

Considering the *Significant impact guidelines 1.3: Coal seam gas and large coal mining developments - impacts on water resource* (DoE, 2013), it is considered that the IPEE project is:

- unlikely to directly or indirectly result in a substantial change in the hydrology of water resources; and
- unlikely to directly or indirectly result in a substantial change in water quality of water resources.

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Appendix A Water balance model catchments and storage curves

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A1 Land use and catchment breakdown

Table A.1 – Land use and catchment breakdown, Stage 1

Catchment	Contributing area (ha)							Total (ha)
	Cleared/ pre-strip	Mining Pit	Roads/ hardstand	Rehabilitated spoil	Spoil dump	Stockpile/ industrial area	Natural	
IPM								
CHPP Process Pond	0.0	0.0	4.7	0.0	0.0	0.0	13.0	**17.7**
N1 Pit	6.5	54.4	29.4	69.8	164.7	0.0	0.7	**326**
N1 SD	0.0	0.0	31.3	147.9	4.6	0.0	79.9	**264**
S2 Pit	2.7	31.9	9.0	14.0	47.4	0.0	0.0	**105**
S2 SD	0.0	0.0	8.4	45.5	0.1	0.0	0.2	**54.2**
S3 Pit	11.2	0.0	9.4	40.2	67.2	0.0	1.3	**129**
S3 SD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Raw Water Dam	0.0	0.0	1.5	0.0	0.0	0.0	0.0	**1.5**
RD1	0.0	0.0	57.3	0.0	0.0	25.1	76.3	**159**
RD2	0.0	0.0	30.9	58.7	5.8	0.0	14.5	**110**
SD 6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
IPE/IPEE								
Pit 2 & 3	39.2	32.4	1.4	0.0	38.9	0.0	20.5	**132**
Pit 2S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Pit 4	56.8	30.6	0.4	0.0	29.4	0.0	32.3	**149**
Pit 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
SD 2	14.0	0.0	8.6	0.0	34.4	0.0	12.6	**69.6**
SD 3a	8.0	0.0	10.1	0.0	0.0	0.0	20.2	**38.3**
SD 3b	15.6	0.0	3.5	0.0	42.3	0.0	0.0	**61.4**
SD 4a	2.1	0.0	4.5	0.0	31.3	0.0	0.1	**38.0**
SD 4b	15.0	0.0	9.5	0.0	65.4	0.0	0.0	**90.0**
SD 5	44.8	0.0	4.3	0.0	0.0	0.0	25.5	**74.6**

Table A.2 – Land use and catchment breakdown, Stage 2

Catchment	Contributing area (ha)							Total (ha)
	Cleared/ pre-strip	Mining Pit	Roads/ hardstand	Rehabilitated spoil	Spoil dump	Stockpile/ industrial area	Natural	
IPM								
CHPP Process Pond	0.0	0.0	4.7	0.0	0.0	0.0	13.0	**17.7**
N1 Pit	5.8	54.4	29.3	90.3	129.3	0.0	0.7	**310**
N1 SD	0.0	0.0	29.7	171.4	3.5	0.0	79.9	**285**
S2 Pit	2.2	27.8	9.0	36.3	29.7	0.0	0.0	**105**
S2 SD	0.0	0.0	8.4	45.5	0.1	0.0	0.2	**54.2**
S3 Pit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
S3 SD	11.3	0.0	9.4	49.7	65.0	0.0	1.3	**137**
Raw Water Dam	0.0	0.0	1.5	0.0	0.0	0.0	0.0	**1.5**
RD1	0.0	0.0	57.3	0.0	0.0	25.1	76.2	**159**
RD2	0.0	0.0	30.9	63.9	0.7	0.0	14.5	**112**
SD 6	17.5	0.0	3.3	1.8	0.0	0.0	3.5	**26.1**
IPE/IPEE								
Pit 2 & 3	40.9	40.0	1.8	0.0	41.7	0.0	0.0	**125**
Pit 2S	1.0	4.7	0.0	0.0	0.0	0.0	0.0	**5.7**
Pit 4	52.5	34.5	0.4	0.0	44.9	0.0	17.1	**149**
Pit 5	14.5	12.7	1.0	0.0	17.6	0.0	1.4	**47.3**
SD 2	21.0	0.0	9.5	0.0	51.5	0.0	0.0	**82.0**
SD 3a	8.0	0.0	10.1	0.0	0.0	0.0	20.2	**38.4**
SD 3b	15.6	0.0	3.5	0.0	42.3	0.0	0.0	**61.3**
SD 4a	2.1	0.0	4.5	0.0	31.3	0.0	0.1	**38.0**
SD 4b	15.0	0.0	9.5	0.0	65.4	0.0	0.0	**90.0**
SD 5	6.1	0.0	3.5	0.0	28.6	0.0	0.4	**38.6**

Table A.3 – Land use and catchment breakdown, Stage 3

Catchment	Contributing area (ha)							Total (ha)
	Cleared/ pre-strip	Mining Pit	Roads/ hardstand	Rehabilitated spoil	Spoil dump	Stockpile/ industrial area	Natural	
IPM								
CHPP Process Pond	0.0	0.0	4.7	0.0	0.0	0.0	13.0	**17.7**
N1 Pit	5.8	54.4	29.3	90.3	129.3	0.0	0.7	**310**
N1 SD	0.0	0.0	29.7	171.4	3.5	0.0	79.9	**285**
S2 Pit	2.2	27.8	9.0	36.3	29.7	0.0	0.0	**105**
S2 SD	0.0	0.0	8.4	45.5	0.1	0.0	0.2	**54.2**
S3 Pit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
S3 SD	0.3	0.0	4.5	130.5	0.0	0.0	1.3	**137**
Raw Water Dam	0.0	0.0	1.5	0.0	0.0	0.0	0.0	**1.5**
RD1	0.0	0.0	57.3	0.0	0.0	25.1	76.2	**159**
RD2	0.0	0.0	28.6	66.3	0.5	0.0	14.5	**110**
SD 6	17.5	0.0	3.3	1.8	0.0	0.0	3.5	**26.1**
IPE/IPEE								
Pit 2 & 3	27.9	31.1	3.4	0.0	107.2	0.0	20.4	**190**
Pit 2S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Pit 4 & 4N	47.6	52.5	5.0	0.7	152.1	0.0	21.0	**279**
Pit 5	5.8	10.3	1.0	0.0	24.6	0.0	0.6	**42.4**
SD 2	8.3	0.0	9.2	0.0	68.5	0.0	0.0	**86.0**
SD 3a	8.0	0.0	10.2	0.0	0.0	0.0	20.2	**38.3**
SD 3b	14.8	0.0	3.4	30.1	13.1	0.0	0.0	**61.4**
SD 4a	2.1	0.0	4.7	17.0	5.9	0.0	0.1	**29.8**
SD 4b	15.0	0.0	10.0	51.0	15.1	0.0	0.0	**91.1**
SD 5	2.6	0.0	3.9	12.5	27.9	0.0	0.0	**46.9**

Table A.4 - Land use and catchment breakdown, Stage 4

Catchment	Contributing area (ha)							Total (ha)
	Cleared/ pre-strip	Mining Pit	Roads/ hardstand	Rehabilitated spoil	Spoil dump	Stockpile/ industrial area	Natural	
IPM								
CHPP Process Pond	0.0	0.0	4.7	0.0	0.0	0.0	13.0	**17.7**
N1 Pit	5.8	54.4	29.3	90.3	129.3	0.0	0.7	**310**
N1 SD	0.0	0.0	29.7	171.4	3.5	0.0	79.9	**285**
S2 Pit	2.2	27.8	9.0	36.3	29.7	0.0	0.0	**105**
S2 SD	0.0	0.0	8.4	45.5	0.1	0.0	0.2	**54.2**
S3 Pit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
S3 SD	0.3	0.0	4.5	130.5	0.0	0.0	1.3	**137**
Raw Water Dam	0.0	0.0	1.5	0.0	0.0	0.0	0.0	**1.5**
RD1	0.0	0.0	57.3	0.0	0.0	25.1	76.2	**159**
RD2	0.0	0.0	28.6	66.3	0.5	0.0	14.5	**110**
SD 6	17.5	0.0	2.6	2.4	0.0	0.0	3.5	**26.1**
IPE/IPEE								
Pit 2 & 3	4.4	20.0	2.3	7.7	117.8	0.0	0.0	**152**
Pit 2S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Pit 4 & 4N	8.9	52.8	5.6	22.8	200.4	0.0	0.0	**290**
Pit 5	4.8	9.4	0.8	5.4	20.4	0.0	0.3	**41.1**
SD 2	5.5	0.0	9.2	75.5	12.8	0.0	0.0	**103**
SD 3a	8.0	0.0	10.2	0.0	0.0	0.0	20.2	**38.4**
SD 3b	13.5	0.0	3.4	59.7	10.2	0.0	0.0	**86.9**
SD 4a	2.1	0.0	4.7	20.5	7.2	0.0	0.1	**34.5**
SD 4b	15.0	0.0	10.0	56.9	1.5	0.0	0.0	**83.4**
SD 5	2.7	0.0	3.7	30.1	11.7	0.0	0.0	**48.2**

Table A.5 – Land use and catchment breakdown, Stage 5

Catchment	Contributing area (ha)							Total (ha)
	Cleared/ pre-strip	Mining Pit	Roads/ hardstand	Rehabilitated spoil	Spoil dump	Stockpile/ industrial area	Natural	
IPM								
CHPP Process Pond	0.0	0.0	4.7	0.0	0.0	0.0	13.0	**17.7**
N1 Pit	5.8	54.4	24.7	96.6	123.1	0.0	0.7	**305**
N1 SD	0.0	0.0	29.7	171.4	3.5	0.0	79.9	**285**
S2 Pit	2.2	27.8	9.0	36.3	29.7	0.0	0.0	**105**
S2 SD	0.0	0.0	8.4	45.5	0.1	0.0	0.2	**54.2**
S3 Pit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
S3 SD	0.3	0.0	4.5	130.5	0.0	0.0	1.3	**137**
Raw Water Dam	0.0	0.0	1.5	0.0	0.0	0.0	0.0	**1.5**
RD1	0.0	0.0	57.3	0.0	0.0	25.1	76.2	**159**
RD2	0.0	0.0	28.6	66.3	0.5	0.0	14.5	**110**
SD 6	17.5	0.0	2.6	2.4	0.0	0.0	3.5	**26.1**
IPE/IPEE								
Pit 2 & 3	2.2	20.0	0.2	38.8	29.6	0.0	0.0	**89**
Pit 2S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Pit 4 & 4N	5.5	54.1	4.0	118.0	54.3	0.0	0.0	**236**
Pit 5	4.4	8.3	0.0	13.0	13.6	0.0	0.3	**39.5**
SD 2	0.0	0.0	9.2	118.8	0.0	0.0	0.0	**128**
SD 3a	6.2	0.0	10.9	2.4	0.0	0.0	20.2	**39.6**
SD 3b	0.0	0.0	2.7	76.6	0.0	0.0	0.0	**79.3**
SD 4a	2.1	0.0	6.1	41.9	0.0	0.0	0.1	**50.1**
SD 4b	0.0	0.0	10.0	71.2	0.0	0.0	0.0	**81.2**
SD 5	0.0	0.0	1.9	47.9	0.0	0.0	0.0	**49.8**

Table A.6 – Land use and catchment breakdown, Stage 6

Catchment	Contributing area (ha)							Total (ha)
	Cleared/ pre-strip	Mining Pit	Roads/ hardstand	Rehabilitated spoil	Spoil dump	Stockpile/ industrial area	Natural	
IPM								
CHPP Process Pond	0.0	0.0	4.7	0.0	0.0	0.0	13.0	**17.7**
N1 Pit	5.8	54.4	24.6	169.2	50.4	0.0	0.7	**305**
N1 SD	0.0	0.0	29.7	175	0.0	0.0	79.9	**285**
S2 Pit	2.2	27.8	9.0	36.3	29.7	0.0	0.0	**105**
S2 SD	0.0	0.0	8.4	45.5	0.1	0.0	0.2	**54.2**
S3 Pit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
S3 SD	0.3	0.0	4.5	130.5	0.0	0.0	1.3	**137**
Raw Water Dam	0.0	0.0	1.5	0.0	0.0	0.0	0.0	**1.5**
RD1	0.0	0.0	57.3	0.0	0.0	25.1	76.2	**159**
RD2	0.0	0.0	28.6	66.3	0.5	0.0	14.5	**110**
SD 6	17.5	0.0	2.6	2.4	0.0	0.0	3.5	**26.1**
IPE/IPEE								
Pit 2 & 3	0.0	17.8	0.2	46.2	24.6	0.0	0.0	**89**
Pit 2S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Pit 4 & 4N	5.5	54.1	0.0	145.9	39.9	0.0	0.0	**236**
Pit 5	4.4	8.3	0.0	17.3	13.6	0.0	0.3	**39.5**
SD 2	0.0	0.0	0.0	128.0	0.0	0.0	0.0	**128**
SD 3a	0.0	0.0	2.4	17.0	0.0	0.0	20.2	**39.6**
SD 3b	0.0	0.0	1.7	77.4	0.0	0.0	0.0	**79.2**
SD 4a	0.0	0.0	1.3	48.8	0.0	0.0	0.1	**50.1**
SD 4b	0.0	0.0	3.4	79.1	0.0	0.0	0.0	**82.5**
SD 5	0.0	0.0	1.9	48.5	0.0	0.0	0.0	**50.3**

A2 IPM stage storage curves

Table A.7 - CHPP Process Pond

Height (mAHD)	Area (ha)	Volume (ML)
229.0	0.1	0.0
230.0	0.2	1.5
231.0	0.3	3.8
232.0	0.3	6.7
233.0	0.4	10.3
234.0	0.5	14.6
234.5	0.5	17.0

Table A.8 - N1 Pit (Stage 1 - 5)

Height (mAHD)	Area (ha)	Volume (ML)
148	0.0	0
149	0.1	1
150	0.4	3
155	2.8	83
160	5.3	284
165	9.5	656
170	14.2	1,250
175	18.3	2,069
180	22.2	3,075
185	25.8	4,273
190	29.4	5,655
195	33.5	7,225
200	38.0	9,009
205	45.6	11,089
210	54.4	13,578
215	62.0	16,502
217	64.7	17,770
220	68.9	19,773
225	78.1	23,429

Table A.9 - N1 Pit (Stage 6)

Height (mAHD)	Area (ha)	Volume (ML)
150	0.0	0
155	1.0	23
160	1.9	93
165	4.7	255
170	8.3	580
175	11.5	1,083
180	14.5	1,727
185	16.7	2,505
190	19.4	3,410
195	22.2	4,446
200	25.5	5,636
205	30.5	7,033
210	34.1	8,649
215	37.4	10,436
217	38.7	11,197
220	40.6	12,385
225	44.3	14,503

Table A.10 - N1 SD

Height (mAHD)	Area (ha)	Volume (ML)
222.4	0.09	0.0
222.5	0.28	0.2
223.0	1.08	3.4
223.5	3.16	14.5
224.0	3.49	31.3
224.5	3.72	49.28

Table A.11 - S2 Pit

Height (mAHD)	Area (ha)	Volume (ML)
150	0.4	0
151	0.7	6
152	1.1	14
153	1.5	27
154	2.3	46
155	4.1	78
160	7.3	373
165	9.2	788
170	11.1	1,292
175	12.7	1,889
180	14.1	2,560
185	15.6	3,302
190	19.3	4,158
195	22.4	5,201
200	25.0	6,387
205	27.1	7,690
210	29.4	9,103
215	35.1	10,724
220	39.6	12,587
225	44.0	14,676
226	45.2	15,122
227	46.8	15,582

Table A.12 - S2 SD

Height (mAHD)	Area (ha)	Volume (ML)
214	0	0.1
215	0.58	3
216	1.02	11
217	1.72	24.7
218	1.74	42
219	2.4	62.7
220	2.5	87.2
221	3.26	116
222	3.42	149.4
222.6	3.98	171.6
223.6	4.1	212
214	0	0.1

Table A.13 - S3 Pit

Height (mAHD)	Area (ha)	Volume (ML)
155.0	0.0	0
160.0	4.5	113
165.0	5.9	373
170.0	7.8	715
175.0	9.5	1,148
180.0	11.5	1,670
185.0	13.8	2,301
190.0	16.0	3,048
195.0	17.8	3,892
200.0	20.2	4,833
205.0	28.2	6,033
210.0	33.6	7,585
215.0	38.8	9,417
217.0	40.2	10,207
220.0	42.2	11,442
225.0	46.5	13,657

Table A.14 - S3 SD (Stages 2 - 6)

Height (mAHD)	Area (ha)	Volume (ML)
0.00	0.70	0.0
0.25	0.76	1.8
0.50	0.82	3.8
0.75	0.88	5.9
1.00	0.94	8.2
1.25	1.00	10.6
1.50	1.05	13.2
1.75	1.11	15.9
2.00	1.17	18.7
2.25	1.23	21.7
2.50	1.29	24.9
2.75	1.35	28.2
3.00	1.41	31.6

Table A.15 - RD1

Height (mAHD)	Area (ha)	Volume (ML)
217.5	0	0
218.0	0.1	2
218.5	0.2	4
219.0	0.6	11
219.5	2.2	22
220.0	3.5	38
220.5	5.6	59
221.0	8.2	89
221.5	11.9	125
222.0	15.0	167
222.4	16.2	205
222.8	16.2	270

Table A.16 - RD2

Height (mAHD)	Area (ha)	Volume (ML)
220.9	0.8	0
221.0	1	0.07
221.5	7.1	25.01
222.0	7.5	60.52
222.5	8	98.6
223.0	8.7	139.21
223.1	8.8	147.71

Table A.17 - SD 6 (Stages 2 - 6)

Height (mAHD)	Area (ha)	Volume (ML)
0.00	0.13	0.0
0.25	0.15	0.4
0.50	0.16	0.7
0.75	0.17	1.1
1.00	0.18	1.6
1.25	0.19	2.0
1.50	0.20	2.5
1.75	0.21	3.0
2.00	0.22	3.6
2.25	0.24	4.2
2.50	0.25	4.8
2.75	0.26	5.4
3.00	0.27	6.1

A3 IPE/IPEE stage storage curves

Table A.18 - SD 2

Height (mAHD)	Area (ha)	Volume (ML)
0.00	0.52	0.0
0.25	0.57	1.4
0.50	0.61	2.8
0.75	0.66	4.4
1.00	0.70	6.1
1.25	0.74	7.9
1.50	0.79	9.8
1.75	0.83	11.9
2.00	0.87	14.0
2.25	0.92	16.2
2.50	0.96	18.6
2.75	1.01	21.0
3.00	1.05	23.6

Table A.19 - SD 3a

Height (mAHD)	Area (ha)	Volume (ML)
0.00	0.20	0.0
0.25	0.22	0.5
0.50	0.23	1.1
0.75	0.25	1.7
1.00	0.27	2.3
1.25	0.28	3.0
1.50	0.30	3.8
1.75	0.32	4.5
2.00	0.33	5.4
2.25	0.35	6.2
2.50	0.37	7.1
2.75	0.38	8.0
3.00	0.40	9.0

Table A.20 - SD 3b

Height (mAHD)	Area (ha)	Volume (ML)
0.00	0.40	0.0
0.25	0.44	1.1
0.50	0.47	2.2
0.75	0.50	3.4
1.00	0.54	4.7
1.25	0.57	6.1
1.50	0.61	7.6
1.75	0.64	9.1
2.00	0.67	10.8
2.25	0.71	12.5
2.50	0.74	14.3
2.75	0.77	16.2
3.00	0.81	18.2

Table A.21 - SD 4a

Height (mAHD)	Area (ha)	Volume (ML)
0.00	0.27	0.0
0.25	0.29	0.7
0.50	0.31	1.4
0.75	0.33	2.2
1.00	0.35	3.1
1.25	0.38	4.0
1.50	0.40	5.0
1.75	0.42	6.0
2.00	0.44	7.1
2.25	0.46	8.2
2.50	0.49	9.4
2.75	0.51	10.6
3.00	0.53	11.9

Table A.22 - SD 4b

Height (mAHD)	Area (ha)	Volume (ML)
0.00	0.46	0.0
0.25	0.50	1.2
0.50	0.54	2.5
0.75	0.58	3.9
1.00	0.62	5.4
1.25	0.66	7.0
1.50	0.70	8.7
1.75	0.73	10.5
2.00	0.77	12.4
2.25	0.81	14.4
2.50	0.85	16.4
2.75	0.89	18.6
3.00	0.93	20.9

Table A.23 - SD 5

Height (mAHD)	Area (ha)	Volume (ML)
0.00	0.38	0.0
0.25	0.41	1.0
0.50	0.44	2.1
0.75	0.48	3.2
1.00	0.51	4.4
1.25	0.54	5.7
1.50	0.57	7.1
1.75	0.60	8.6
2.00	0.63	10.1
2.25	0.67	11.8
2.50	0.70	13.5
2.75	0.73	15.2
3.00	0.76	17.1

Table A.24 - Pit 2 & 3 (Stage 1)

Height (mAHD)	Area (ha)	Volume (ML)
196	0.0	0
200	0.9	14
204	1.9	71
208	4.3	195
212	7.6	436
216	12.1	834
220	18.6	1,440
224	25.9	2,322
228	32.8	3,499
230	35.4	4,182

Table A.25 - Pit 2 & 3 (Stage 2)

Height (mAHD)	Area (ha)	Volume (ML)
188	0.0	0
192	0.2	3
196	0.7	19
200	3.0	84
204	7.1	286
208	12.2	659
212	19.1	1,272
216	25.1	2,165
220	31.2	3,289
224	39.0	4,689
228	46.1	6,387
230	50.0	7,345
234	57.3	9,492

Table A.26 - Pit 2 & 3 (Stage 3)

Height (mAHD)	Area (ha)	Volume (ML)
178	0.0	0
182	1.1	16
186	3.9	106
190	8.0	340
194	11.8	735
198	14.0	1,251
202	16.8	1,870
206	19.3	2,597
210	21.8	3,417
214	25.5	4,354
218	33.1	5,509
222	39.2	6,969
226	44.5	8,643
230	49.7	10,526
234	57.0	12,652

Table A.27 - Pit 2 & 3 (Stage 4)

Height (mAHD)	Area (ha)	Volume (ML)
142	0.0	0
146	1.3	21
150	2.4	94
154	3.5	213
158	4.7	373
162	5.9	586
166	6.7	837
170	7.4	1,119
174	8.3	1,433
178	9.5	1,790
182	11.1	2,201
186	12.4	2,669
190	14.3	3,202
198	18.8	4,524
202	20.9	5,316
206	24.5	6,214
210	29.0	7,281
214	33.7	8,541
218	37.6	9,970
222	39.8	11,519
226	41.7	13,147
230	44.0	14,860
234	46.7	16,673

Table A.28 - Pit 2 & 3 (Stages 5 & 6)

Height (mAHD)	Area (ha)	Volume (ML)
142	0.0	0
146	1.2	19
150	2.4	90
154	3.4	208
158	4.6	366
162	5.8	577
166	6.6	827
170	7.4	1,108
174	8.3	1,422
178	9.5	1,779
182	11.0	2,189
186	12.4	2,656
190	14.3	3,188
194	16.5	3,800
198	18.7	4,505
202	20.7	5,293
206	24.0	6,179
210	28.1	7,220
214	32.2	8,431
218	35.5	9,789
222	37.3	11,247
226	38.9	12,770
230	40.7	14,360
234	42.8	16,029

Table A.29 - Pit 2S (Stage 2)

Height (mAHD)	Area (ha)	Volume (ML)
208	0.1	0
210	0.3	4
212	0.8	15
214	1.2	35
216	1.6	63
218	1.9	97
220	2.3	139
222	2.6	188
224	2.8	242
226	3.1	301
228	3.4	367
230	3.7	438
232	4.1	516
233	4.3	558

Table A.30 - Pit 4 (Stages1)

Height (mAHD)	Area (ha)	Volume (ML)
190	0.0	0
195	0.3	4
200	1.5	37
205	4.4	168
210	8.8	521
215	11.2	1,022
220	13.7	1,652
225	16.7	2,405
230	20.5	3,335
233	23.0	3,988

Table A.31 - Pit 4 (Stage 2)

Height (mAHD)	Area (ha)	Volume (ML)
175	0.0	0
180	0.2	3
185	1.0	33
190	2.5	119
195	4.1	282
200	5.6	527
205	7.3	845
210	9.9	1,267
215	13.1	1,835
220	16.6	2,575
225	19.8	3,485
230	23.5	4,560
233	26.8	5,308

Table A.32 - Pit 4 (Stage 3)

Height (mAHD)	Area (ha)	Volume (ML)
135	0.0	0
140	0.5	14
145	1.1	52
150	1.6	120
155	2.1	212
160	3.6	351
170	10.0	1,059
180	18.2	2,469
185	21.1	3,451
190	26.2	4,613
195	35.6	6,154
200	42.0	8,118
205	46.2	10,321
210	52.1	12,764
215	59.1	15,548
220	66.9	18,708
225	74.6	22,240
230	82.1	26,156

Table A.33 - Pit 4 (Stage 4)

Height (mAHD)	Area (ha)	Volume (ML)
113	0.0	0
120	2.4	77
130	5.9	501
140	9.6	1,265
150	17.9	2,632
160	27.4	4,911
165	31.4	6,378
170	35.1	8,044
175	38.2	9,877
180	41.6	11,871
190	50.9	16,483
200	61.7	22,115
205	67.6	25,343
210	75.0	28,896
215	82.4	32,833
220	90.2	37,147
225	98.1	41,849
230	106.1	46,949

Table A.34 - Pit 4 (Stages 5 & 6)

Height (mAHD)	Area (ha)	Volume (ML)
114	0.0	0
115	0.5	3
120	2.5	83
125	4.3	250
130	5.9	512
135	7.8	844
140	9.6	1,273
145	13.5	1,854
150	17.5	2,628
155	22.6	3,620
160	26.7	4,857
165	30.6	6,290
170	34.3	7,918
175	37.2	9,706
180	40.4	11,647
185	44.5	13,765
190	49.0	16,107
195	54.1	18,688
200	59.3	21,526
205	64.8	24,626
210	71.6	28,024
215	78.2	31,774
220	85.3	35,861
225	92.4	40,300
230	99.9	45,097

Table A.35 - Pit 5 (Stage 2)

Height (mAHD)	Area (ha)	Volume (ML)
180	0.0	0
185	0.1	2
190	0.5	17
195	1.2	57
200	2.3	145
205	3.1	279
210	4.1	456
215	7.8	745
220	12.5	1,247
225	15.3	1,948
230	17.8	2,765
231	18.2	2,945

Table A.36 - Pit 5 (Stages 3 - 6)

Height (mAHD)	Area (ha)	Volume (ML)
155	0.0	0
160	1.7	31
165	2.7	143
170	3.5	295
175	4.4	496
180	5.1	736
185	5.9	1,011
190	7.0	1,331
195	8.1	1,708
200	8.9	2,132
205	10.0	2,603
210	11.8	3,148
215	13.3	3,780
220	14.4	4,475
225	15.5	5,224
230	16.9	6,033
231	17.3	6,203

Appendix B Hydrologic and hydraulic modelling

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B1 Hydrological model

B1.1 OVERVIEW

A hydrological model was developed of the study area using the XP-RAFTS runoff-routing model (Innovyze, 2019). This section of the report describes the development, configuration and calibration of the hydrological model.

The XP-RAFTS model was calibrated to hydrographs for Smoky Creek recorded upstream of IPM for two flow events (February 2016 and March 2017).

The calibration XP-RAFTS model was then used to estimate design discharges for Smoky Creek and Billy's Gully for input into the hydraulic model. Design flood discharge hydrographs were estimated for the 1% and 0.1% AEP design.

B1.2 HYDROLOGIC MODEL CONFIGURATION

B1.2.1 Spatial configuration

Figure B.1 shows the XP-RAFTS model configuration of Smoky Creek and Billy's Gully. The model consists of a total of 34 sub-catchments, ranging in size from 0.25 km^2 to 22.3 km^2. This includes 26 sub-catchments for Smoky Creek and 8 sub-catchments for Billy's Gully.

B1.2.2 Sub-catchment parameters

The XP-RAFTS model uses a single sub-catchment approach to determine runoff hydrographs, based on the overall sub-catchment parameters (fraction impervious, roughness and slope). Sub-catchment fraction impervious and roughness (PERN 'n') parameters were weighted based on the various land use types in each sub-catchment based from available topographic data and aerial photographs.

Model parameters for each sub-catchment were determined as follows:

- A percentage impervious of zero was adopted for all sub-catchments;
- Catchment slopes were determined based on the available topographic data;
- A sub-catchment storage coefficient multiplication factor 'Bx' of 1.0 was adopted for all events;
- A sub-catchment PERN 'n' value was 0.05 for sub-catchments was adopted for all events; and
- The selection of initial and continuing losses for design events is described in Section B1.4.5.

Channel routing was modelled using the RAFTS method, based on the channel length and average channel slope for each "link" between catchment nodes

Table C.1 summarises the model catchment areas and vectored slopes for each waterway.

Table B.1 – XP-RAFTS model sub-catchment parameters

XP-RAFTS sub-catchment	Area (km^2)	Vectored slope (%)	XP-RAFTS sub-catchment	Area (km^2)	Vectored slope (%)
Smoky Creek			SC18	2.6	1.1
SC01	8.0	1.5	SC19	4.1	0.5
SC02	13.5	1	SC19b	0.3	1.4
SC03	19.4	1.7	SC20	2.3	1.0
SC04	22.3	0.8	SC21	5.4	0.6
SC05	3.8	1	SC22	1.7	0.6
SC06	6.5	1.08	SC23	5.5	1.6
SC07	5.8	1.5	SC24	1.5	0.1
SC08	5.0	1	SC25	5.6	0.2
SC09	4.1	0.6	*Billy's Gully*		
SC10	2.8	0.9	BG01	10.8	1.5
SC11	4.0	1.12	BG02	17.9	1.2
SC12	4.7	1.1	BG03	7.8	1.7
SC13	2.2	2.9	BG04	2.6	1.1
SC14	11.5	1.1	BG05	6.0	1.2
SC15	5.6	0.8	BG06	5.0	0.6
SC16	5.4	1.15	BG07	2.7	0.6
SC17	2.8	1.33	BG08	15.0	0.4

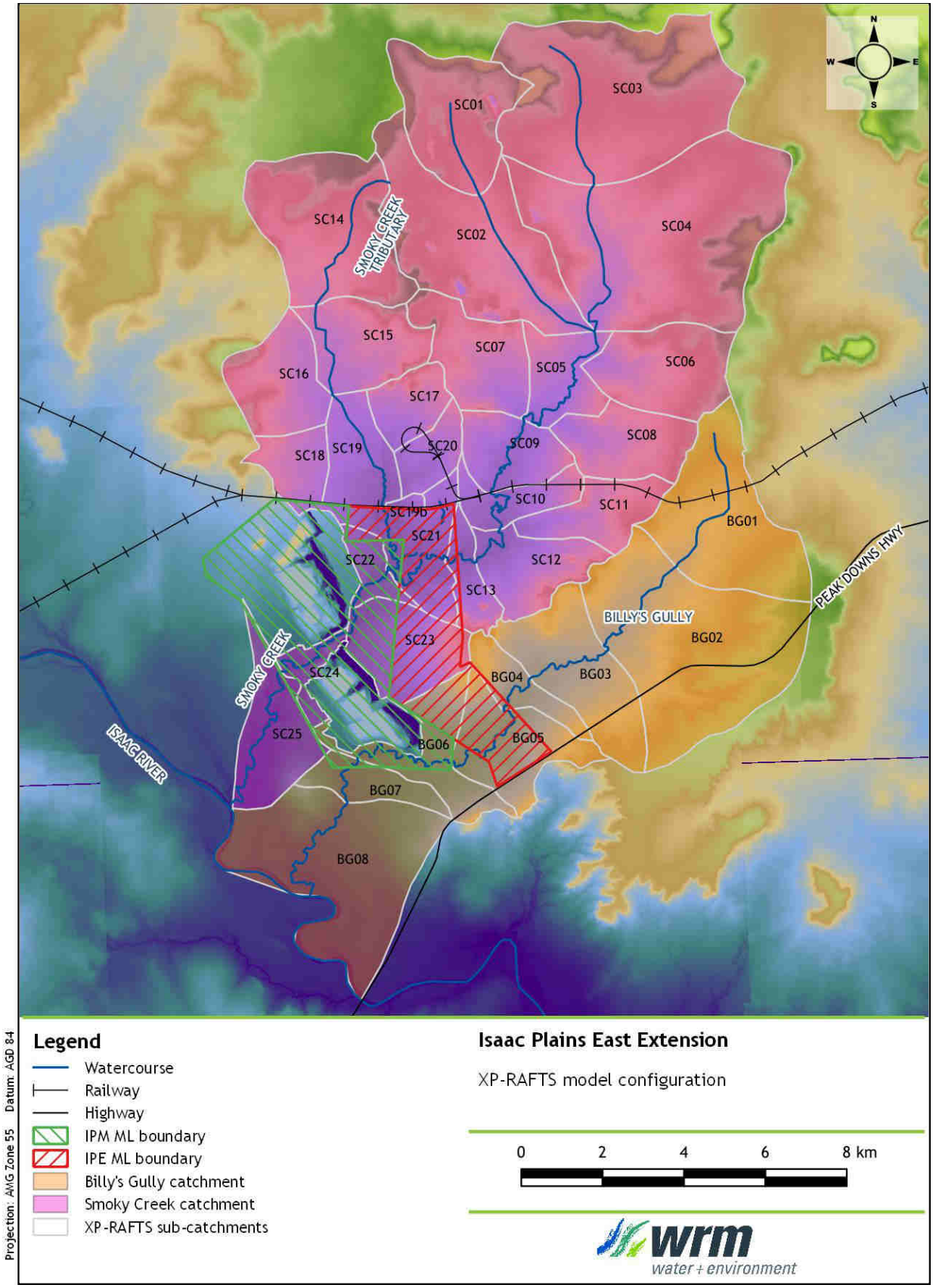

Figure B.1 – XP-RAFTS model configuration

B1.3 HYDROLOGIC MODEL CALIBRATION

B1.3.1 Methodology

The XP-RAFTS model was calibrated to hydrographs recorded at the Smoky Creek Upstream IPM (station no. 332401) gauge for flow events (February 2016 and March 2017). The routing parameters and losses were adjusted to match the timing and magnitude of peak discharge in the recorded hydrograph.

Each sub-catchment of the model was assigned the rainfall from the nearest rainfall station. A constant loss model (initial loss/continuing loss) was adopted uniformly for all sub-catchments.

B1.3.2 Available data

The available data for the two calibration events is summarised in Table C.2. The water level recorded for Smoky Creek Upstream IPM was converted into continuous streamflow data using a water level vs discharge curve obtained for the gauge location from the hydraulic model. The XP-RAFTS model was calibrated using sub-daily rainfall data as well as streamflow data recorded for Smoky Creek Upstream IPM. Table C.3 shows the date range and peak discharges for each of the calibration events.

Table B.2 - Available rainfall and streamflow data

Station ID	Station name	Data type	Data frequency	Source	Calibration event	
					Feb-16	Mar-17
332401	Smoky Creek Upstream IPM	Water level	Continuous	Stanmore	✓	✓
332404	Isaac Plains AWS	Rainfall	Sub-daily	Stanmore	-	✓
	Broadlea AWS	Rainfall	Sub-daily	Vale	✓	-

Table B.3 - Adopted calibration events, Isaac River catchment

Calibration event	Start date	Event duration (days)	Recorded peak discharge (m^3/s)
February 2016	31/01/2016	7	371
March 2017	27/03/2017	4	484

B1.3.3 Calibration results

The calibration of the XP-RAFTS model was achieved by adjusting the catchment and routing parameters and adjusting initial and continuing rainfall losses to obtain the best fit between recorded and predicted discharge hydrographs. The adopted initial and continuing losses for the two events are shown in Table C.4.

Table C.5 compares recorded and predicted peak discharges at the Smoky Creek gauging station.

Table B.4 – Adopted initial and continuing loss rates, calibration events

Calibration event	Initial loss (mm)	Continuing loss (mm)
February 2016	44	1.4
March 2017	70	0.5

Table B.5 – Comparison of recorded and modelled peak flood discharges, Smoky Creek upstream IPM gauging station

Calibration event	Peak discharge (m^3/s)		Difference (%)
	Recorded	Modelled	
February 2016	371	369	0.5
March 2017	484	314	42.7

February 2016 calibration

Figure B.2 show comparisons of recorded and predicted discharge hydrographs at the upstream IPM gauging station for the February 2016 event. A good calibration was achieved for the gauge, with the XP-RAFTS model satisfactorily reproducing the flood peak, timing and shape of the hydrograph.

March 2017 calibration

Figure B.3 show comparisons of recorded and predicted discharge hydrographs at the upstream IPM gauging station for the March 2017 event. The model reproduced the timing and shape of the hydrograph relatively well. However, the model underestimates the peak discharge and flood volumes. This is likely due to spatial variation in rainfall that was not covered by the recorded rainfall data. Only one pluviograph, located at the downstream end of the catchment, was available to represent rainfall over the entire catchment for the 2017 event.

B1.3.4 Summary

Overall the calibration of the XP-RAFTS hydrological model is considered acceptable. There is a less than 0.5% difference between the XP-RAFTS hydrologic model predicted peak discharge at the upstream IPM gauge and the recorded peak discharge for the 2016 calibration event. This is considered a good calibration of the XP-RAFTS hydrological model for Smoky Creek at the upstream IPM gauge for timing and peak flow.

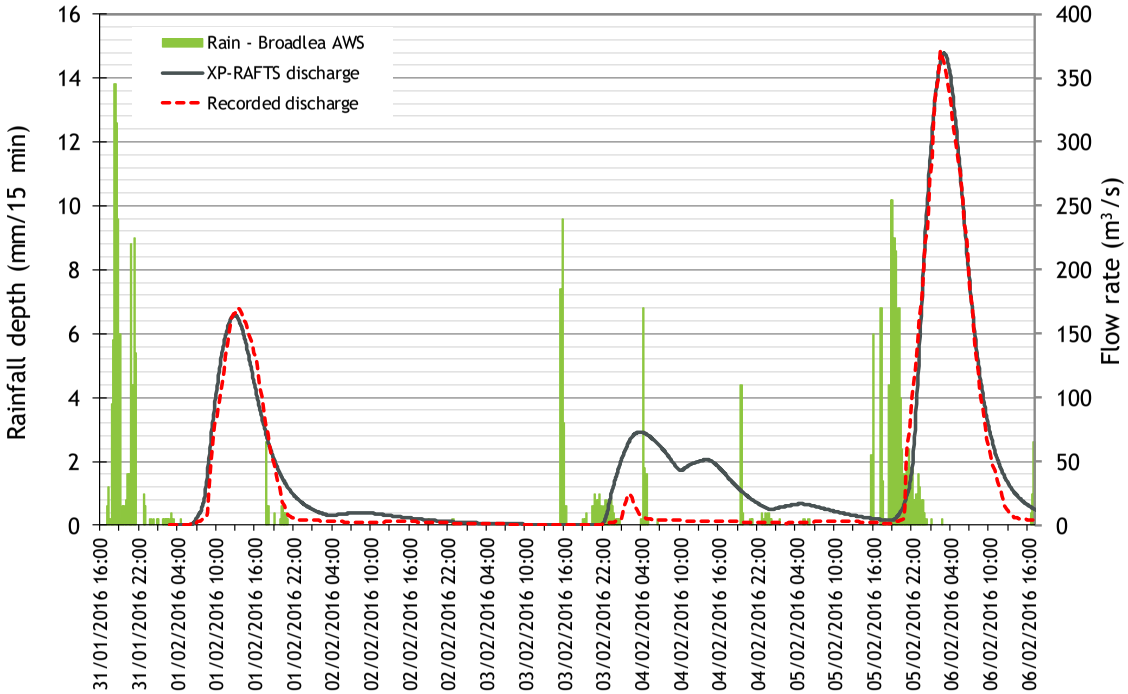

Figure B.2 – Comparison of recorded and modelled discharge hydrographs, February 2016, Smoky Creek upstream IPM

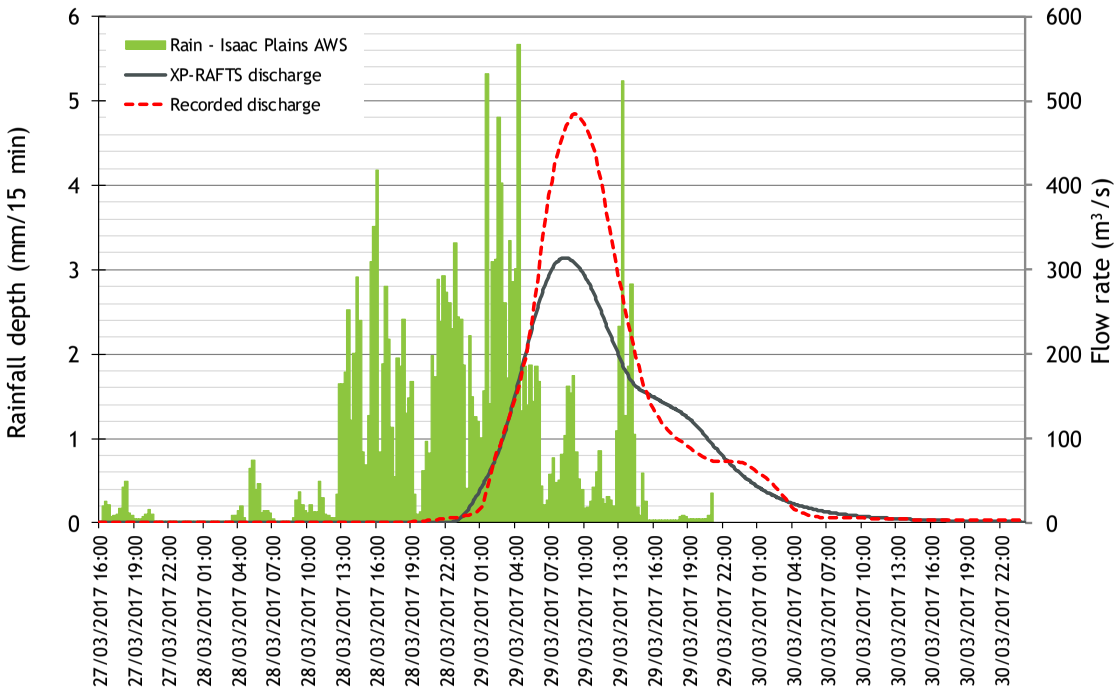

Figure B.3 – Comparison of recorded and modelled discharge hydrographs, March 2017, Smoky Creek upstream IPM

B1.4 DESIGN HYDROLOGY

B1.4.1 Overview

AR&R methodology (Ball et al., 2019) has been used to derive design rainfall estimates and design discharge estimates for the Smoky Creek and Billy's Gully catchments. Design rainfall data (rainfall depths, areal reduction factors and temporal patterns) was applied in accordance with procedures in AR&R (Ball et al., 2019), based on data downloaded from the AR&R Data Hub (Geoscience Australia, 2017). AR&R Data Hub (Geoscience Australia, 2017) downloads were based on the Smoky Creek and Billy's Gully catchment extents.

The flowing sections describe the derivation of the design rainfall and discharge estimates for the 1% and 0.1% AEP events.

B1.4.2 Design rainfall depths

Design rainfall depths and intensities for design events up to 0.1% AEP were derived using intensity-frequency duration (IFD) data obtained from the Bureau of Meteorology's (BOM's) 2016 Rainfall IFD Data System. Design rainfall IFDs were obtained based on a point location at the centroid of the Smoky Creek catchment to the Isaac River.

To obtain the design Smoky Creek and Billy's Gully hydrographs for input into the hydraulic model, the design rainfall depths and intensities were adjusted to be based on a point location at the centroid of the two catchments. Comparison of the IFDs at the centroid of both catchments revealed on average less than 1% difference in rainfall for the 1% AEP event across all durations.

Table C.6 shows the design rainfall depths adopted for the Smoky Creek and Billy's Gully catchments.

Table B.6 – Design rainfall depths for Smoky Creek and Billy's Gully catchments

Storm duration (hours)	Smoky Creek catchment		Billy's Gully catchment	
	1% AEP	0.1% AEP	1% AEP	0.1% AEP
1	82.9	133	83.2	133
1.5	94.9	152	95.3	152
2	104	166	104	167
3	118	188	118	188
4.5	133	214	134	214
6	146	235	146	234
9	168	270	168	269
12	187	300	186	298

B1.4.3 Spatial and area variability

A comparison of Smoky Creek and Billy's Gully IFDs at the southern, eastern and western catchment boundaries, and at the centroid, revealed on average less than 1% variance in rainfall for the 1% and 0.1% AEP events across all durations. Due to the small variation in design rainfall estimates over the catchment, a uniform spatial rainfall distribution was adopted across the catchment.

Areal reduction factors (ARFs) appropriate to Smoky Creek catchment and Billy's Gully (Semi-Arid Inland Queensland ARF region) was applied for design events up to 0.1% AEP rainfalls per the recommendation in AR&R (Ball et al., 2019). Table C.7 shows the adopted ARFs for both catchments for storm durations less than 12 hours.

Table B.7 - Areal reduction factors applied to Smoky Creek and Billy's Gully catchments

Storm duration (hours)	Smoky Creek		Billy's Gully	
	1% AEP	0.1% AEP	1% AEP	0.1% AEP
1	0.737	0.700	0.797	0.766
1.2	0.757	0.713	0.812	0.776
2	0.767	0.718	0.819	0.778
3	0.782	0.727	0.830	0.784
4.5	0.817	0771	0.859	0.820
6	0.858	0.830	0.892	0.868
9	0.895	0.879	0.922	0.908
12	0.904	0.888	0.929	0.915
18	0.923	0.915	0.942	0.937

B1.4.4 Temporal patterns

The East Coast North temporal patterns from AR&R Data Hub (Geoscience Australia, 2019) were used for the 1% and 0.1% AEP design events.

B1.4.5 Design rainfall losses

The initial (IL) and continuing loss (CL) method of accounting for rainfall losses was adopted for this assessment.

The recommended regional loss values for the Smoky Creek and Billy's Gully catchments from the AR&R Data Hub (Geoscience Australia, 2019) are an initial loss of 44.0 mm (prior to adjustment for preburst rainfall) and a continuing loss of 2.5 mm/h.

The AR&R recommended initial loss (44.0 mm) was adopted for the 1% AEP and adjusted by the median preburst depth associated with each event frequency and duration. The initial loss for the 0.1% AEP design rainfall was set to 0 mm as per the recommendations from AR&R for arid and semi-arid regions (Ball et al., 2019).

The continuing losses adopted for the calibration of the XP-RAFTS model (0.5 to 1.4 mm/h) were lower than the recommended 2.5 mm/h. A more conservative continuing loss of 1.4 mm/hr was adopted for the 1% and 0.1% AEP.

Table C.8 summaries the initial and continuing rainfall losses adopted in the XP-RAFTS model.

Table B.8 - Adopted initial and continuing losses

Source/scenario	Initial loss (mm)	Continuing loss (mm/hr)
AR&R Data hub	44	2.5
February 2016 calibration	44	1.4
March 2017 calibration	70	0.5
1% AEP	44	1.4
0.1% AEP	0	1.4

B1.4.6 Critical duration and adopted temporal pattern

The AR&R 2019 temporal pattern methodology involves the use of an 'ensemble' of 10 temporal patterns, which produces 10 design hydrographs (and peak discharges) for each duration for each AEP. The temporal pattern which results in a peak discharge closest to,

but higher than, the ensemble mean is selected as the representative temporal pattern for that storm duration.

Design storms from 1 hour to 12 hours were initially tested and a critical duration chosen for each design event at the Peak Downs Highway for the Smoky Creek and Billy's Gully catchments.

B1.5 ADOPTED DESIGN DISCHARGES

Based on the methodology described in AR&R (Ball et al, 2019), the design discharges were estimated for the 1% and 0.1% AEP events. Table C.9 shows the adopted peak design discharges for Smoky Creek and Billy's Gully.

To illustrate the range of peak discharges produced by the AR&R ensemble event methodology, Figure B.4 to Figure B.7 show box and whisker plots (box plots) to summarise the statistics of the XP-RAFTS model peak discharge results for the 1% and 0.1% AEP design events in Smoky Creek and Billy's Gully. The box plots present the maximum, minimum, median, average, 25th and 75th percentile predicted peak discharges based on the model results for the 10 design storms for each storm duration.

Table B.9 - Estimated design discharges, Smoky Creek and Billy's Gully

Design event	XP-RAFTS Ensemble mean peak discharge (m^3/s)	XP-RAFTS adopted design peak discharge (m^3/s)[1]	Critical storm duration (hours)	Temporal pattern
Smoky Creek				
1% AEP	497	509	12	3
0.1% AEP	1,041	1,046	6	3
Billy's Gully				
1% AEP	176	180	6	2
0.1% AEP	386	439	6	8

[1]Adopted design peak discharge calculated from the temporal pattern which generated a peak discharge closest to, but higher than, the ensemble mean.

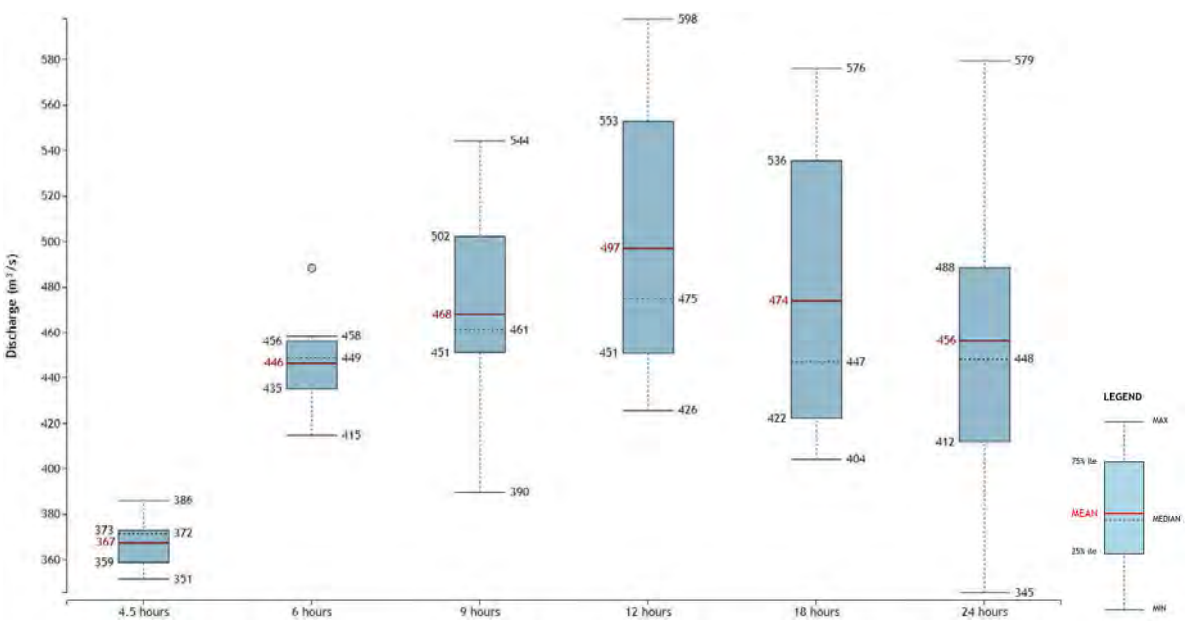

Figure B.4 - Box plot of XP-RAFTS 1% AEP predicted peak discharges in Smoky Creek

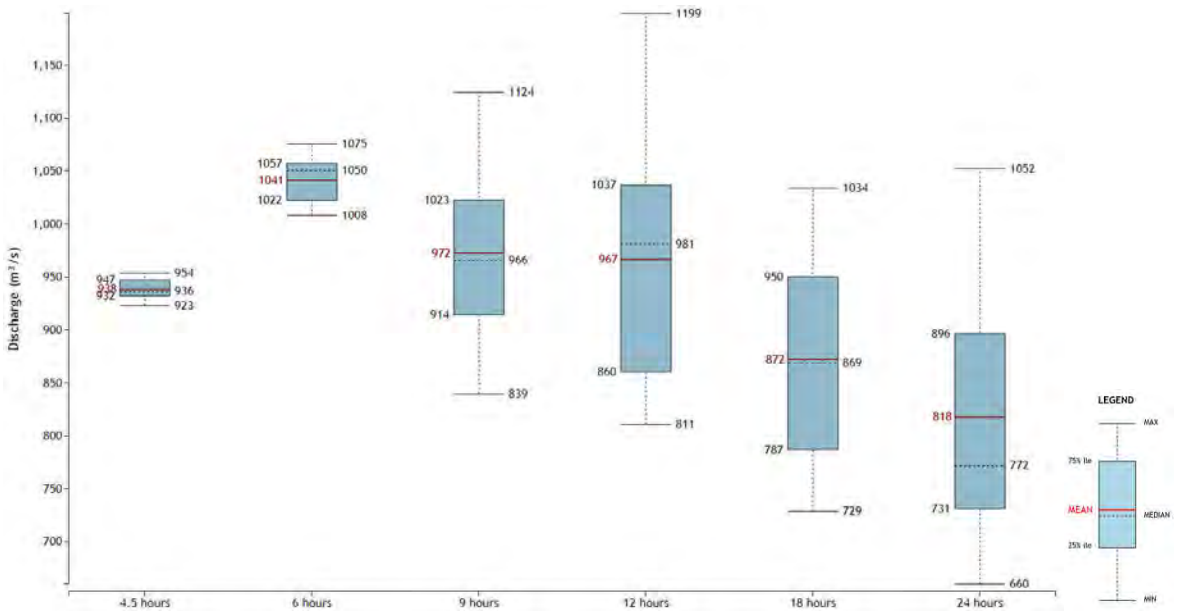

Figure B.5 – Box plot of XP-RAFTS 0.1% AEP predicted peak discharges in Smoky Creek

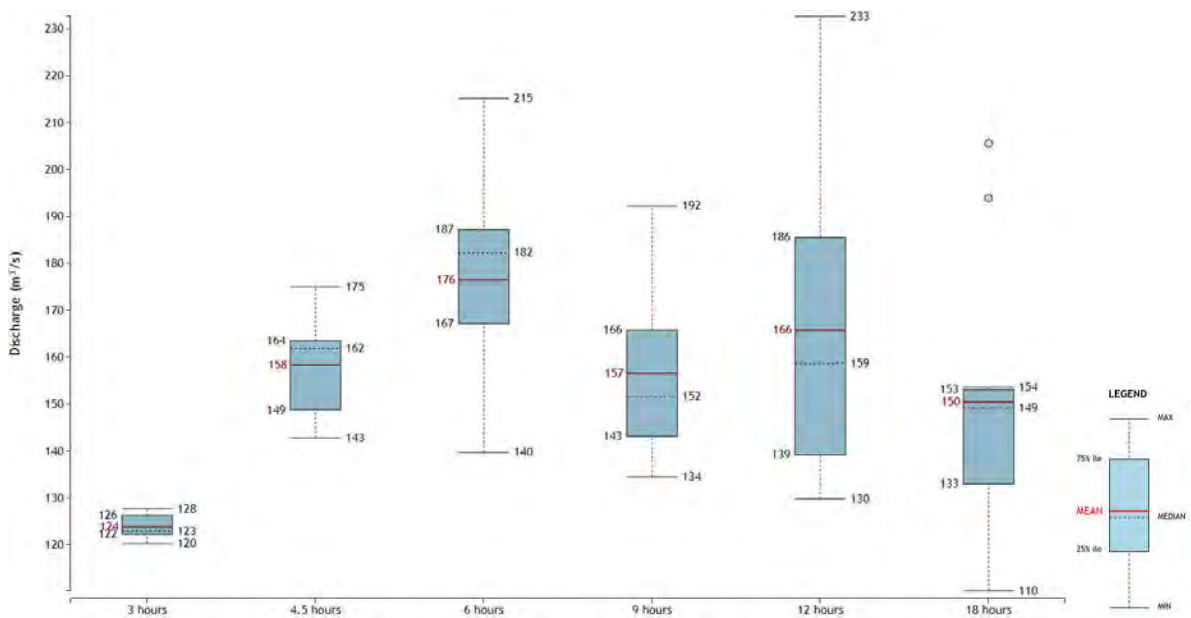

Figure B.6 - Box plot of XP-RAFTS 1% AEP predicted peak discharges in Billy's Gully

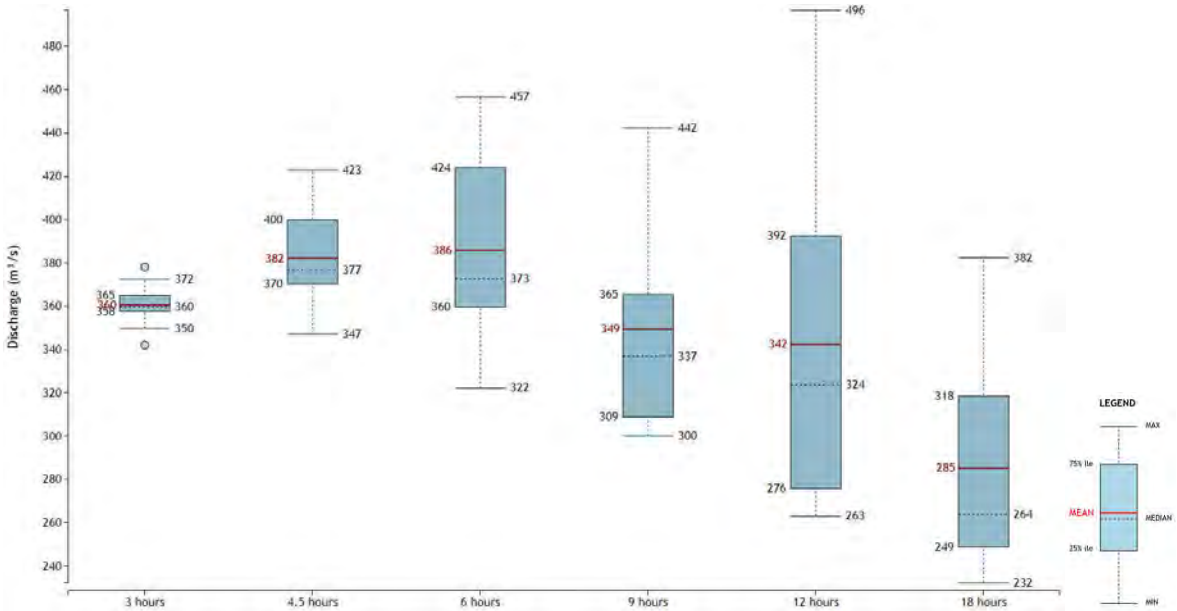

Figure B.7 – Box plot of XP-RAFTS 0.1% AEP predicted peak discharges in Billy's Gully

B2 Hydraulic model

B2.1 OVERVIEW

The TUFLOW hydrodynamic model (BMT, 2018a) was used to simulate the flow behaviour of Smoky Creek and Billy's Gully in the vicinity of the project.

TUFLOW represents hydraulic conditions on a fixed grid by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow (BMT, 2018b). The model automatically calculates breakout points and flow directions within the study area.

TUFLOW hydraulic models were developed for three scenarios:

- Approved Conditions - which includes the previously approved IPE mine plans;
- Operational Conditions – which includes the changes to the floodplain under the proposed IPEE mine plans; and
- Post-mining Conditions – which includes the proposed final landform for the project.

B2.2 APPROVED CONDITIONS MODEL CONFIGURATION

B2.2.1 Spatial configuration

Figure B.8 shows the configuration of the Approved Conditions TUFLOW model. The model extends approximately 1 km upstream and 6 km downstream of the project site and covers an area of some 20 km^2. A 5 m grid cell size was adopted for this model to obtain the best representation of flow distributions between the channel and floodplain.

Note that the Isaac River does not impact on flood levels in the project area as the ground levels in the project site are some 15 m to 20 m above the Isaac River bank level. For this reason, the hydraulic model does not include the Isaac River.

The Heavily Parallelised Compute (HPC) version of TUFLOW was used for all modelling. The HPC version of the TUFLOW model adaptively reduces the computation time-step during the simulation to maintain stability criteria across the model domain.

B2.2.2 Topographic data

The TUFLOW model uses topographic aerial survey data (LiDAR) supplied by Atlass via Stanmore. The ground surface model was obtained by LiDAR capture in September 2018. AAM quote the LiDAR data has a vertical RMS error of 0.04 m.

Overall, the available topographic data is considered suitable to assess the relative impacts of the project.

B2.2.3 Hydraulic roughness

Hydraulic roughness in the TUFLOW model is represented by Manning's 'n' roughness coefficients. The higher the roughness number, the more the flow would be impeded. Manning's 'n' values for the various land use types were selected based on typical published values (such as those in Chow (1959)). Land use types within the approved conditions model were identified using aerial photography supplied by Stanmore from October 2018.

The adopted Manning's 'n' values in the TUFLOW model are as follows:

- Channel bed (sand) - 'n' = 0.04;
- Light vegetation – 'n' = 0.045;
- Dense vegetation – 'n' = 0.06; and
- Road/track/compacted areas – 'n' = 0.015.

B2.2.4 Inflow and outflow boundary conditions

Figure B.8 shows the locations of the inflow boundaries in the hydraulic model. The model inflow boundaries were applied within the 2D model domain using surface-area "SA" polygons. Using this approach, flows are initially applied to the lowest point within each SA polygon. Design discharge hydrographs for these inflow boundaries were obtained from the XP-RAFTS hydrologic model.

The downstream boundaries of the hydraulic model were set well downstream of the project area to minimise their influence on predicted flood behaviour. The downstream outflow boundaries were configured as an automatically calculated stage-discharge (HQ) boundary. TUFLOW automatically calculates the stage-discharge relationship using the specified slope and hydraulic roughness at each boundary.

The adopted tailwater slopes are as follows:

- Smoky Creek – main channel: 0.5 %; and
- Billy's Gully – main channel: 0.5 %.

B2.2.5 Approved infrastructure

The approved mine plan required haul road crossing at two locations:

- The Smoky Creek tributary; and
- Across Billy's Gully, between Pit 1 and Pit 2.

The concept arrangement for the crossings is as follows:

- Two 0.9 m circular culverts at the invert of the waterway.
- Provide 0.3 m of cover to the culvert, to the deck level of the haul road embankment.
- Where required, grade at 10% to natural surface.

Figure B.8 shows the locations of the approved haul road crossings.

The approved mine plan includes a drainage plug across the minor drainage line at the northern end of Pit 4 to prevent backwater from inundating Pit 4 during extreme events in

the operational phase and another drainage plug on the northern side of Pit 1. The nominal locations of the proposed drainage plugs are shown in Figure B.8.

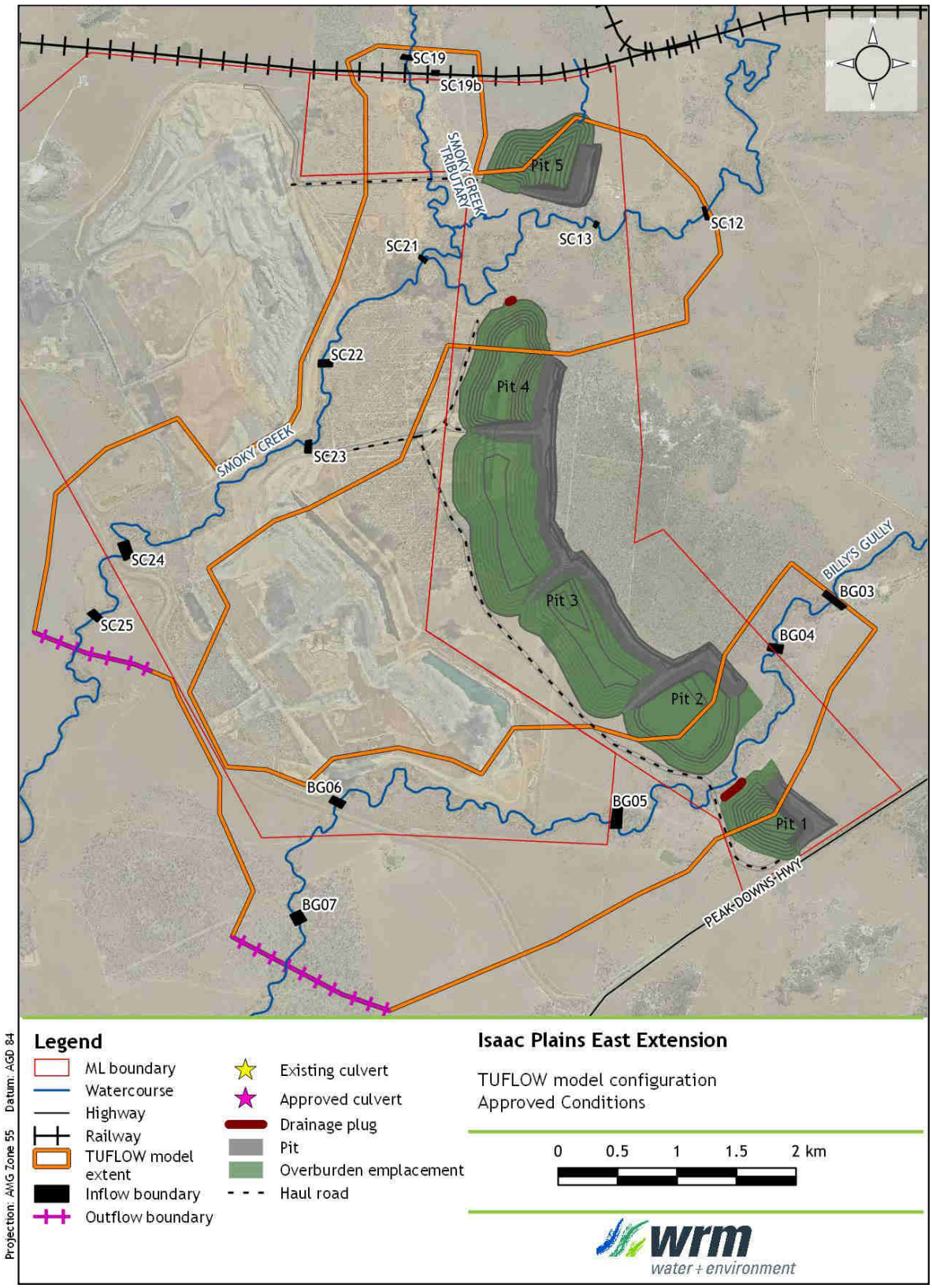

Figure B.8 – Hydraulic model configuration, Approved Conditions

B2.3 OPERATIONAL CONDITIONS MODEL CONFIGURATION

An Operational Conditions scenario was modelled to assess the flood impacts of the proposed mining pit protection levees during mining operations.

To determine the possible impacts on flooding behaviour resulting from the project, the approved conditions hydraulic model was amended as follows:

- inclusion of the flood protection levees along Pit 2 and Pit 4;
- inclusion of a haul road between Pit 4 and 5 with two culvert crossings. The concept arrangement of the additional culvert crossing is provided in Table C.10;
- widening of the two approved haul road crossings over Billy's Gully and Smoky Creek tributary from 35 m to 80 m;
- inclusion of an additional drainage plug at Pit 1; and
- removal of the Pit 4 drainage plug.

All other aspects of the operational conditions model configuration remained the same as the existing conditions model. Figure B.9 shows the configuration of the proposed TUFLOW model.

The operational conditions model was simulated for the 1% and 0.1% AEP event.

Table B.10 - Concept arrangement for additional culvert crossings

Crossing	Concept arrangement
Smoky Creek	3 x 1.2 m circular pipes with 0.3 m cover
Smoky Creek overflow path	1 x 0.6 m circular pipe with 0.3 m cover

B2.4 POST-MINING CONDITIONS MODEL CONFIGURATION

A Post-mining Conditions scenario was modelled to assess the flood impacts of the final project landforms once mining has ceased. The Post-Mining Conditions model configuration differs from the operational case through removal of the mining pit protection levees and haul roads and the inclusion of the proposed final landform.

The final landform modelling configuration was simulated for the 0.1% event.

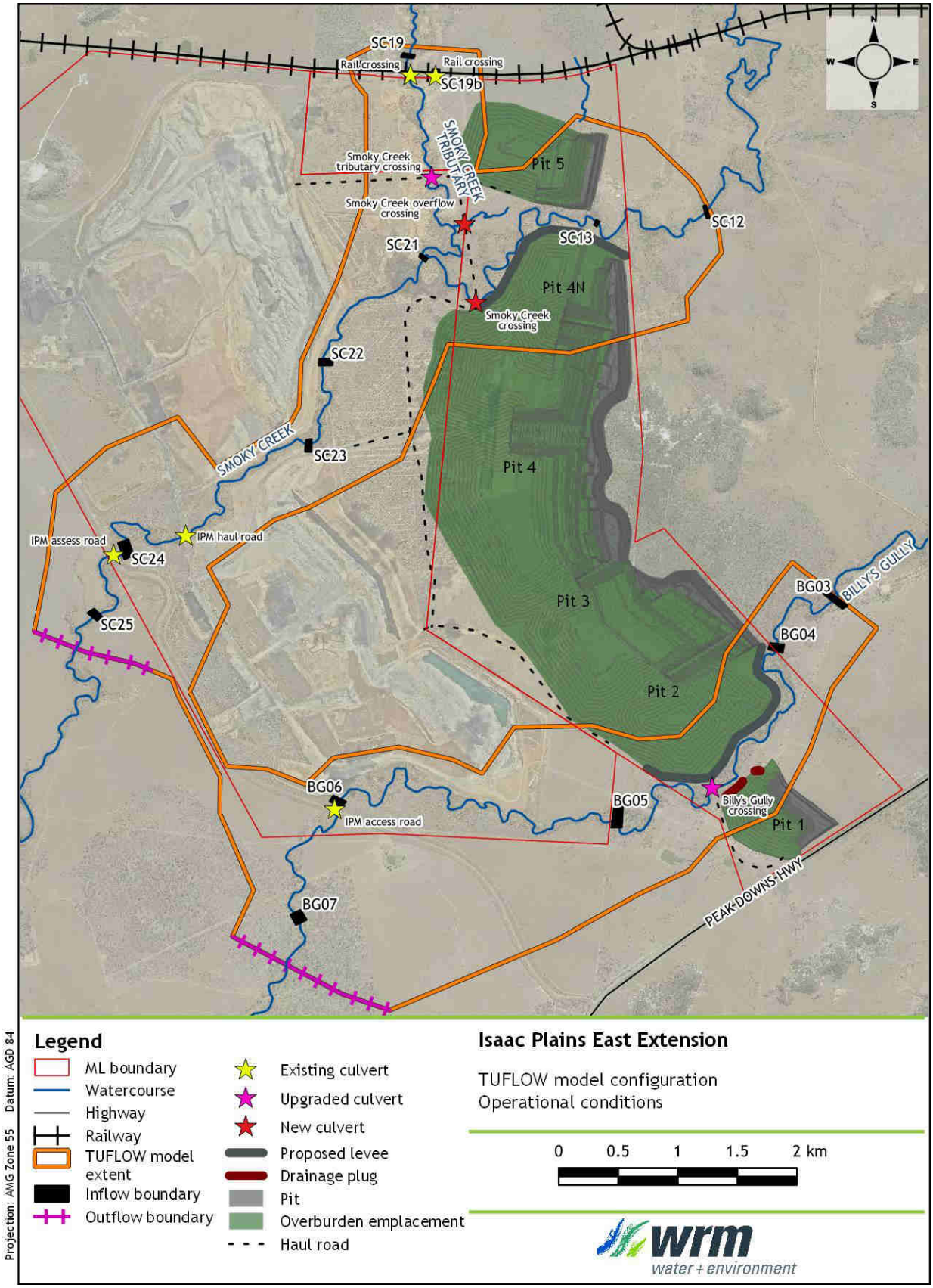

Figure B.9 – Hydraulic model configuration, Operational Conditions

APPENDIX E GDEMMP

Groundwater Dependent Ecosystem (GDE) Management and Monitoring Plan

Isaac Plains East Extension Project

Prepared for **Stanmore IP Coal** *by*

3d Environmental

Revision 5 – 22 September 2020

Project No. 2020_233_A

Project Manager: David Stanton

Client: Stanmore IP Coal Pty Ltd

Purpose: Groundwater dependent ecosystem assessment for Isaac Plains East Extension project

Draft	**Date Issued**	**Issued By.**	**Purpose**
Revision 1	24 August 2020	David Stanton	First Draft GDEMMP
Revision 2	10 September 2020	David Stanton	Second Draft GDEMMP following Stanmore review.
Revision 3	19 September 2020	David Stanton	Third draft following threshold assessments
Revision 4	22 September 2020	David Stanton	Final edits and adjustments
Revision 5	22 September 2020	David Stanton	Updates to decision tree

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List of Abbreviations

Abbreviation	Description
DAWE	Department of Agriculture Water and Environment (Commonwealth)
DES	Department of Environment and Science (Qld)
DoEE	Department of Environment and Energy (Commonwealth)
DSITI	Department of Science, Information, Technology and Innovation (Qld)
EA	Environmental Authority **EPML00932713** – Isaac Plains Mine
EIS	Environmental Impact Statement
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)
EPBC Approval	Approval granted by the Commonwealth under the EPBC Act
EP Act (Water)	Environmental Protection Act (Qld) 1994
ESCP	Erosion and Sediment Control Plan
EWR	Environmental Water Requirement
GDE	Groundwater Dependent Ecosystem
GDEMMP	Groundwater Dependent Ecosystem Monitoring and Management Plan
GMMP	Groundwater Management and Monitoring Plan
IP	Isaac Plains
IPC	Isaac Plains Complex
IPE	Isaac Plains East
IPEE	Isaac Plains East Extension
LAI	Leaf Area Index
LWP	Leaf Water Potential
ML	Mining Lease
MNES	Matters of National Environmental Significance, as defined under the EPBC Act.
NDVI	Normalised Difference Vegetation Index
PER	Public Environment Report
REMP	Receiving Environment Monitoring Program
SMP	Soil Moisture Potential
WMP	Water Management Plan

Glossary

Alluvial aquifer	An aquifer comprising unconsolidated sediments deposited by flowing water usually occurring beneath or adjacent to the channel of a river.
Aquifer	A geological formation or structure that stores or transmits water to wells or springs. Aquifers typically supply economic volumes of groundwater
Base flow	Streamflow derived from groundwater seepage into a stream.
Capillary fringe	The unsaturated zone above the water table containing water in direct contact with the water table though at pressures that are less than atmospheric. Water is usually held by soil pores against gravity by capillary tension.

Confined aquifer	A layer of soil or rock below the land surface that is saturated with water with impermeable material above and below providing confining layers with the water in the aquifer under pressure.
Perched groundwater system	A groundwater system or aquifer that sit above the regional aquifer due to a capture of infiltrating moisture on a discontinuous aquitard.
Phreatic zone	The zone of sub-surface saturation separated from the unsaturated zone in unconfined aquifers by the water table.
Phreatophyte	Plants whose roots extend downward to the water table to obtain groundwater or water within the capillary fringe
Obligate phreatophyte	A plant that is completed dependent on access to groundwater for survival
Evapotranspiration	The movement of water from the landscape to the atmosphere including the sum of evaporation from the lands surface and transpiration from vegetation through stomata
Facultative phreatophyte	A plant that occasionally or seasonally utilises groundwater to maintain high transpiration rates, usually when other water sources aren't available.
Fractured rock aquifer	An aquifer in which water flows through and is stored in fractures in the rock caused by folding and faulting.
Fluvial	Relating to processes produced by or found in rivers
Groundwater	Those areas in the sub-surface where all soil or rock interstitial porosity is saturated with water. Includes the saturated zone and the capillary fringe.
Water table	The upper surface of the saturated zone in the ground, where all the pore space is filled with water.
Groundwater dependent ecosystems (GDE)	Natural ecosystems which require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services (Richardson et al. 2011)
Infiltration	Passage of water into the soil by forces of gravity and capillarity, dependent on the properties of the soil and moisture content.
Leaf water potential (LWP)	The total potential for water in a leaf, consisting of the balance between osmotic potential (exerted from solutes), turgor pressure (hydrostatic pressure) and matric potential (the pressure exerted by the walls of capillaries and colloids in the cell wall).
Leaf area index (LAI)	The ratio of total one-sided area of leaves on a plant divided by the area of the canopy when projected vertically on to the ground.
Percolation	The downward movement of water through the soil due to gravity and hydraulic forces.
Permeability	A materials ability to allow a substance to pass through it, such as the ability of soil or rocks to conduct water under the influence of gravity and hydraulic forces.
Preferential flow	Movement of surface water rapidly from surface to aquifer along preferential flow paths, bypassing older moisture in the upper soil profile.

Unconfined aquifer	An aquifer whose upper surface is at atmospheric pressure, producing a water table, which can rise and fall in response to recharge by rainfall
Soil water potential	A measure of the difference between the free energy state of soil water and that of pure water. Essentially a measure of the energy required to extract moisture from soil.
Stable isotope	An isotope that does not undergo radioactive decay.
Surface water	Movement of water above the earths' surface as runoff or in streams
Transpiration	The process of water loss from leaves, through stomata, to the atmosphere.
Terrestrial GDE	Terrestrial vegetation supported by sub-surface expression of groundwater (i.e. tree has roots in the capillary fringe of groundwater table).
Vadose zone	The unsaturated zone, above the water table in unconfined aquifers
Water Potential	The free energy potential of water as applied to soils, leaves plants and the atmosphere.

1.0 Introduction

1.1 Background

3d Environmental has been engaged by Stanmore IP Coal Pty Ltd (IP Coal) to develop a Groundwater Dependent Ecosystem (GDE) Management and Monitoring Plan (GDEMMP) for the Isaac Plains East Extension (IPEE), which is an extension to the existing Isaac Plains East (IPE) coal mine. IP Coal is the operator of the Isaac Plains Complex (IPC), located approximately 5 – 7 km from Moranbah in Central Queensland (**Figure 1**). The IPC produces metallurgical coal used in the production of steel on State approved mining leases (ML) 70342, ML 700016, ML 700017, ML 700018, and ML 700019. In 2018 approval was received from State and Commonwealth agencies for mining on ML 700016, ML 700017, ML 700018 and ML 700019 (as part of the IPE Project). However, the Commonwealth approval for the IPE mining area limited the allowable disturbance area for mining activities, and the Extension area is outside the Commonwealth approved mining area. The State approved mining in the Extension area in February 2020. A new Referral under the Environment Protection and Biodiversity Act 1999 (EPBC) was lodged on 01 October 2019 for extension activities (EPBC 2019/8548). On 31 January 2020 the Referral was listed as a Controlled Action with the following controlling provisions:

- Listed threatened species and communities (sections 18 & 18A); and
- Water resources/trigger (sections 24D & 24E).

The Department of Agriculture, Water and Environment (DAWE) determined that the Referral for the Extension would be assessed by Public Environment Report (PER) and the project is currently being assessed via this process.

As a component of the PER, a GDE assessment was undertaken by 3d Environment which verified GDEs within the area that may potentially be impacted by the Extension (3d Environmental, 2020). This GDEMMP has been developed to monitor and manage potential impacts of mining activities, if any, on GDEs .

1.2 Purpose of the Management Plan

This GDEMMP has been prepared to manage the environmental impacts of the Extension on GDEs through the development of consistently applied monitoring actions, analysis and reporting of data trends. Corrective actions (mitigations) are described and should be implemented when statistically significant impacts on GDE function caused by mining activity are detected. The plan is to be used as a reference for management actions prior to construction, during construction and operation, extending though stages of project decommission and post operation.

1.3 Objectives

Objectives of this GDEMMP are described as follows:

1. Characterise GDEs in the Extension area in terms of ecological function, interaction with surface water and interaction with groundwater as presented in 3d Environmental (2020).
2. Provide a detailed synopsis of the potential risks to GDE integrity posed by mining activities associated with the Extension.
3. Identify biophysical parameters that can be applied to the monitoring of GDE function that can be repeated objectively and consistently throughout the life of the mining project to measure GDE health.
4. Describe the most appropriate actions to measure changes to biophysical function of GDEs that may indicate a decline in GDE health, and provide a statistically robust framework that

can demonstrate whether impacts to GDEs are associated with mining activities rather than natural variation.

5. Develop triggers that may be used to initiate the application of corrective actions, which can be refined over time as baseline data is collected.
6. Develop a suite of corrective actions that may be applied to ameliorate impacts to GDEs and prevent or repair declining GDE health.

1.4 Relevant Legislation

The Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act) provides for the protection of environmental values, prescribed under the Act as Matters of National Environmental Significance (MNES). Any action that will or may cause a significant impact on MNES is subject to assessment approval process under the EPBC Act. In June 2013, the EPBC Act was amended to capture water resources as MNES. Under the amendment, water resources include groundwater and surface water, and organisms and ecosystems that depend on it to maintain ecological function and condition. These ecosystems are otherwise termed groundwater dependent ecosystems or GDEs and are listed under the water trigger.

The regulatory guideline *Significant impact guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources (DoEE 2013a)* identify a 'significant impact' as 'an impact which is important, notable, or of consequence, having regard to its context or intensity'. The assessment of the significance of impacts to GDEs as a result of the IPE Project is currently being undertaken through the Public Environment Report (PER) process under the EPBC Act.

Within the state approval process, an EA amendment application for the Extension was submitted to the Queensland Department of Environment and Science (DES) in September 2019 in accordance with the requirements of the EP Act. The EA amendment was granted on 26 February 2020, inclusive of the Extension activities. Therefore, at State level the necessary approval under the EP Act has been secured to progress the Extension activities.

1.5 Relationship with other plans and management controls

This GDEMMP interacts with the following plans which directly aim to avoid and minimise impact to MNES:

1. **Groundwater Monitoring and Management Plan (GMMP)** (KCB 2019): Identifies monitoring, management, and mitigation with respect to approved impacts to groundwater resources, which includes impacts to GDEs.
2. **Isaac Plains Complex REMP Design Document (C&R Consulting 2019):** Monitors, identifies and describes any impacts to aquatic ecology and surface water quality values from discharges associated with approved mining activities.
3. **Isaac Plains Complex Erosion and Sediment Control Plan (ESCP) (C&R Consulting, 2018):** Provides actions and processes to manage sediment dispersal, which may impact GDEs when associated with surface water flows.
4. **Isaac Plains Complex Water Management Plan (WMP) (WRM Water & Environment, 2018):** The WMP includes a study of potential contaminants, a water balance model, a description of the site water management system, measures to manage and prevent saline and acid rock drainage, contingency procedures for emergencies and a monitoring and review program for the effectiveness of the WMP.

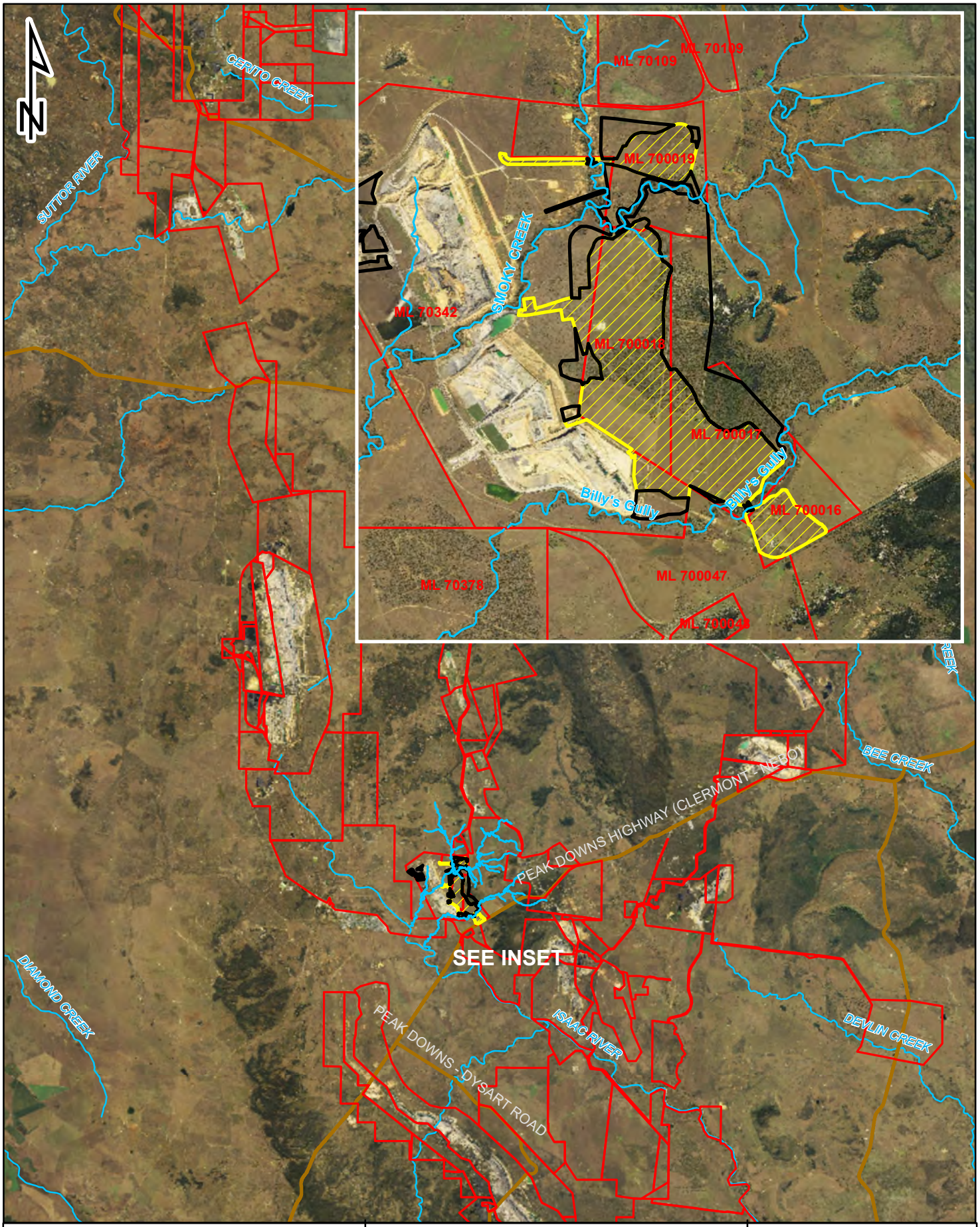
5. **Isaac Plains East Extension – MNES Significant Species Management Plan** (Base Consulting Group, 2020): Identifies koala (vulnerable), greater glider (vulnerable), ornamental snake (Vulnerable) and squatter pigeon (vulnerable) that may be incur impacts through degradation of regional ecosystem 11.3.25, which is associated with the alluvial system of Billy's Gully.
6. **Isaac Plains East Project – EPBC Act Riparian Baseline Monitoring:** Satisfies condition 10 of the IPE approval, which requires, ecological surveys be undertaken required to determine the extent (in hectares) and habitat condition for four EPBC Act listed threatened species in the riparian area.
7. **Environmental Authority (EA) no EPML00932713** – Provides conditions of approval under the Queensland Environmental Protection Act for all mining activities on ML 70342, ML 700016, ML 700017, ML 700018, and ML 700019, inclusive or trigger levels for water quality and contaminant release which are relevant for management of groundwater resources under the EPBC Act.

1.6 Structure of this Document

As the GDEMMP intends to compile knowledge on the ecohydrological function of relevant GDEs, scope has been made to update monitoring requirements including methods, timing and interval as the knowledge base increases with each subsequent monitoring survey. A summary of the key components of this GDEMMP is provided below:

- Section 2: A contextual description of the project in relation to mining layout and timeframes.
- Section 3: A general description of the existing environment to contextualise hydrogeological and ecological setting as presented in 3d Environmental (2020).
- Section 4: Provides a summary for what are considered the major risks to GDE health imposed by the IPEE Project, as presented in 3d Environmental (2020).
- Section 5: A summary of how the biotic impacts to GDEs may manifest in the environment.
- Section 6: The general approach to the monitoring program.
- Section 7: An overview of monitoring techniques and their application.
- Section 8: A summary of reporting requirements for each monitoring event as well as preparation of a baseline synopsis.
- Section 9: Approach to determining trigger thresholds for which impacts to GDEs are investigated and corrective actions applied where appropriate.
- Section 10: A discussion identifying potential corrective actions that may be applied to ameliorate impacts to GDEs that have been created by mining activities.

The Appendix also provides a summary of monitoring methods, monitoring timing and raw data from prior GDE surveys.



Legend

- IPE Pit Extension
- Approved IPE Outline
- Mining leases

Figure 1. Project location

Stanmore IP Coal Pty Ltd

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Kilometers

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2.0 Project Description and Timing

2.1 Proposed Activities

The Extension activities will occur in areas outside of existing and approved activities, as shown in **Figure 2** and **Figure 3** (from the IPC Project Description, Reach Environmental 2020), and comprise:

- extension of the open cut mine pits at IPE Pit 2, 3 and 4 (extends into Pit 4N)
- area for overburden dumping around IPE Pit 2, 3, 4 and 5
- levee between Pit 4 and Smoky Creek
- haul roads, including a new crossing of Smoky Creek and a powerline corridor
- water management infrastructure, being sediment dams and clean water diversions
- areas for topsoil stockpiles
- areas for laydowns
- modular extension to the CHPP
- additional ROM coal stockpile area
- water management infrastructure around the CHPP area, being clean water diversion drains.

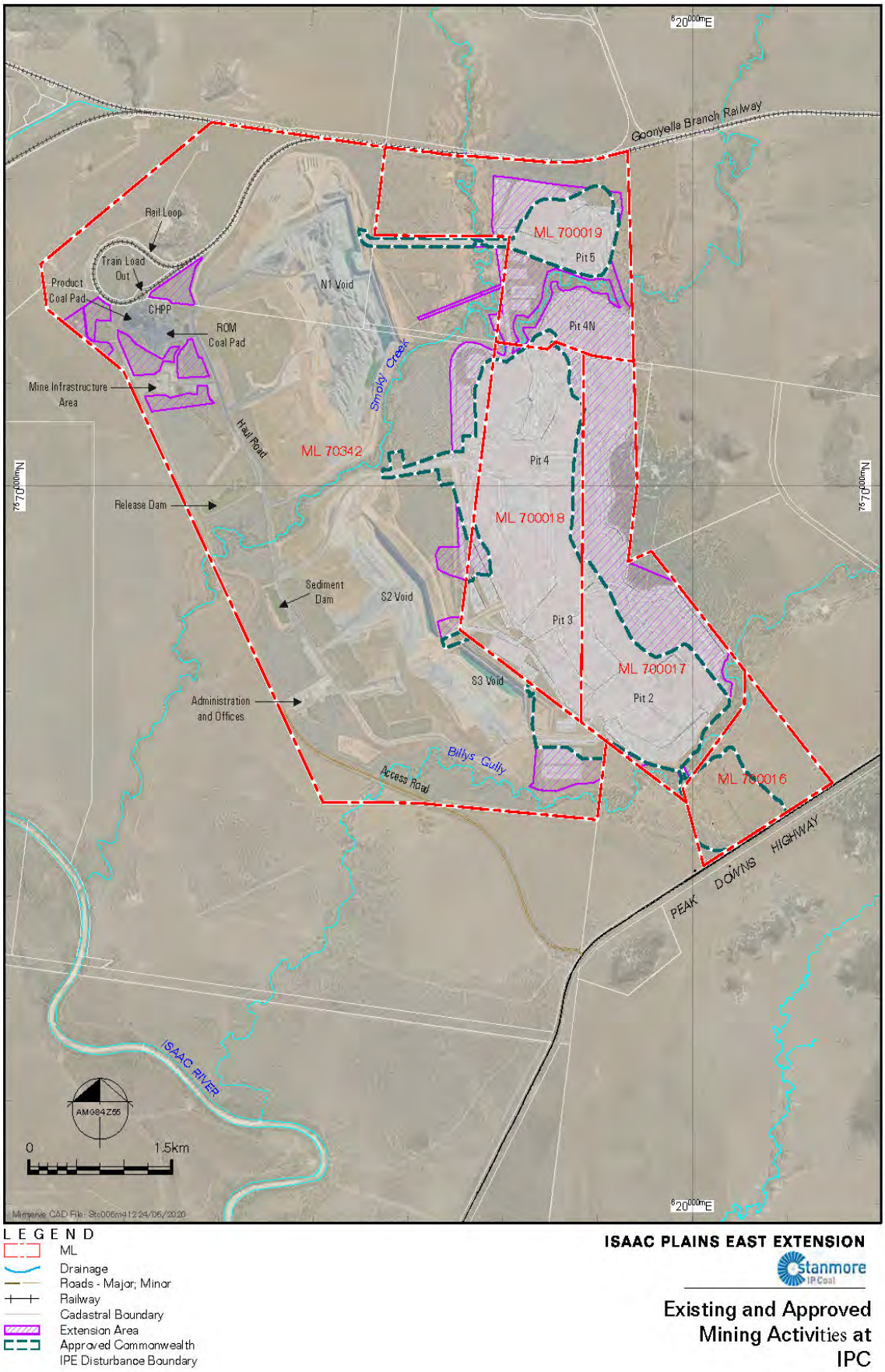
The disturbance area of the Extension is 466 ha, which includes buffer zones around infrastructure locations to allow operational flexibility and includes some areas between the Extension's infrastructure and activities which may be fragmented, but not directly disturbed. This footprint therefore provides a conservative estimate (over-estimate) of the actual likely footprint of the Extension area.

2.2 Mining Schedule

Plans for staged mining at IPE and the Extension area have been prepared for 2021, 2024 and 2028 as provided in **Appendix A**. Activities for stage plans are described below:

- 2021 shows areas in which clearing, grubbing, topsoil removal and pre-stripping of overburden are proposed beyond the current Commonwealth IPE approved area.
- 2024, where coal mining has moved into the Extension areas and progressive rehabilitation has commenced on dump areas at IPE.
- 2028, being the final year of open cut mining operations, with progressive rehabilitation of dump areas at IPE well advanced).
- The final landform, as approved by DES in the Rehabilitation Management Plan required under IPC's EA, and showing residual void areas and rehabilitated dump and infrastructure areas (**Appendix A**).

Under the IPE approved action, the final landform would have comprised residual voids near the eastern extent of the IPE approved action area. The final landform, as approved for IPE and as proposed for the Extension show that the Extension areas result in a similar residual void configuration but further to the east and deeper.



LEGEND

- ML
- Drainage
- Roads - Major; Minor
- Railway
- Cadastral Boundary
- Extension Area
- Approved Commonwealth IPE Disturbance Boundary

ISAAC PLAINS EAST EXTENSION

Stanmore IPCoal

Existing and Approved Mining Activities at IPC

Figure 2. Existing and approved activities at IPC including the Extension Area (Reach Environmental 2020).

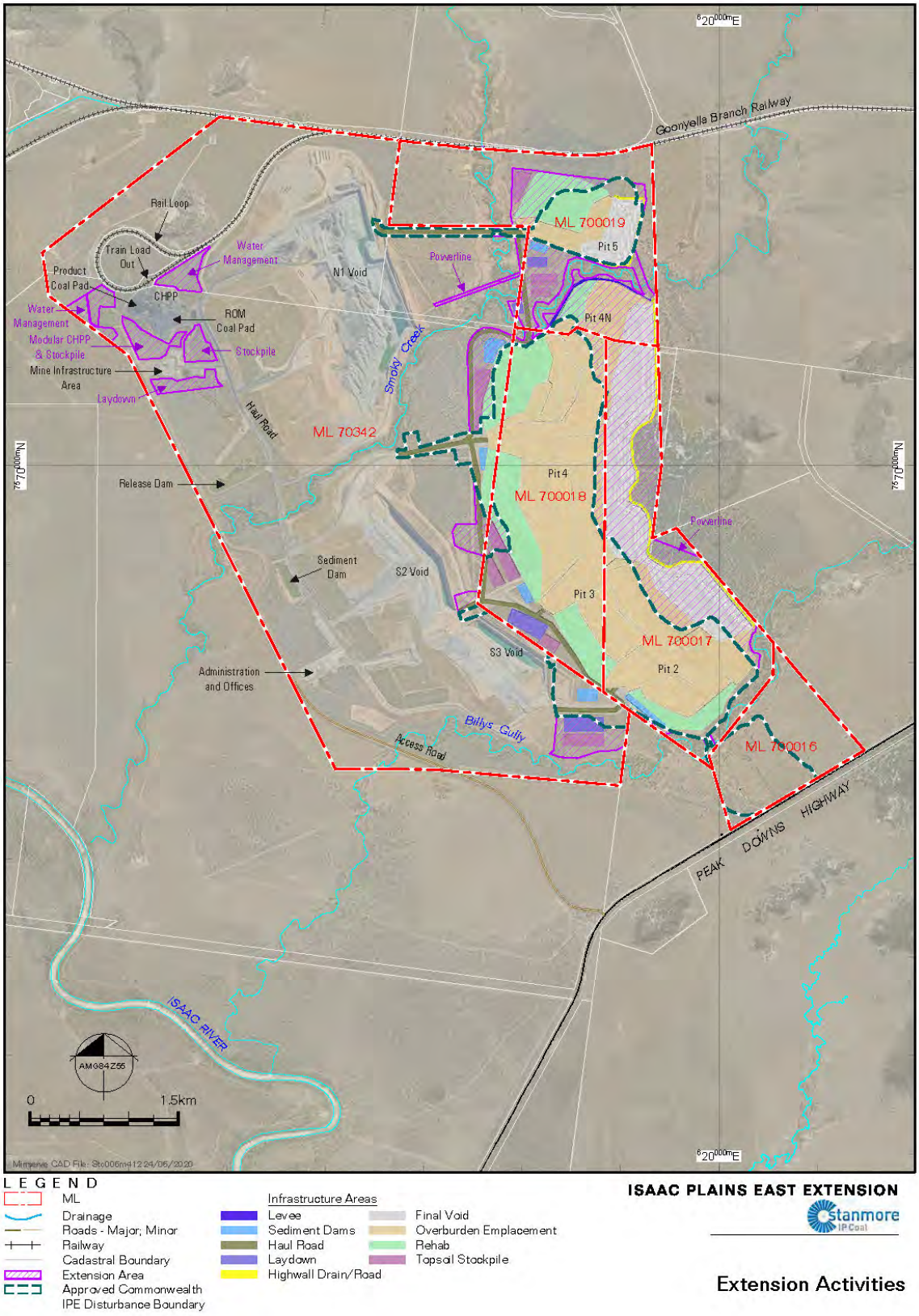


Figure 3. Activities associated with IPEE (Reach Environmental 2020).

3.0 Existing Environment

A description of the existing environment including general setting surface water flow, hydrogeology and interplays with GDEs are described in **Section 3**.

3.1 Site Setting

The IPE extension is located within the Northern Bowen Basin subregion of the Brigalow Belt Bioregion in central Queensland. The Brigalow Belt North Bioregion is an ecologically complex area characterised by clay soils interspersed with Tertiary plateaus, sand plains, basalt plains and some more expansive ranges formed on sandstone and granite. Vegetation is typically dominated by forests and woodlands of *Acacia harpophylla* (Brigalow), *Acacia shirleyi* (lancewood) eucalyptus woodlands and grassland habitats.

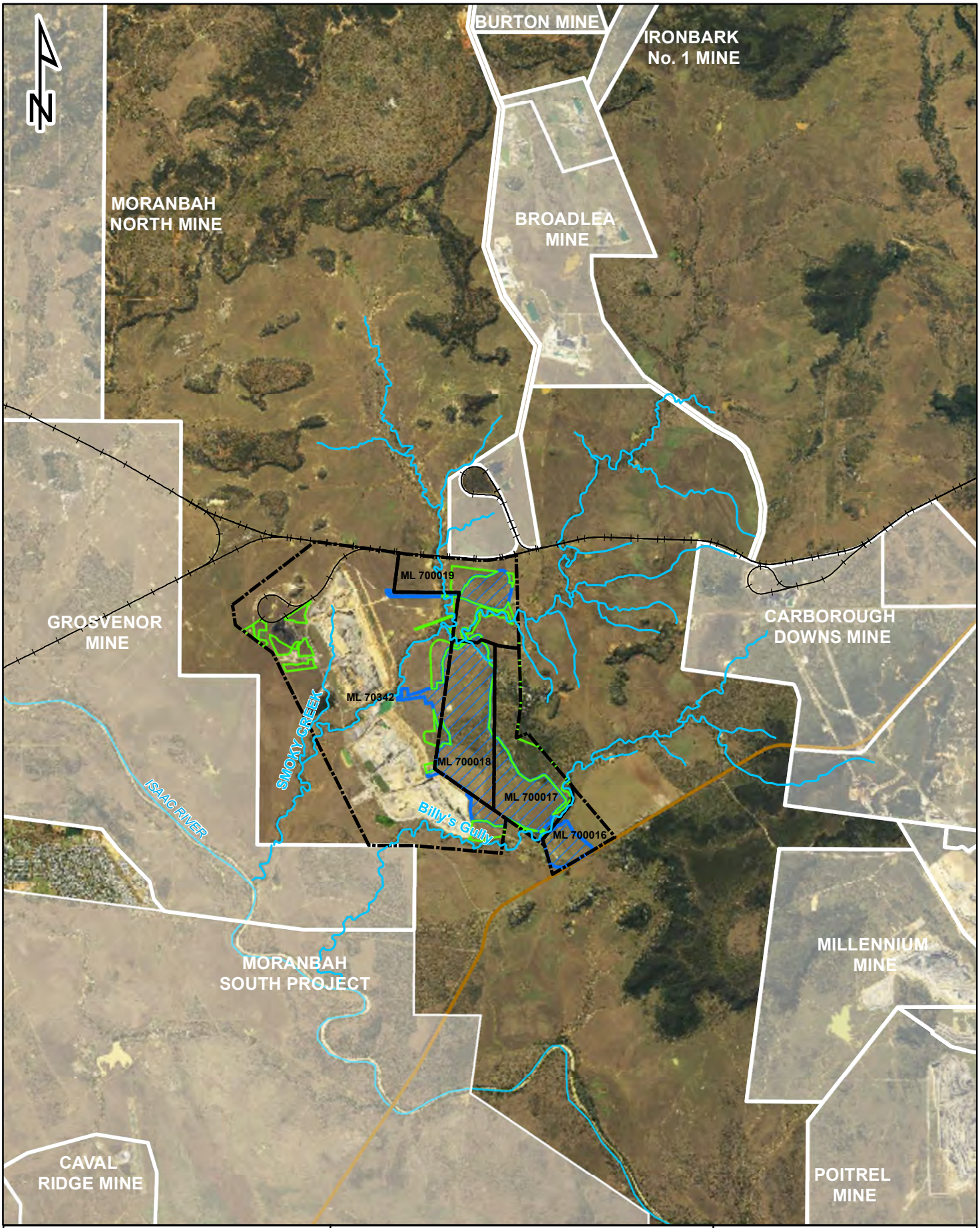
The region surrounding the IPE mining area has been extensively cleared of native vegetation to accommodate pastoral activities, except for topographically rugged areas and drainage lines where intact vegetation has generally been retained. Riparian vegetation associated with the larger watercourses is generally continuous, though largely restricted to channel margins with attenuations along minor tributaries and occasionally buffered by broader areas of floodplain woodland. Coal mining has been a more recent activity in the region, emerging in the 1970's as a major industrial activity. The Project description for the Extension project (Reach Environmental 2020) identified several coal mines and projects approved in the region including:

- the Grosvenor Mine adjacent to the IPC;
- the Moranbah North Mine located northwest;
- the Burton, Broadlea and Ironbark No. 1 Mines located north;
- Carborough Downs Mine located east;
- Millennium and Poitrel Mines located southeast; and,
- the Moranbah South Project and Caval Ridge Mine located southwest.

Other non-approved projects that are in the process of being developed include:

- the Winchester South Project, located approximately 20 km south, to be developed by
- Whitehaven Coal;
- Olive Downs Project, located approximately 30 - 40 km south, to be developed by Pembroke
- Resources;
- Isaac Downs Project, located approximately 5– 10 km south, to be developed by Stanmore IP
- South Pty Ltd; and,
- Eagle Downs Project located approximately 20 km southeast, to be developed by South32.

The location of coal mining operations that fringe the IPE MLs is shown in **Figure 4**.



Legend

- Isaac Plains Complex Mining Lease
- IPE Pit Extension
- Approved IPE Outline

Figure 4. Isaac Plains Complex adjacent mining activity.

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3.2 Climatic considerations

The region is sub-tropical with average temperatures recorded in Moranbah of between 21.1°C and 34.8°C in the summer months, and 8.9°C and 25.2 °C in the winter months. The long-term average rainfall (30 years of data between January 1990 and December 2019) from the Moranbah Water Treatment Plant is 590.4mm (SILO 2020) with a pronounced wet season. Approximately 75% of the annual rainfall is recorded between November and March, inclusive (BoM 2020). Plant growth in the region is strongly limited by moisture rather than temperature (Hutchinson et al. 1992) which is reflected in the evapotranspiration rates at the Moranbah Airport for the 2019 – 2020 period being considerably higher than rainfall for all months (except for the wettest months). Between January 2015 and December 2019, the largest offset between rainfall and evapotranspiration occurred between October to December during the build-up to summer storms (**Figure 5**) (data from SILO 2020).

The region has experienced several significant drought events, many of which have resulted in tree dieback. The early to mid-1990's drought, the worst on record for north Queensland, and the millennium drought from 2000 through to 2007 both resulted in substantial dieback of native woodland habitats, typically affecting ironbark woodlands and most severely on basaltic substrates (Fensham and Holman 1999; Fensham et al 2009). **Figure 6** demonstrates the major climatic cycles in terms of Cumulative Rainfall Departure (CRD) (Weber and Stewart 2004), representing a cumulative departure of monthly rainfall from the long term mean monthly rainfall (1990 to 2020) at the Moranbah Water Treatment Plant (SILO 2020). Strongly decreasing rainfall trends between 1990 to 1996; and 2000 to 2007 representing major drought periods are strongly evident, interspersed with periods of above average rainfall between January 1998 and January 2001, January 2010 and July 2012, and January 2016 to March 2017, which were considerably wetter than average conditions.

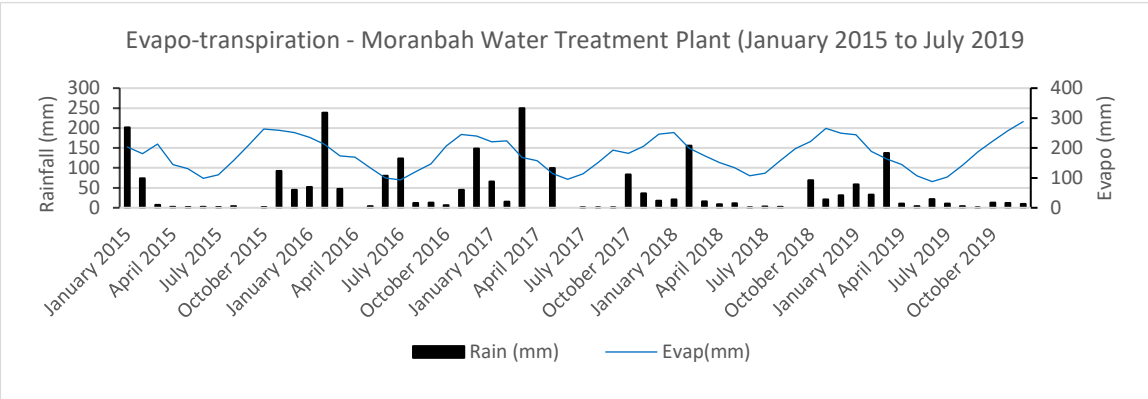


Figure 5. Evapotranspiration trends on a seasonal basis for Moranbah Water Treatment Plant.

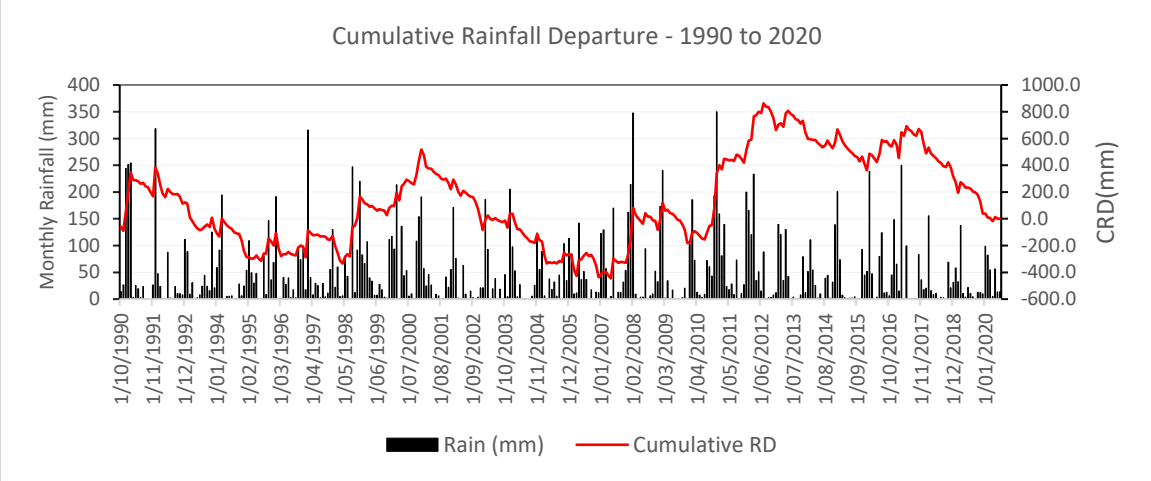


Figure 6. Cumulative rainfall departure calculated for the Moranbah Water Treatment Plant.

3.3 Topography and Drainage

The topography is relatively suppressed in the west, gently rising from 240m AHD with slopes <2° to a low plateau east of the Extension at 300m AHD. The plateau splits the drainage of Billy's Gully and Smoky Creek, with the former passing south of the existing IPE mine. Smoky Creek and its northern tributary converge and then dissect the existing Isaac Plains Mine. Both watercourse features flow toward the south-west, joining with the Isaac River approximately 4km to the west of the IP mining lease. Billy's Gully and Smoky Creek are ephemeral watercourses, characterised by short duration flows, though Smoky Creek holds surface water in discontinuous pools for longer periods than Billy's Gully which consistently demonstrates a dry sandy channel. Both drainage lines form part of the Isaac River sub-catchment, which flows into the Fitzroy River draining to the coast near Rockhampton.

3.4 Surface Water Flows

The characteristics of surface flows associated with Billy's Gully have been described in detail by WRM (2020) in the surface water report prepared for the IPEE PER. This information is summarised below. Further description is also provided for Smoky Creek (a non-GDE drainage system), which is the dominant drainage feature in the IPEE area to provide site context.

3.4.1 Billy's Gully

Billy's Gully is a minor order 3 tributary of the Isaac River with a total catchment area of 67.5 km^2. Billy's Gully drains into the Isaac River about 2.5 km to the south east of Smoky Creek and 3.0 km upstream from the Isaac River crossing on the Peak Downs Highway. The entire catchment of Billy's Gully is characterised by gentle slopes limited to upper values of 5% and a lower channel draining at a slope of approximately 0.3%. The Carborough Downs coal mine is in the upper catchment of the watercourse. There are three flow gauging stations on Billy's Gully being:

- 332402 Billy's Gully DS flow gauge which commenced readings on 06/06/2013.
- 332403 Billy's Gully US IPM (unknown).
- 332401 Smoky Creek US IPE (unknown).

The location of the Billy's Gully catchment and flow gauging stations is shown on **Figure 7**.

At the Billy's Gully DS (332402), flows were recorded on 0.2% of the days between July 2013 and June 2020 and the water levels recorded in Billy's Gully are consistently lower than those recorded in Smoky Creek. A maximum water level of 12.6 mGH was recorded at the Billy's Gully DS gauge in February 2016 (flow depth of around 2.6 m at the gauge).

3.4.2 Smoky Creek

Smoky Creek is a minor tributary of the Isaac River with a total catchment area of 164.9km^2 that drains between the N1 pit and S2 pit. It is formed by the main Smoky Creek Channel, which is an order 4 tributary, and the un-named 'Northern Tributary' which is an order 3 watercourse. The lower reaches of Smoky Creek are relatively flat (0.2% slope) and the main channel of the creek is highly sinuous. The channel sediments are mobile and there is considerable erosion of the outside bends of meanders. There are three flow gauges on Smoky Creek used to measure surface flows being:

- 332400 Smoky Creek Downstream (DS) flow gauge which commenced readings on 24/09/2013.
- 332401 Smoky Creek Upstream (US) IPM which commenced readings on 08/04/2019.
- 332401 Smoky Creek Upstream (US) IPE which commenced readings on 01/08/2018.

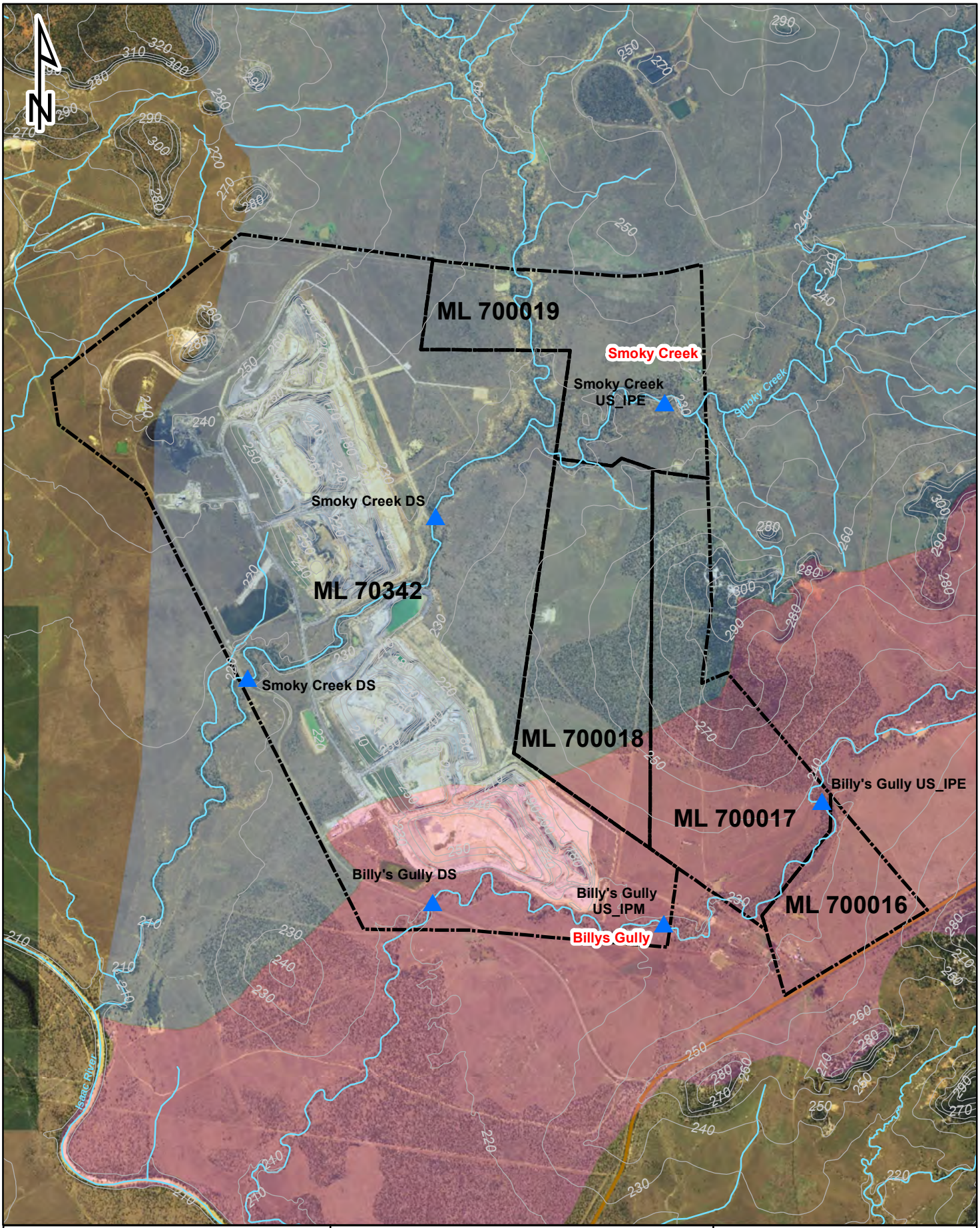
At Smoky Creek DS (gauge no. 332400), flows were recorded on approximately 15% of the days. The maximum water level recorded at Smoky Creek DS was 18.2 mGH in February 2016 (flow depth of around 7.8 m at the gauge) (see **Figure 8**). Smoky Creek drains through the project area between the proposed Pit 4/4N and Pit 5 mining areas. The location of the Smoky Creek catchment and flow gauges is shown on **Figure 7**.

3.4.3 Water Quality

Routine water quality samples for the upstream and downstream Smoky Creek monitoring points are summarised as follows:

- Typical EC values in Smoky Creek (combined upstream and downstream) vary from 144 µS/cm (20th percentile) to 447 µS/cm (80th percentile), with a median value of 231 µS/cm from 2016 to 2020;
- pH is slightly alkaline;
- Typical TSS values in Smoky Creek vary from 96 mg/L (20th percentile) to 1,070 mg/L (20th percentile), with a median value of 292 mg/L from 2016 to 2020; and
- All metal toxicants, except for aluminium and copper, are lower than the default water quality objectives for aquatic ecosystem protection (for slightly to moderately disturbed level of protection).

There is limited water quality sampling data available for Billy's Gully due to its highly ephemeral nature (i.e. flows were recorded on approximately only 0.2% of the days) (see **Figure 8**). However, 15 months of surface flow monitoring between 18/11/2010 and 21/03/2012 indicates that the salinity of surface waters range from 271 to 840 µs/cm.



Legend

- Stream Gauge
- Isaac Plains Complex Mining Lease
- Billys Gully
- Smoky Creek

Figure 7. Catchments, drainage and topography and stream gauging stations in the locality of the IPEE project.

Client

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Kilometers

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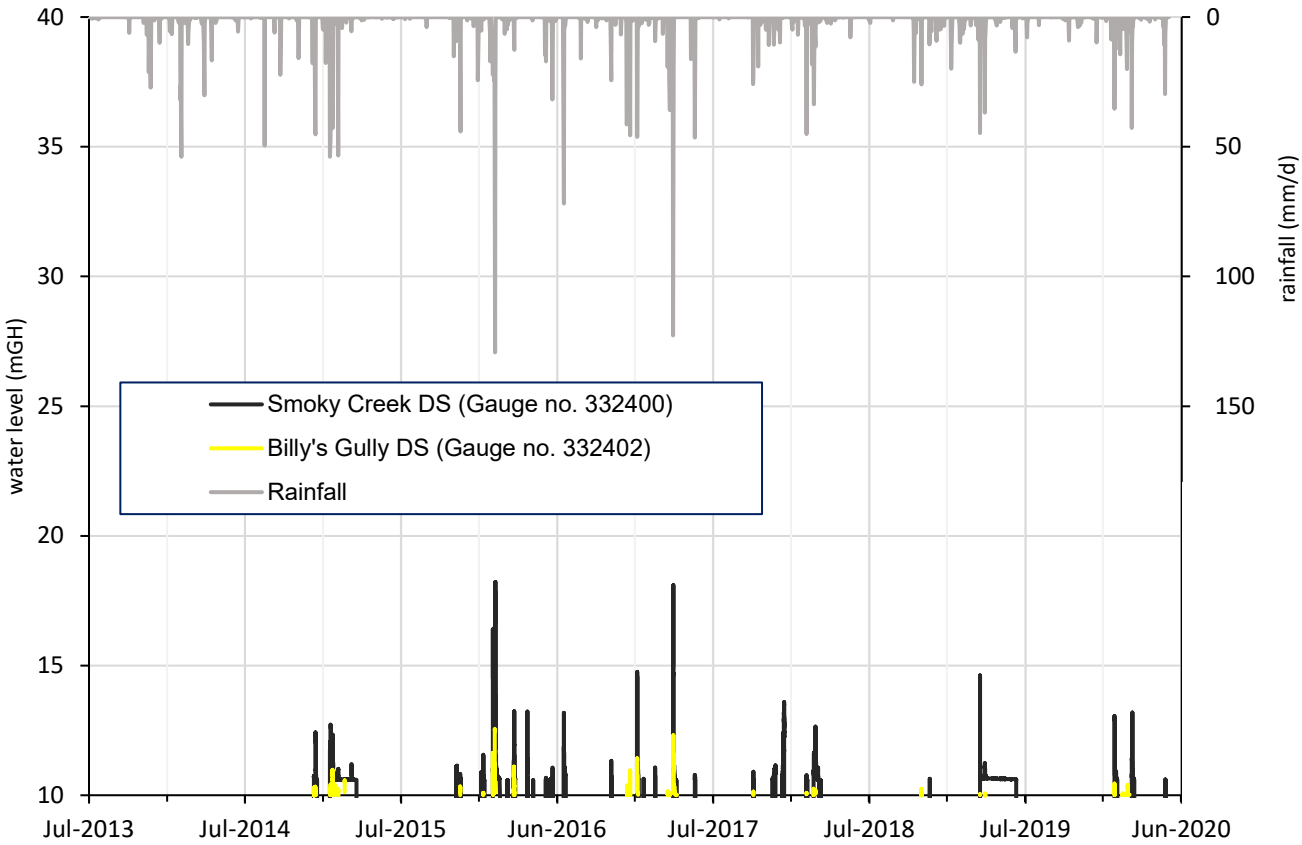


Figure 8. Stream flows and rainfall from Smoky Creek and Billy's Gully DS gauges (from WRM 2020).

3.5 Hydrogeological Setting

The project mining area is in the north-west extent of the Bowen Basin, a broad sedimentary basin formed in the Permian / Triassic period with a variable cover of Tertiary period sediment and basic volcanic rocks (basalts). The surface geology, shown in **Figure 9**, is summarised from KCB (2020) as below:

- Quaternary age alluvial deposits associated with Billy's Gully.
- Surface deposits of Quaternary age colluvium (Qr), Tertiary age alluvium (TQa) and Tertiary age sediments of the Suttor Formation (Ts); all of which show similar lithological characteristics and therefore are grouped together as the Tertiary sediments.
- Tertiary age basalt (Tb) outcropping the northern and eastern portions of the IPEE area.
- Triassic age lithic sandstone and conglomerate of the Rewan Group.
- Permian period sedimentary rocks of the Rangal Coal Measures (Rr) which includes the Leichardt Coal Seam mined at IPE and the deeper Fort Cooper Coal Measures (Pwt).

Field assessments by KCB (2020) indicate that there are limited Quaternary alluvial deposits associated with Smoky Creek, comprising fluvial deposits on the channel floor. Field investigations completed as part of the GDE field survey identified thin (~2 m), localised deposits of sandy alluvium within and adjacent to the drainage channel of Billy's Gully.

KCB (2020) described the hydrogeological regimes associated with the various lithologies in the assessment area. Information from this assessment is summarised below:

3.5.1 Quaternary Alluvium

Quaternary alluvium occurs within, and adjacent to, the water course of Billy's Gully as identified during field studies conducted by 3d Environmental (2020). The Billy's Gully flood plain is approximately 150 m wide with alluvial deposits to 2m deep. The alluvium comprises coarse sands with minor clays and intermittent lenses of gravel. The lithology underlying the alluvium comprises highly plastic clay with mottled clay features and some weathered sandstone. Both of these lithologies are representative of Tertiary age weathered residual bedrock and colluvium.

Field investigation completed in March 2020 (3D Environmental) identified a shallow saturated layer at the base of the alluvium drawing water to a depth of approximately 20 cm and this is perched on low permeability Tertiary sediments. As the field assessment was undertaken in the wet season following significant rainfall, it is inferred that the saturated sands drain quickly through subsurface flow or transpiration and saturation is likely to be ephemeral.

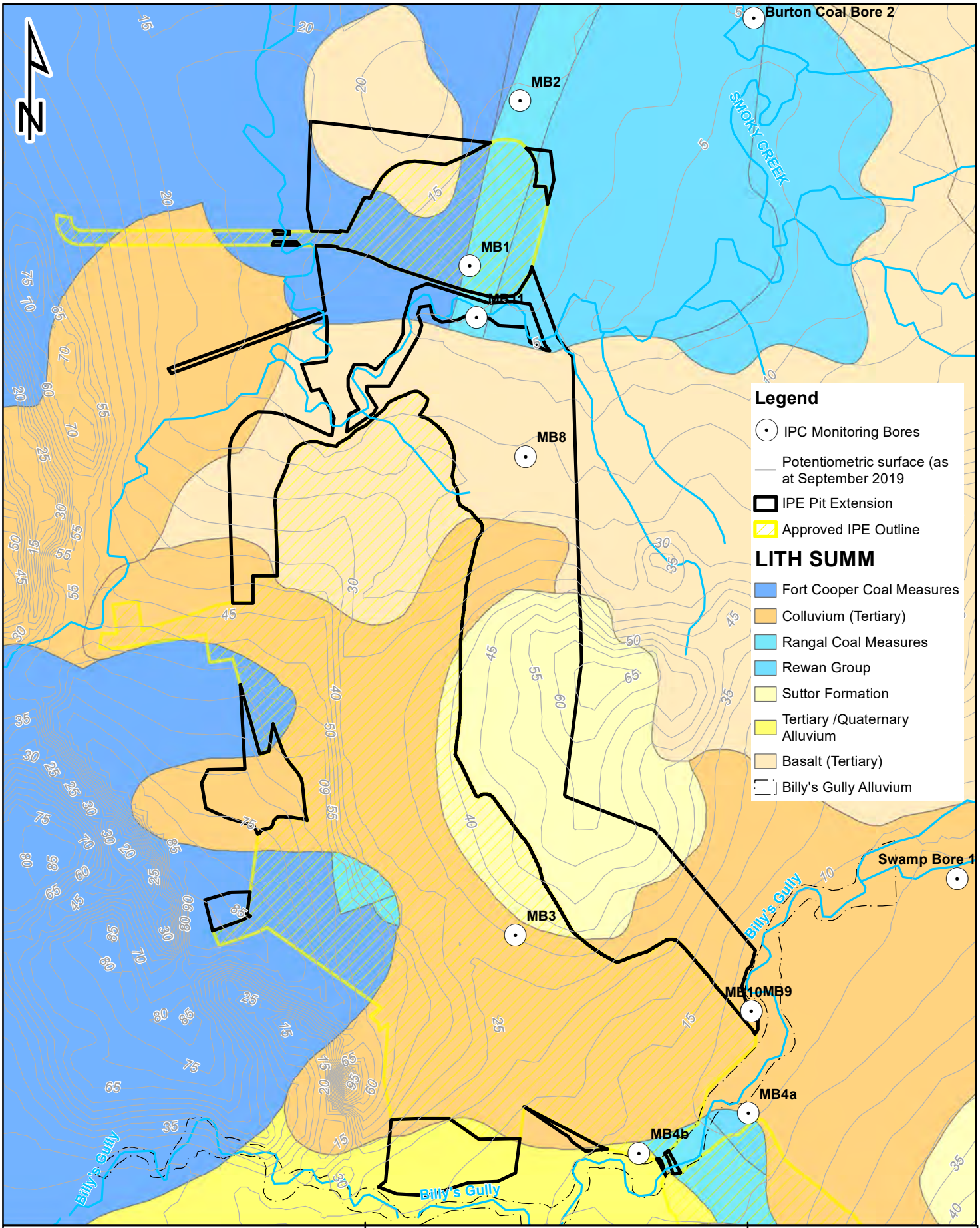
The water level in the alluvium (230.3 mAHD) is ~8 m higher than the water level in the underlying Tertiary Sediments (MB4b) (see Appendix III); indicating that the alluvium is not in hydraulic connection with the Tertiary Sediments and not in connection with the regional groundwater system. For this reason, the perched alluvial system was not simulated in the numerical groundwater model completed by KCB (2020).

3.5.2 Tertiary Sediments

The Tertiary sediments comprise a heterogeneous profile of deeply weathered semi-consolidated sandstone, mudstone and clays and other minor sediments that are widely distributed over the project mining area and its surrounds forming undulating sandy plains.
Tertiary sediments have been extensively weathered resulting in the formation of a heterogeneous layer of residual soils and weathered clays. The Tertiary sediments form a blanket of low porosity sediments that are up to 10 m thick in the project area although the low primary porosity of these sediments result in limited capacity for groundwater storage and movement. The Tertiary sediments are recharged by direct infiltration from rainfall and by the groundwater regime where they are hydraulically connected to the water table. Groundwater quality in the Tertiary sediments can be extremely saline (e.g. EC 51660 µS/cm at MB4a), reflecting the degree of weathering and the long residence time in this formation.

3.5.3 Tertiary Basalt

Fresh Tertiary basalt forms the main water bearing unit in the project area although the basalt is also associated with low permeability basaltic clays. Basalt exposures in the Project Area are on the margins of the regional basalt flow and are relatively massive compared to thicker, more vesicular portions of the flow to the east. Basalt outcrops are typically dry or with a saturated profile of <5 m, although the saturated thickness of the basalt increases to over 50 m further to the east of the Extension. The basalt aquifer is recharged directly by rainfall or infiltration from overlying Tertiary sediments where they form overburden. Associated groundwater is typically moderately saline (e.g. 2653 µS/cm at MB10).



Source: KCB (2019)

Figure 9. Surface geology, groundwater monitoring network and potentiometric surface.

Stanmore IP Coal Pty Ltd

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Kilometers

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3.5.4 Rewan Group

The Triassic age Rewan Group is a thinly interbedded sequence of siltstone, claystone and minor fine-grained sandstone uniformly saturated at depth, becoming unsaturated where it outcrops above the regional water table east of the mining project. The Rewan Group is a regional aquitard, acting as a confining unit overlying Permian sediment with saturation and groundwater movement associated with fracturing. Recharge occurs via direct rainfall infiltration where the unit outcrops, or from seepage from overlying basalts or Tertiary sediments. The groundwater is moderately saline with an average salinity of 5795 µS/cm for Burton Coal Bore 2 and 8933 µS/cm for Swamp Bore 2 respectively.

3.5.5 Permian Sediments

The Permian sediments of the Rangal Coal Measures, Fort Cooper Coal Measures and Moranbah Coal Measures comprise alternating layers of fine to medium grained sandstone and siltstone which are hydraulically tight, meaning the coal seams are the main water bearing structures. The coal seams are typically saturated throughout their full thickness. The salinity of the groundwater associated with the Permian sediments is saline (e.g. MB5 average salinity reading of 24214 µS/cm).

3.5.6 Potentiometric surface and monitoring network

The potentiometric surface produced from available groundwater bores in relation to surface geology and the groundwater monitoring bore network has been shown in **Figure 9** (adapted from KCB 2020). The potentiometric surface occurs as close as 5 to 10 metres below ground level (mbgl) in the north-eastern reach of Smoky Creek (see MB1, MB11 and Burton Coal Bore 2) and in the upper portions of Billy's Gully (see MB9, MG10 and Swamp Bore 1) to over 40mbgl in the central eastern portion of the IPEE area (see MB3). A summary of groundwater monitoring bores, total depth, standing water level (SWL), target formation and salinity is provided in **Table 1**. Data was drawn from a range of sources including KCB (2020) and C&R Consulting (2019) and recent groundwater monitoring data supplied from Stanmore IP Coal Pty Ltd.

Table 1. Details of registered water monitoring bores used to inform assessment.

DNRM Reg. Bore Name	Easting (GDA94-Zone 55K)	Northing (GDA94 – Zone 55K)	Surface RL (mAHD)	Screened Aquifer	Screen Depth (mbgl)	Total Depth (mbTOC)	Recorded SWL (mbgl)	Salinity (µS/cm)
Burton Coal Bore 2	620383.37	7573599.08	240.79	Rewan Group	30.3 – 34.6	35.5	13.37[1]	5795[1]
Swamp Bore 1	621517.97	7568789.72	244.989	Rewan Group	24.0 – 55.1	59.37	9.5[1]	8933[1]
MB1	618792.84	7572213.92	236.376	Rangal Coal Measures	22.5 - 28.5	28.9	15.54[1]	3742[1]
MB2	619073.87	7573137.24	242.669	Rangal Coal Measures	48.7 - 51.7	52.3	15.98[1]	7871[1]
MB3	619047.16	7568472.75	252.971	Rangal Coal Measures	49.64 – 52.64	53.15	-27.95[1]	21543[1]
MB4a	620351.36	7567478.64	237.598	Tertiary sediments	7.80 – 10.80	11.34	10.02[2]	51660[2]
MB4b	619739.67	7567253.00	233.925	Tertiary sediments	8.50 – 11.50	11.84	9.41[1]	31167[1]
MB5	618507.00	7570878.00	235.7-	Rangal Coal Measures	36.4 – 39.3	39.4	-	24214[1]

DNRM Reg. Bore Name	Easting (GDA94-Zone 55K)	Northing (GDA94 – Zone 55K)	Surface RL (mAHD)	Screened Aquifer	Screen Depth (mbgl)	Total Depth (mbTOC)	Recorded SWL (mbgl)	Salinity (µS/cm)
MB8	619105.16	7571148.56	245.916	Rangal Coal Measures	117.3 – 120.3	126.3	24[1]	12013[1]
MB9	620368.48	7568048.86	239.495	Basalt & Rangal Coal Measures	77.50 – 80.50	80.57	12.73[1]	10725[1]
MB10	620368.24	7568045.82	239.495	Tertiary Basalt	21.30 – 27.30	27.44	11.28[1]	2653[1]
MB11	618831.91	7571923.52	232.302	Quaternary - Undefined	3.00 – 4.00	4.53	Dry[1]	NA

[1]From KCB (2020); [2]C&R Consulting (2019)

3.6 Groundwater Dependent Ecosystems and other Riparian Vegetation

A comprehensive assessment of the nature, distribution and ecohydrological function of GDEs was undertaken across the IPEE assessment area by 3d Environmental in March 2020. The assessment included multiple field and laboratory techniques to infer use of groundwater by vegetation communities. Multiple lines of evidence to suggest groundwater use included measurement of leaf water potential (LWP), soil moisture potential (SMP) and stable isotope analysis supported by geomorphology observation.

Groundwater dependent ecosystems are defined as:

> *'Natural ecosystems which require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services (Richardson et al. 2011)'.*

The assessment identified that riparian vegetation associated with the alluvial floodplain of Billy's Gully provided the only representation of vegetation in the assessment area that would meet the definition of a GDE. The larger drainage feature of Smoky Creek is not considered to represent a GDE, and riparian vegetation utilises moisture held in the unsaturated portion of the soil profile above the phreatic zone. The ecohydrological function of the Billy's Gully GDE system is described below.

3.6.1 Billy's Gully GDE system

The terrestrial ecology assessment for the IPEE project (EcoSM 2020) identified riparian vegetation on Billy's Gully as regional ecosystem 11.3.25 under Queensland's *Vegetation Management Act 1999*. Typical canopy trees associated with this vegetation include Queensland blue gum (*Eucalyptus tereticornis),* Moreton Bay ash (*Corymbia tessellaris),* Poplar box (*Eucalyptus populnea)* and Dallachy's bloodwood (*Corymbia dallachiana).* Queensland blue gum was most common adjacent to the channel and become less frequent in marginal areas of the flood plain. Ground cover is typically exotic, formed by green panic (*Panicum maximus var trichoglume).* From the GDE Assessment completed by 3d Environmental (2020), the following features relevant to ecohydrology are noted:

1. Billy's Gully is an ephemeral drainage system that has developed on a flood plain characterised by coarse sandy alluvial soils overlying a basement of Tertiary sediments.
2. The thick sandy deposits provide a favourable substrate for the capture and storage of surface water and the sands and clayey sands of the flood plain host a saturated zone perched above low-permeability clays and sediments. This shallow unconfined groundwater table is likely to be seasonally variable though retaining sufficient moisture through seasonally dry periods to sustain robust riparian vegetation.

3. The perched groundwater system demonstrates a slight enrichment of stable isotopes when compared to overlying alluvial sediments. This indicates downward displacement of surface moisture through infiltration of younger surface flows, with mixing of flow events occurring at the zone of saturation. The isotopic signatures obtained from xylem samples are consistent with the perched groundwater system suggesting that trees are utilising water from within the saturated zone. This observation is supported by data from biophysical measurements of LWP and SMP.
4. The saturated alluvial profile would likely facilitate some shallow infiltration into underlying Tertiary clays which may provide diffuse recharge to the Tertiary sediments. The high salinity of the Tertiary groundwater system however indicates that recharge from the perched groundwater system is insignificant. There is no evidence of strong hydraulic connectivity with groundwater in the underlying Tertiary sediments. The relative height difference between the top of the Tertiary groundwater system and the base of the perched groundwater (approximately 8m), coupled with the low hydraulic conductivity of the Tertiary sediments (approximately 7.0×10^{-4} to 0.04 m/d from KCB 2020) precludes any recharge of the perched groundwater system by baseflow.
5. From all evidence, Billy's Gully is considered to represent a GDE reliant on a shallow seasonal perched groundwater system sustained by surface water infiltration.

The location of the Billy's Gully GDE system, coinciding with the field verified alluvial floodplain, is shown in **Figure 9**. A north-south section through Billy's Gully provided in **Figure 10**, demonstrates the sandy alluvium that defines the flood plain, which is drained by a sparse system of shallowly incised anastomosing sandy channels. Based on consistency of landform, tree size and species dispersal, the sandy alluvial sediments are expected to be relatively uniform over large areas. During the wet season, the anastomosing drainage channels are activated with surface flow and bank overflow. This occurs during the wet season when the sandy alluvium is totally saturated, or surface runoff exceeds infiltration during intense storm events (**Figure 11**). There may be some minor infiltration into the Tertiary sediments that confine the flood plain margins. The landform associated with Billy's Gully relies on its own local catchment and surface flows to replenish the perched groundwater system.

Billy's Gully is considered a GDE that is reliant on a shallow perched aquifer, possibly with some deeper roots penetrating into the surface of the moist Tertiary clays for anchorage and a source of soil moisture utilised as the perched groundwater system dries. As the landform that hosts the perched groundwater system will not be directly impacted by the mine footprint and there is limited connectivity to the Tertiary sediments due to low hydraulic conductivity, the groundwater hydrology in this alluvial system is not expected to be impacted by drawdown associated with mine pit development.

3.6.2 Ecohydrological function of characteristic tree species

The following provides a characterisation of the groundwater dependence and known ecohydrological function of the major canopy species associated with Billy's Gully. The purpose of the characterisation is to identify those species most likely to exhibit groundwater dependence to allow monitoring and corrective actions to be appropriately targeted.

Eucalypts: The GDE investigation area and surrounds are characterised by the presence of forest red gum *(Eucalyptus tereticornis*) typically on river banks and levees; poplar gum (*Eucalyptus platyphylla),* swamp mahogany (*Lophostemon suaveolens),* Moreton Bay ash (*Corymbia tessellaris),* Clarkson's bloodwood (*Corymbia clarksoniana)* on more elevated alluvial terraces; and poplar box *(Eucalyptus populnea),* and ironbark (*Eucalyptus crebra)* on elevated upper terraces at greatest distance from the stream channel.

River red gum (*Eucalyptus camaldulensis)* is a well-studied species known to have deep sinker roots, hypothesised to grow down towards zones of higher water supply (Bren et al., 1986) although the species has only an occasional occurrence on Smoky Creek. For this assessment, the physiological attributes of *Eucalyptus tereticornis* and *Eucalyptus camaldulensis* are assumed to be similar as the species inhabit a similar ecological niche. *Eucalyptus tereticornis* is however a more adaptable species, occupying dry hill slopes in some localities and it would be expected that it would be more tolerant of changes to hydrological regime than *Eucalyptus camaldulensis* which is a riparian specialist. Malik and Sharma (2004) found that *Eucalyptus tereticornis* also has a strong capacity to extract moisture from the shallow soil profile (0 – 150cm).

The water requirements of river red gum are obtained from three main sources being groundwater, rainfall, and river flooding. Flooding enables the species to survive in semi-arid areas (ANBG 2004). Stands of river red gum are intimately associated with the surface-flooding regime of associated watercourses and related groundwater flow. The high-water use of river red gums contributes to maintaining water tables at depth (Mensforth et al 1994; Lamontagne et al 2005). River red gum are considered partially opportunistic in their use of water and are considered a facultative phreatophyte, shifting between a combination of surface soil moisture and groundwater during periods of high rainfall, then shifting to exclusive use of groundwater during drier periods. They are likely to achieve this shift through inactivation of surface roots during drier periods with increased reliance on deeper tap roots when surface water is unavailable.

Doody et al. (2015) demonstrated that soil moisture alone can sustain the health of *Eucalyptus camaldulensis* through periods of drought up to six years before significant decline in tree health is noted. The maximum potential rooting depth of river red gum is subject to considerable conjecture in current literature, although it is widely accepted that the species has capacity to access deep groundwater sources (Eamus et al 2006a). Horner et al. (2009) found rooting depths at 12–15 mbgl based on observed mortality in plantation river red gum forests on the Murray River Floodplain. From excavations in 20 year-old plantation forests of *Eucalytpus tereticornis,* Kallarackal and Somen (1998) found that roots were traceable to depths of 9.3 mbgl and Jones et al (2020) found maximum

Figure 10. Conceptual model of the Billy's Gully GDE system in the dry season.

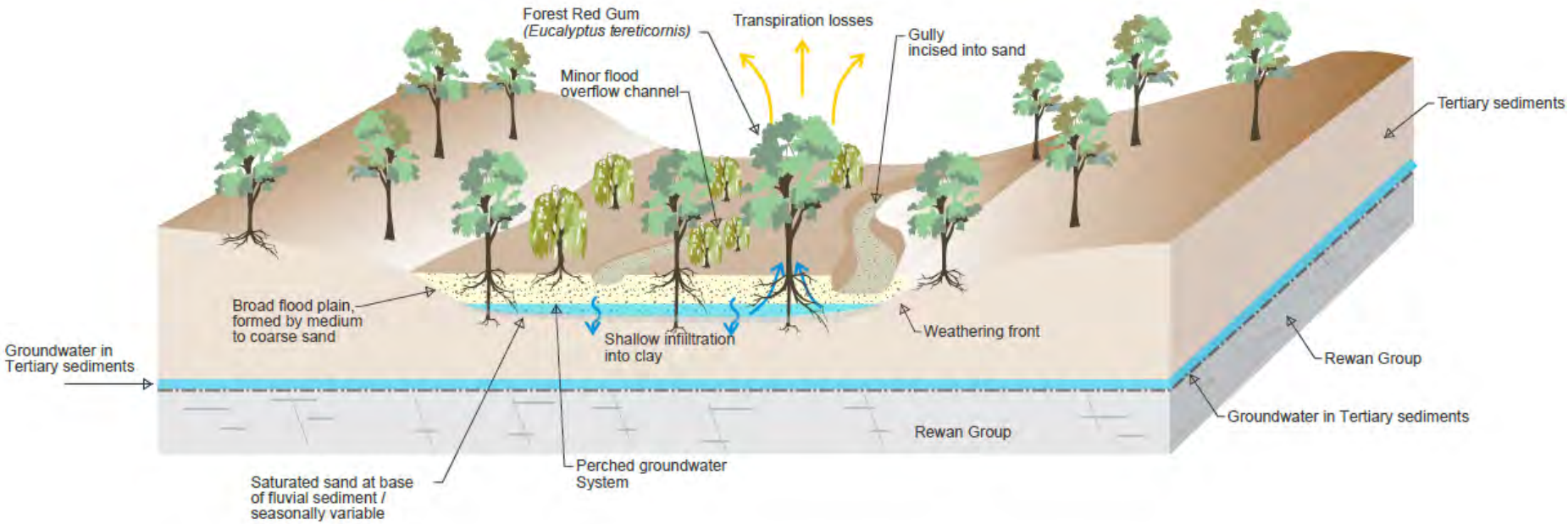

Figure 10. Billy's Gully - Dry Season Regime

Figure 11. Conceptual model of the Billy's Gully GDE system in the wet season showing groundwater recharge mechanisms.

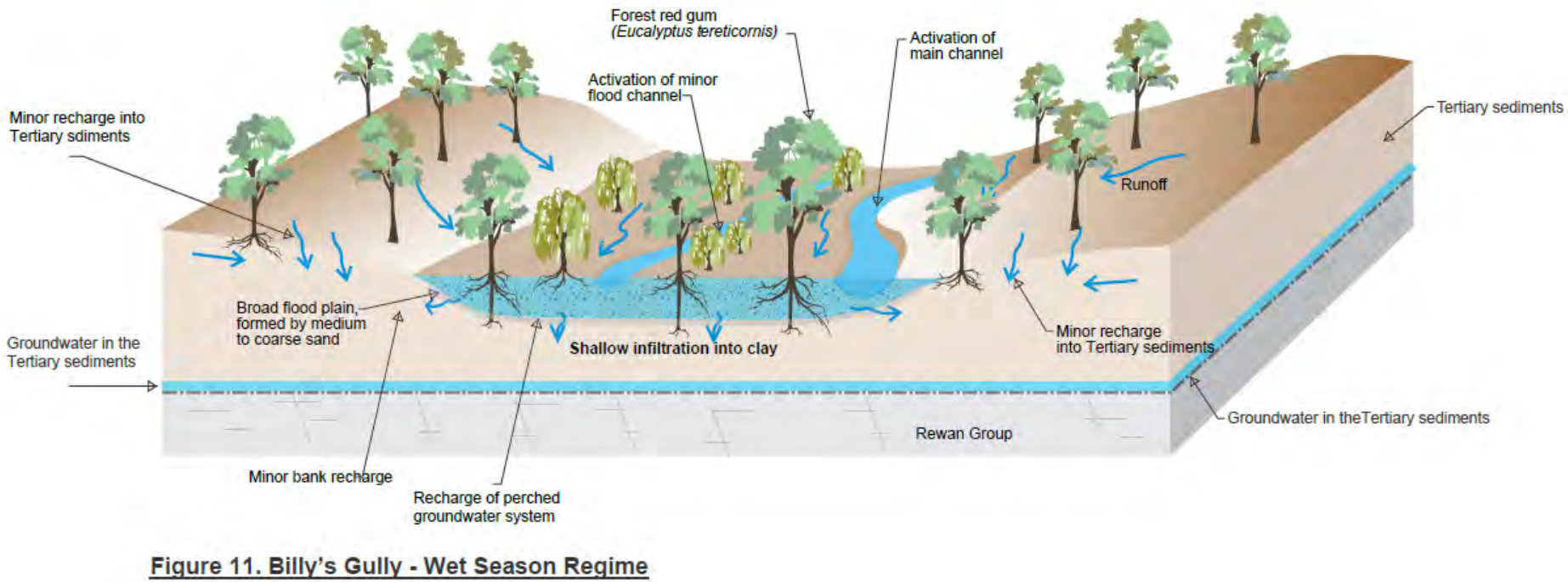

Figure 11. Billy's Gully - Wet Season Regime

rooting depths of 8.1 mbgl in river red gum in a broad study area in the Great Artesian Basin. In conclusion, maximum rooting depth of red gum is likely to be variable, dependent on-site geology and depth to saturation with the capillary fringe being the general depth at which root penetration will be arrested (Eamus et al 2006b). All eucalyptus species are potential users of groundwater (Cook et al 2007) although few studies demonstrating this dependence exist. Fensham and Fairfax (2007) consider both ironbark and poplar box to possess shallow rooting systems with limited investment in deep root architecture, rendering them susceptible to droughting. These species are more typically associated with elevated terraces associated with the Tertiary sediments away from alluvial areas and stream channels and it is considered unlikely that they would be utilising groundwater to any significant degree. Root penetration of these species would be further hindered by the heavy clay substrates which provides an unsuitable medium for development of the deep tap root system necessary for penetration to the groundwater table (Dupuy et al 2005). Soils with low hydraulic conductivities, such as clays, also greatly limit the ability of trees to utilise groundwater (Feikema 2010).

For the remaining species, O'Grady et al (2006b) concluded the following when studying groundwater usage of trees on a tropical floodplain savannah:

1. Clarkson's bloodwood utilised groundwater when the water table was at 10 mbgl indicating the potential for the species to develop a deep sinker root. Clarkson's bloodwood should be considered a facultative phreatophyte. It is likely that Clarkson's bloodwood occurring on the floodplain of Billy's Gully will utilise perched groundwater when it is available.
2. Moreton Bay ash demonstrated groundwater usage when the water table was at 4 mbgl, although it is not known whether the species has capacity to utilise deeper groundwater sources. Moreton Bay ash should be considered a facultative phreatophyte and the closely related Dallachy's bloodwood (*Corymbia dallachiana)* should be considered to possess similar water utilisation strategies.

Brigalow: Brigalow (*Acacia harpophylla)* habitats and individual trees regularly occur adjacent to the floodplain of the major drainage systems and generally occupy heavy clay soils (vertosols) with well-developed gilgai microtopography in the upper soil profile (0.6m to surface) where the bulk of nutrient recycling occurs. The subsoil components are however typically strongly cohesive clays with high levels of salinity, sodicity, acidity and phytotoxic concentrations of chloride which may reduce the effective rooting depth in these soils (Dang et al 2012). Johnson et al (2016) describe brigalow as 'a clonal species with stems arising from horizontal roots which draw resources from a substantial area around the plant'. The concentration of the brigalow root mass in the upper soil profile enables the species to sucker profusely from horizontal roots after physical disturbance and limits the capacity for other woody species to compete for moisture and nutrients. Brigalow's shallow rooting habitat is evident with the tendency of mature trees to topple because of churning in the upper soil profile with fallen trees universally exposing a well-developed lateral root system with little evidence for development of deeper sinker roots.

Melaleuca species: Fringing *Melaleuca bracteata* are almost ubiquitous with heavy clay soils, particularly soils derived from basalt and associated drainage lines. This suggests a root mass concentrated in the upper soil profile where the bulk of nutrient cycling occurs. While many melaleuca

species are considered to be facultative phreatophytes, *Melaleuca bracteata* is thought to obtain its moisture requirements entirely from the soil (Soonthornvipat, 2018).

River oak: The water use strategy of river oak (*Casuarina cunninghamiana)* appears dependent on its position relative to a watercourse. O'Grady et al (2006b) determined river oak mainly utilised river water when adjacent to a stream channel, which is its most common topographic position. There has been no demonstration that river oak has capacity to utilise deeper groundwater sources.

4.0 Major Risks to GDE Function

The GDE Toolbox, developed by Richardson et al (2011), provides a starting point for investigating potential impacts to GDEs exposed to development through the following mechanisms:

1. A total or partial loss or reduction in the volume or pressure of the aquifer being utilised by GDEs.
2. A change in the magnitude and timing of volume fluctuations in the aquifer being utilised by GDEs.
3. Changes to the interaction between surface flows and aquifers being utilised by a GDE.
4. Change in chemical composition of an aquifer detrimentally impacting the health of a GDE.

There will be no direct clearing of vegetation associated with the GDE system at Billy's Gully during IPEE development, operation and decommission, other than the widening of the crossing. Widening of the existing road crossing will result in the clearing of 0.6 ha of riparian vegetation (RE11.3.25 from EcoSM, 2020), however offsets are proposed for this clearing associated with the Extension, with offsets also required for the original crossing for the IPE Project under the Commonwealth approval for IPE. A risk assessment for each potential impact pathway was undertaken as a component of the IPEE GDE assessment report. The methods and results of the risk assessment are fully described in 3d Environmental (2020) and a summary provided in **Table 2.** The pathways with highest risk of impact to GDEs at IPEE are associated with shallow perched groundwater systems with surface flows, representative of the GDE characteristics of Billy's Gully.

Table 2. Potential pathways for impact to the Billy's Gully GDE system with an assessment of the unmitigated risk of impact.

Impact Mechanism	Context	Unmitigated Risk	Mitigation Measures	Mitigated Risk
1. A total or partial loss or reduction in the volume or pressure of the aquifer being utilised by GDEs.	The perched groundwater system supporting the Billy's Gully GDE system and underlying groundwater system associated with the Tertiary sediments do not show evidence of hydraulic linkage.	Low[1]	• Monitoring of groundwater and vegetation communities to detect changes in aquifer pressure and application of mitigation strategies.	Low
2. A change in the magnitude and timing of volume fluctuations in the aquifer being utilised by GDEs[1].	Volume fluctuations in the perched groundwater system are regulated by surface flows. Changes to flow regimes associated with IPEE development are not expected due to the limited catchment excision. Haul road construction with not alter the hydrology or lateral connectivity of the perched groundwater system.	Moderate[2]	• Water Management System • Erosion and Sediment Control plan. • Monitoring of groundwater and vegetation communities to detect changes in aquifer pressure and application of mitigation strategies. • Engineering solutions are provided for construction of the Haul Road crossing on Billy's Gully to ensure the lateral connectivity of the perched groundwater table is not disrupted.	Low
3. Changes to the interaction between surface flows and aquifers being utilised by a GDE.	Flooding volume and frequency will not be significantly impacted by the IPEE development	Moderate[2]	• Water Management System • Erosion and Sediment Control plan. • Monitoring of groundwater and vegetation communities to detect changes in aquifer pressure and application of mitigation strategies.	Low
4. Change in chemical composition of an aquifer detrimentally impacting the health of a GDE[1].	No controlled releases of mine water planned for Billy's Gully. Uncontrolled releases of mine water not predicted for Billy's Gully.	Moderate[2]	• Water Management System • Erosion and Sediment Control plan. • Monitoring of groundwater and vegetation communities to detect changes in aquifer pressure and application of mitigation strategies.	Low

[1]Low - Moderate (loss <25% of keystone trees) within ecosystem although impact contained on mining lease. Reversible in 1 to 5 years with rehabilitation.
[2]Moderate - Significant impact on ecosystem (loss >25% of keystone trees) although impact is contained on mining lease and is reversible with rehabilitation.

5.0 Biophysical Response to Reduced Water Availability / Quality

Eamus et al (2009) provides a conceptual assessment of the major stressors that contribute to declining GDE health. Reduced water availability is the major determinate of GDE health and the flow-on effects of this are outlined in **Figure 12**. The potential impact pathway for the GDE system at Billy's Gully may arise from reduced groundwater recharge because of reduced surface flows, rather than groundwater abstraction. Reduced surface flows and a subsequent reduction in recharge is a low risk (**Section 4.0**) (noting, that the GDE assessment identified that surface flows will have very minor change in flow duration or catchment excision), however is an important consideration. Similarly, increasing salinity levels within the groundwater table would result in stomatal closure, reduction in Leaf Area Index (LAI) and longer-term plant mortality. These adverse physiological responses would ultimately result in the conversion of a diverse, functioning habitat to a simplified system with reduced ecological value (Doody et al 2009). As described in **Figure 12**, the time taken for the first measurable impacts to manifest may take months. As a result, habitat conversion due to dieback of the original canopy for instance, could take many years. Therefore, annual monitoring using the most sensitive indicator is an important measure to detect measurable changes. Many of the physical responses of vegetation to reduced water availability can also occur as a result of natural seasonal variation and hence any monitoring program must have capacity to distinguish what is natural variation from impacts that result from anthropogenic interference.

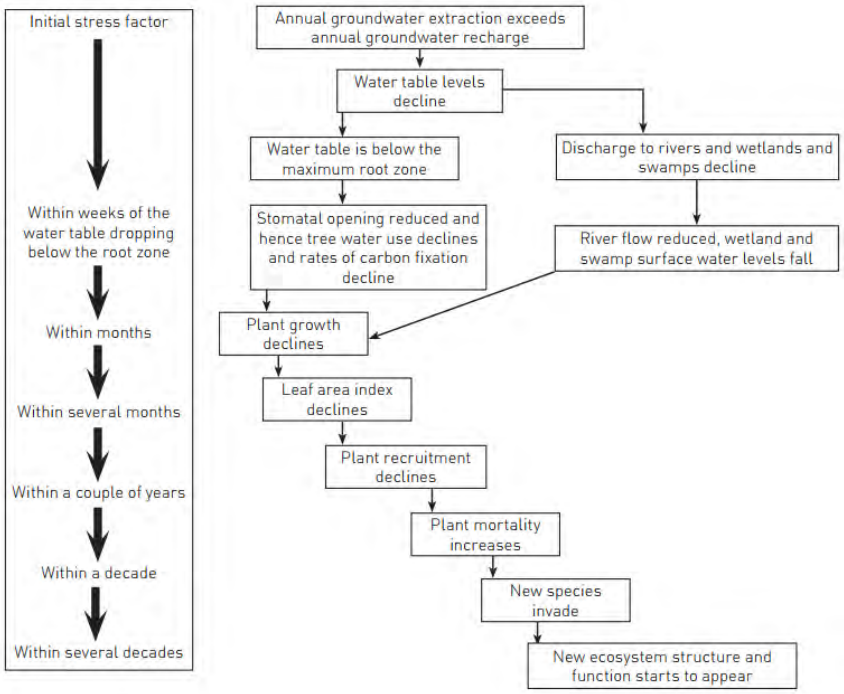

Figure 12. Schematic outline of the response of plants and communities of plants to reduced availability of groundwater from Eamus (2009).

6.0 Approach to Monitoring and Management Program

6.1 Overview

This document provides a framework for the management and monitoring of GDEs in the IPEE area, developed specifically for the Billy's Gully GDE system. A sequential approach to monitoring and management has been applied which allows for adaptive implementation of monitoring and management protocols reliant on results of prior assessment activities. The major components of the GDEMMP include provision to:

- Apply monitoring and assessment techniques that support development of an environmental baseline for GDE function prior, commencing prior to Extension operations, including an upstream control site for monitoring.
- Produce a statistically robust multi-parameter dataset that can be used to validate perturbations in GDE function that fall beyond thresholds of natural seasonal variation.
- Allow a flexible approach to monitoring which is subject to ongoing review and allows methods to be adapted based on results of lead-up monitoring and data analysis.
- Utilise this baseline data to establish an appropriate ecological trigger threshold, applied to indicate requirement for further investigation or corrective action.
- Develop a comprehensive suite of management actions and corrective measures which can be applied if a breach of trigger threshold is identified.

The sequential approach above is consistent with the GDE Toolbox approach (Richardson 2011a and 2011b) which recommends a sequential assessment, as outlined below:

- Stage 1 – GDE location, classification and basic conceptualisation. The focus of Stage 1 is to gain a baseline understanding of where potential GDEs exist including classification of GDE type and ecohydrological function.
- Stage 2 – Characterisation of groundwater reliance. Stage 2 assessment builds on conceptual information provided in Stage 1 to characterise the degree of reliance of the GDE on groundwater.
- Stage 3 – Characterisation of ecological response to change: During Stage 3 assessment, knowledge of baseline ecohydrological function is utilised to describe and quantify likely changes to biophysical function and health of GDEs if impacts to groundwater regimes are manifested.

The GDE characterisation undertaken by 3d Environmental (2020) as a component of the PER process meets the requirements of Stage 1, the outcomes of which are described in accordance with conceptual models in **Section 3.6**. Ongoing adjustment of the ecohydrological models for Billy's Gully may be required as the monitoring program develops, and baseline data is collected and analysed.

Stage 2 and Stage 3 of the monitoring program will rely on collection of temporal data to support characterisation of baseline ecohydrological function. Seasonal monitoring events will allow for baseline data to be acquired to predict trends in GDE function and identify impacts that extend beyond the range of natural variation.

6.2 Approach

The monitoring and management program has been separated into two stages:

- The initial 2 years, for which thresholds have been defined (see **Section 9**).
- The period after 2 years, comprising the remainder of operations and the post mining period, which will utilise data collected in the initial two years to re-assess the thresholds.

The process for establishing thresholds is described in **Section 9**, involving data from the impact site (being the Billy's Gully GDE system adjacent to the IPEE) and a control site. The thresholds for impact are linked to vegetation health and provide a comparison between the control and impact site. Should the thresholds be exceeded, this will trigger an investigation that will make use of other monitoring data (See **Section 9.2**) on the eco-physical function of vegetation a, groundwater and surface water to determine the cause of a threshold exceedance. If the Extension is found to be cause of the threshold exceedance, then mitigation measures (see **Section 10**) will be implemented and the effect of mitigation measures monitored. If mitigation measures are not effective, habitat quality data from the riparian monitoring program will be used to assess whether there has been a significant residual impact to habitat for listed species that are likely to occur (EcoSM, 2020). The riparian monitoring program is described in Chapter 5 of the public environment report (PER) for the Extension.

The initial two year of assessment specifically aims to establish thresholds for monitoring and impact assessment, including provision of a dataset to support investigative action. For the subsequent period after 2 years, the process remains the same; however, the thresholds may be amended to reflect alternative parameters for monitoring and / or the threshold values attached to those parameters.

7.0 Monitoring and Analysis Techniques

The GDE Toolbox – Part 2 (Richardson 2011b) provides a suite of technically robust tools to identify GDEs and determine their ecological water requirements. These tools are based on established methods repeated in studies within Australia and abroad, many of which are published in peer-reviewed scientific journals. Many of these tools were applied in the GDE assessment (3d Environmental 2020) and for the purpose of data continuity and baseline characterisation, will be recommended for inclusion as a component of ongoing monitoring. **Table 3** provides a list of tools used in the GDE assessment and describes their purpose and ongoing relevance to monitoring. Several additional methods adapted from the GDE Toolbox have also been included, being recommended components of an ongoing monitoring program. Technical details of recommended assessment methods are detailed in **Appendix B.**

Table 3. Assessment methods that may be applied during GDE monitoring.

Assessment Method	Utilised in IPEE GDE Assessment	GDE Toolbox Method No.	Method Description	Primary Utility
Conceptual modelling	Yes	Tool 2	Aims to conceptualise the interactions between biotic factors (e.g. trees) and abiotic (e.g. soil, surface water and groundwater). Conceptualisation formalises the understanding of the major components of a GDE system and allows impact pathways to be contextualised.	Conceptualisation and informing monitoring program design and implementation.
Leaf water potential	Yes	Tool 3	LWP provides the primary biophysical measure of tree water availability and defines a continuum between the relationship of soil, water and plant. Trees associated with high water availability will have a high (least negative) LWP. LWP provides an indication of which trees have access to a saturated or near saturated water source, although does not identify the nature of the source (i.e. groundwater, saturated pockets in the soil, surface water from stream pools).	Site based assessment with some application for seasonal monitoring to identify plant water deficits. Used in conjunction with Leaf Area Index (LAI).
Stable Isotopes of water in plants	Yes	Tool 4	The stable isotopic signature (2H and 18O) of the dominant water source for a tree will be imparted on its hydraulic architecture, typically measured in twigs. The stable isotope signature in twigs may be directly analogous to a single water source if that source provides a predominant contribution to a trees water requirement. It may also be a combination of a number or sources, requiring a mixing model to be employed to calculate relative contributions of each water source.	Identifies plant water sources. Ongoing monitoring application during baseline development to demonstrate seasonal variations in plant water sources.
Leaf Area Index	No	Tool 1, Tool 2	Leaf Area Index (LAI) is a ratio of the total leaf area within a canopy to the ground area covered by the canopy. It is a measure of canopy vigour and the rationale applied is that plants with access to permanent sources of water (i.e. groundwater) will have greater vigour and LAI than vegetation that has only periodic access to groundwater resources (e.g. Zolfagher 2014). LAI is likely to vary on a seasonal basis if the sustaining	Has an applicable monitoring application which may be used in conjunction with remote sensing for longer term monitoring.

Assessment Method	Utilised in IPEE GDE Assessment	GDE Toolbox Method No.	Method Description	Primary Utility
			source of moisture is variable, or the groundwater is only seasonally utilised.	
Remote sensing	No	Tool No 1	Assessment utilises the Normalised Difference Vegetation Index (NDVI) as a measure of canopy health and vigour, that can be directly correlated to LAI. It is a widely accepted method and with advances in satellite technology, has the capacity to assess the health of individual trees rather than landscapes.	Application for long-term monitoring once baseline conditions have been established.
Site based groundwater monitoring	Yes – for data from regional groundwater units. Site- specific shallow bores in Billy's Gully alluvium proposed.	Tool No 10, 13	Local installation of groundwater monitoring bores targeted to monitor the groundwater source which the GDE is utilising.	Long term monitoring applications as a basis to draw correlations with biotic assessment parameters (e.g. LAI).
Surface Water Monitoring	Ongoing monitoring under the site WMP and ESCP.	Tool No 10	Ongoing monitoring of surface water flows and quality from dedicated monitoring points (see Section 2.4).	Long term monitoring applications to draw correlations between surface flows and recharge of unconfined alluvial aquifers on Billy's Gully.

7.1 Site Selection and Application

Table 4 provides the recommended data collection requirements for each of the chosen monitoring parameters. Parameters to be applied include LAI, LWP, NDVI image capture, stable isotope assessment of twig xylem, soil, surface water and groundwater from the Billy's Gully GDE system, including an associated control site located upstream at -21.9778 / 148.1796. The control site is approximately 1.7 km upstream of the IPEE, directly west of the Broadlea Road crossing. Further information on each of these monitoring parameters is provided in the Appendix as detailed below:

1. LWP and SMP provided in **Appendix B1**
2. Stable Isotope analysis in **Appendix B2**
3. Measurement of field-based LAI in **Appendix B3**
4. NDVI assessment in **Appendix B4**
5. Groundwater monitoring bores in **Appendix B5.**

The location of trees for LWP and stable isotope sampling, shown in relation to proposed shallow groundwater monitoring bores and habitat quality sites from EcoSM (2018) is provided in **Figure 13**. A summary of all trees that were sampled for LWP and stable isotopes during development of the PER report is provided in **Appendix E** for future reference.

Table 4. Recommended GDE sampling program

Sampling Method	Sampling Locality	Sampling Intensity
LAI	Billy's Gully	Ten capture points in the GDE assessment area including: a) Three sites associated with groundwater monitoring bores BGMB1, BGMB3, BGMB4. b) Co-location of additional sites with habitat quality Monitoring Site 1, Monitoring Site 2 and Monitoring Site 3 as proposed for the Billy's Gully riparian monitoring program.
	Billy's Gully Control	Ten capture points in the riparian ecosystem associated with Control Site 1 on Billy's Gully.
LWP	Billy's Gully	Sampling for LWP will be completed for: a) Ten trees (10) sampled at Billy's Gully by 3d Environmental 2020. Details of these trees are provided **Appendix E** (IP4_T1a, IP4_T1 to IP4_T9). b) A selection of three canopy (3) trees in the vicinity of GDE monitoring bore BGMB3. c) A selection of three canopy trees in the vicinity of GDE monitoring bore BGMB4. Sampling is to focus on red gum (*Eucalyptus tereticornis / camaldulensis)* which is a known facultative phreatophyte.
	Billy's Gully Control	A selection of ten trees will be sampled at a Control Site 1 on Billy's Gully upstream. Sampling is to focus on red gum (*Eucalyptus tereticornis / camaldulensis)* which is a known facultative phreatophyte.
Stable Isotopes	All localities	The program aims to sample selected trees for stable isotopes which are broadly representative of the range of LWP readings at each assessment site. This will include trees with the highest LWP readings, trees with the lowest LWP readings and a range of values between the two end points. Stable isotope sampling will be applied to: a) Twigs from representative trees

Sampling Method	Sampling Locality	Sampling Intensity
		b) Surface water. c) Groundwater from alluvial monitoring bores collected during routine sampling events. d) Soil samples where a particular need arises, including explanation of unusually high or low LWP measurements.
NDVI Capture	Approximately 100km2 capture to cover the relevant parts of Isaac Plains and Isaac Plains East MLs (ML700019, 700018, 700017, 700016, ML70342) plus the control site.	Minimum quality requirements would be fresh capture WorldView 2 and GeoEye-1 (0.5m Resolution 4-8 band Pan) imagery to coincide with the timing of field survey events. Finer resolution imagery from the WorldView 3 and WorldView 4 satellites (0.3m resolution, 4 -16 band multispectral) is also available and may be recommended dependant on any supplementary imagery requirements considered beneficial by Stanmore IP Coal.
Groundwater Monitoring Bores	Monitoring bores are to be installed as a component of the GDEMMP in the Billy's Gully alluvium.	Three monitoring bores include: a) BGMB1[1] (-21.99536, 148.16267) installed to base of alluvium at 3.5m depth with a screened depth of 3.0 to 3.5m. b) BGMB3[1] (-21.98686, 148.16662) installed to base of alluvium at 4.5m with a screened depth of 3.5m to 4.5m. c) BGMB4[1] (-21.99597, 148.16008) installed to base of alluvium at 3.0m with a screened depth of 2.5m to 3.0m. The location of GDE monitoring bores is intended to coincide with the location of Monitoring Site 1, Monitoring Site 2 (HQ17) and Monitoring Site 3 (HQ18) from the riparian monitoring program (EcoSM 2016) (see **Figure 13** and **Appendix C**). Lithology logs from the shallow auger holes is provided in **Appendix B5**.

[1] Temporary monitoring bore name.

7.2 Interactions with Established Monitoring Programs and Parameters

Monitoring of surface water quality and environmental flows will continue to form a component of the IPC mine site (including the Extension) surface water management system. Monitoring of upstream, onsite and downstream flow depths and water quality on Billy's Gully extending to the Isaac River will continue in accordance with the IPC EA (which includes the Extension) and the IPC REMP Design Document (C&R, 2019), allowing for early detection of any impacts and employment of appropriate corrective actions. Surface flow and water quality datasets will be used, in conjunction with other parameters, to inform the baseline characterisation of the Billy's Gully GDE system and assess project impacts. The riparian habitat quality monitoring program (EcoSM 2018) that is in action for Smoky Creek has been extended to cover Billy's Gully, with habitat quality monitoring to be completed every two years post wet season. The program includes three monitoring sites in the Billy's Gully GDE area of potential impact, plus a control site co-located with the GDE control site (Control Site 1) 1.7km upstream from the IPEE boundary. The location of the proposed riparian habitat quality monitoring sites is shown in **Appendix C.**

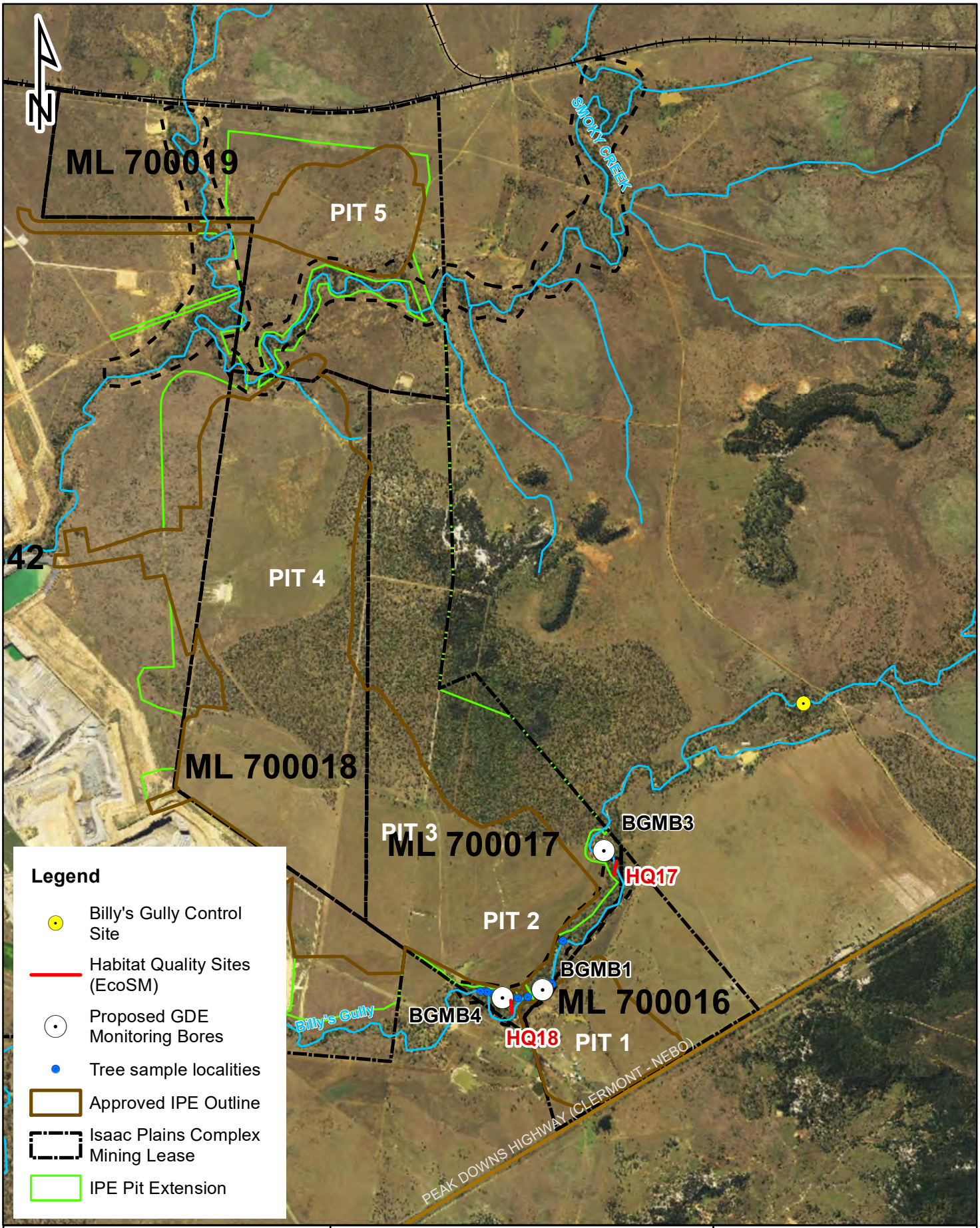

Figure 13. Assessment locations relevant to GDE monitoring.

Client
Stanmore IP South Pty Ltd

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Kilometers

3d Environmental
LANDSCAPE AND VEGETATION SCIENCE

P. O. Box 959
Kenmore, Qld 4069
Mobile: 0447 822 119
www.3denvironmental.com.au

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7.3 Detection of Trends and Statistical Analysis

The BACI (Before After / Control Impact) provides a statistically robust survey design to test for environmental change in response to disturbance. The method takes single impact site and a single control site (outside the impact area) before and after the management or impact is incurred to detect environmental change. Monitoring controls can be augmented with regional data collected during NDVI capture on a temporal basis. In this context, image capture should be extended east along Billy's Gully and Smoky Creek to augment the analysis of locally collected data and ensure habitats associated with the proposed control site are captured.

Statistical analysis will need to consider interactions between multiple datasets to establish baseline conditions and allow identification of statistically significant deviations from these conditions that may be associated with IPE Extension activities. The most critical interactions will be between biotic health (typically measured in LAI, LWP and NDVI) and abiotic factors such as groundwater levels and salinity. Statistical tests applied to analysis of data will depend on whether datasets are normally distributed and may include bivariate analysis of two datasets (e.g. NDVI and LAI) applying a Pearson or Spearman Correlation. 'T-tests' will be applied to identify significant differences in mean values between sampling localities. More complex statistical analysis may be applied if investigative actions are required including multivariate analysis of variance (PERMANOVA) to interacting datasets.

The overriding purpose of the data collection and subsequent statistical analysis is to provide representation of natural variation in the system applied to both biotic factors and abiotic controls and allow appropriate trigger thresholds to be proposed, which are further discussed in **Section 9.0**.

8.0 Reporting, Periodic Review, Timing and Objectives

General program: This GDEMMP proposes methods that will result in collection of baseline ecological and biophysical data that will facilitate increased understanding of the ecohydrological function of the Billy's Gully GDE system. During compilation and analysis of monitoring data, information gaps or data trends may be identified that indicate a need to update the GDEMMP approach and methods. To accommodate this requirement:

1. Reporting will be prepared at the completion of each monitoring event which describes:
    a. Methods employed.
    b. Factors that may have influenced data and monitoring results
    c. Data trends for each of the parameters measured.
    d. Information gaps which may influence the assessment.
    e. Correlations between datasets which characterise ecological function.
    f. Trends which appear abnormal or indicative of unexplained / un-natural decrease in ecological function, warranting further investigation or corrective action.
2. Bi-annual monitoring (four events covering two wet seasons and two dry seasons) should be undertaken for a two-year period.
3. At the completion of four monitoring events (excluding the original GDE assessment associated with the PER), a consolidated report will be prepared which provides a synopsis of the data collected, including correlations between parameters and statistical analysis (where possible) of baseline ecological function.

The aim of the four-event baseline characterisation is to determine the range of natural seasonal variation in the measured parameters, particularly LWP and LAI which are fundamental indicators of plant stress. These parameters can be correlated to the NDVI signature, allowing future monitoring to be undertaken remotely at an 'on demand' basis, supplemented with field assessment if a significant departure from baseline condition is detected. Reporting and review requirements have been incorporated into a proposed two-year monitoring schedule as per **Appendix D**.

Ongoing monitoring following baseline: Following completion of the two-year (four-event) baseline. program in March 22, NDVI will be captured on an annual basis during the height of dry season (nominally October / November) to support ongoing monitoring of GDE health. NDVI threshold values will be calculated from correlations to LAI established during the baseline assessment, and annually checked for statistically significant threshold exceedance events that affect the impact site, in the absence of similar affects at the control site. Annual capture of NDVI data will be completed until completion of mining operations, as described below.

Monitoring completion: A monitoring event that includes field assessment of monitoring parameters should be undertaken to coincide with completion of mining at the IPEE. This event will include:

1. A comparison to the baseline GDE dataset to identify any significant departure from pre-impact conditions.
2. Provision of a summary memorandum detailing ecological condition of the Billy's Gully GDE system and recommendations for future monitoring requirements.

Providing there has been no significant decline in ecological condition that can be attributed to mining operations, follow up survey periods should be:

1. Two years from completion of mining operations, timed to coincide with the driest portion of the year (typically September to November).
2. Four years following completion of mining operations, timed to coincide with the driest portion of the year.
3. A final survey event at six years following completion of the mining operation.

Based on correlations drawn between LAI and NDVI during baseline characterisation, completion of post mining monitoring through capture of remotely sensed data should be feasible.

9.0 Triggers for Investigative Action and Supporting Parameters

While groundwater associated with the alluvial flood plain is a major abiotic control on the ecohydrological function of the Billy's Gully GDE system, it is the actual health of the vegetation that defines GDE habitat values. In the absence of long-term groundwater monitoring data to characterise seasonal variation and persistence of the alluvial groundwater system, it is pertinent that vegetative indices be utilised to provide a baseline for ecological health and define trigger thresholds to direct when investigative actions are required. The indices used to define trigger thresholds, including potential parameters applied during investigative action are described in following sections. The management framework is intended to be adaptive, with future capacity for update dependent on the ongoing results of the baseline assessment, and any information gaps identified.

9.1 Vegetative Indices

Section 5.0 (**Figure 12**) identifies a decrease in LAI as an initial indicator of vegetative stress. LAI is a precursor to more intensive impacts to habitat values including canopy dieback and conversion to an alternative ecological state over a longer time frame. LAI varies on a seasonal basis dependent on water availability, generally within the space of weeks to months, with the highest values lagging slightly behind moisture recharge events. Doody et al (2015) document typical annual LAI variation in the range of 14% to 35%, with LAI = 0.5 (i.e. 50% foliage to canopy ratio) identified as a potential threshold, indicative of critical water stress beyond which vegetation health rapidly declines. This value is however taken from river red gum forest on the Murray River and may not be directly applicable to the Billy's Gully GDE system due to the vastly different climatic regimes and hydrological controls. The process for thresholds based on LAI applies the following principles:

1. Collection of time series data of LAI from control and impact sites for a period of two years to establish a baseline.
2. Identifying appropriate thresholds which may be applied as a trigger for investigation and provide a mechanism to review the appropriateness of the derived trigger.
3. Statistical analysis of time series data to characterise seasonal differences in assessment parameters at control and impact sites to identify if a threshold breach occurs.

Where a threshold breach occurs, appropriate baseline data from a range of biotic and abiotic parameter will be available to provide a sound basis for investigation. **Figure 14** details the process and decision framework from initial data collection through to corrective actions in the case that a threshold breach can be linked to mining activity. The initial two years of the assessment cover wet and dry season surveys, to provide a baseline against which future vegetation condition trends can be assessed. The two-year baseline assessment and decision-making process are as follows:

1. Establish suitable impact and control sites on Billy's Gully and collect and capture LAI and supporting biophysical data (LWP and NDVI) in an initial dry season assessment event (November 2020). The proposed location of the impact and control sites has been previously identified in **Section 7.1** and **Table 4**.
2. Establish an appropriate trigger threshold value based on the percentile method detailed in DSITI (2017). The proposed process for establishment of the investigative trigger thresholds is:
    a. Collect LAI data from a minimum of 10 permanently located monitoring points at both the impact site and control site in the initial dry season GDE assessment.
    b. Undertake statistical analysis (t-test) to compare dataset means and ensure the appropriateness of the control site for comparative purposes.
    c. If a significant difference is detected between the mean values of control and impact datasets in the initial assessment, the location of the control site will be re-evaluated.
    d. Assuming suitability of the control site, set the lower of the 10th percentile (or LAI of 0.5 as per Doody et al 2015, whatever value is lowest) as a trigger value for investigative action.
3. Collect seasonal data (post wet season in March to April 2021) to provide a baseline which incorporates seasonal variation.

4. Complete a follow up dry season assessment (October to November 2021). Assess appropriateness of applied thresholds and assess data for significant differences in means (t-test) to identify if a threshold breach occurs.
5. Undertake a final wet season assessment to complete the baseline data collection phase.

At each stage, decision pathways are provided when threshold breaches are identified, including requirements for investigative action and corrective measures where causal factors can be linked to mining activity. Corrective actions, including potential requirement for biodiversity offsets in a worst-case scenario, are discussed in **Section 10**.

Following the two-year baseline assessment, statistical correlation between various assessment parameters will be drawn, particularly the relationship between LAI and NDVI to allow ongoing monitoring to be completed remotely, and trigger thresholds to be adapted. The full suite of parameters collected during the baseline assessment period, with their relevance, intended application in both the baseline assessment and longer-term monitoring program is provided in **Table 5.** Supporting parameters are further discussed in **Section 9.2**. The process that occurs after the two-year baseline assessment will follow the same process as shown in the flowchart in **Figure 14.** Instead of using LAI as a threshold parameter however, NDVI is proposed for use; with the relevant parameter threshold value to be established using the baseline data collected in the previous two years. NDVI will be measured in the dry season at impact and control sites to determine if the threshold is exceeded and, if exceeded, trigger the flow chart process for investigation, mitigation (corrective action) and offsets.

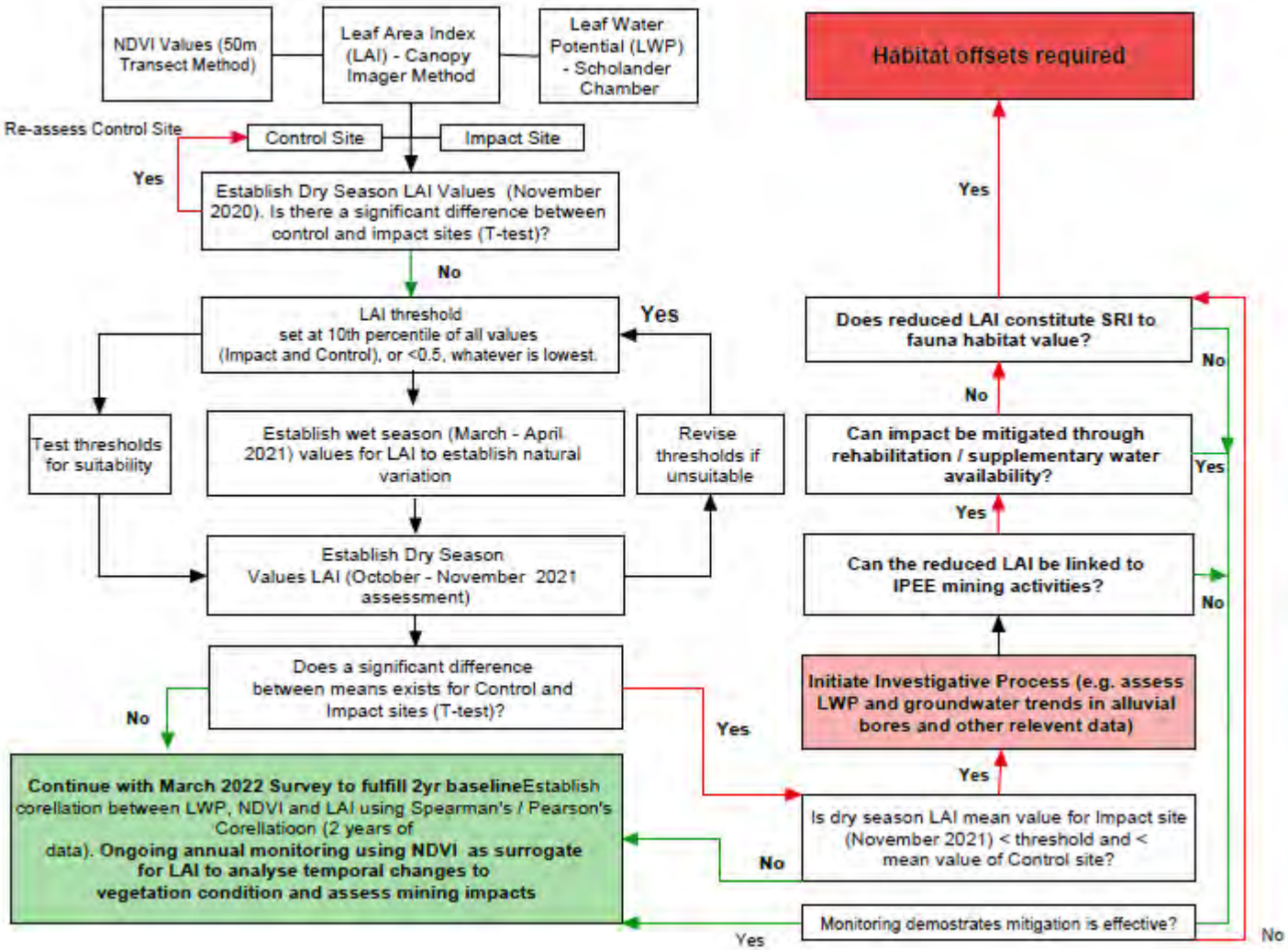

Figure 14. Decision process for application of investigative and corrective actions when trigger thresholds are exceeded for the initial 2-year baseline assessment.

9.2 Supporting Parameters

Supporting parameters are those that will be measured to provide a component of the baseline dataset and will be drawn on to support both the longer-term monitoring program and provide input into investigative action if required. Specifically, these supporting parameters will include LWP, stable isotopes, NDVI and groundwater monitoring in the alluvial aquifer.

9.2.1 Leaf water potential

LWP provides the primary biophysical measure of tree water availability and defines a continuum between the relationship of soil, water, and plant. LWP typically demonstrates a strong positive correlation to LAI and where this relationship breaks down, indicates factors other than water availability may be influencing the relationship (e.g. insect defoliation). LWP measurements established during the two-year baseline will be a fundamental consideration for any future investigative action.

9.2.2 Normalised Difference Vegetation Index

NDVI is a measure of vegetation vigour, including a combination of greenness and biomass, which has a direct positive correlation to LAI. A correlation between field-based measurements of LAI and NDVI will be established over the 2-year baseline period, to allow GDE monitoring to be undertaken remotely at a landscape scale on an annual basis. Upon completion of the two- year baseline, trigger threshold values for investigative action will be calculated based on the correlation between LAI and NDVI, and it is proposed that ongoing annual monitoring will utilise high resolution NDVI as a surrogate for field-based LAI measurements. Further information on the NDVI process is provided in **Appendix B4**.

9.2.3 Stable isotopes

The primary role of stable isotope investigations is to inform how sources of moisture utilised by trees vary on a seasonal basis. The dataset will be used to identify endpoints where vegetation is utilising groundwater alone, shifting in status to primary utilisation of soil moisture in the unsaturated zone. While stable isotope analysis provides insight into site ecological function, allowing risks to GDE function to be characterised, its relevance to ongoing monitoring diminishes once a baseline dataset is established as it is not an indicator of plant health. Stable isotope analyses might be may be applied beyond baseline dataset collection to support investigative actions, allowing status shifts in seasonal water utilisation to be identified.

9.2.4 Groundwater levels and quality

There is no baseline characterisation of the groundwater fluctuations or quality for the Billy's Gully alluvium as construction of the proposed alluvial monitoring bores (BCMB1, BGMB3, BGMB4) is not complete. As the monitoring bores are likely to be seasonally wet, the imperatives of groundwater monitoring at the alluvial bores will be to:

1. Confirm linkages between recharge of the alluvial aquifer and surface flows.
2. Establish the period of saturation, including saturated thickness of the alluvial aquifer and lags in recharge following surface water flows.
3. Identify natural groundwater quality parameters to provide a baseline dataset for comparison to water quality of surface flows.
4. Identify the degree to which the alluvial aquifer is utilised by vegetation (typically through analysis of stable isotopes) on a seasonal basis.

5. Identify ecological response to aquifer recharge including correlations between alluvial aquifer recharge, LAI, LWP, NDVI and climate data.

The baseline dataset for groundwater levels and water quality in the Billy's Gully alluvial aquifer will be developed during the two-year baseline characterisation. Water levels and water quality will be directly correlated to LAI to determine the relationship between groundwater and vegetation health. While Eamus (2006) defines 1500 µS/cm as a measure where salinity becomes toxic to red gum, any impact to the seasonality and water quality of the alluvial aquifer will be directly imparted on LAI and supporting vegetative parameters. Establishing threshold values for water levels and quality in a seasonally variable aquifer will not be meaningful in the absence of longer-term groundwater datasets where seasonality and aquifer recharge rates can be ascertained. Hence thresholds for investigative action that relate to water levels and quality are not proposed in this GDEMMP, which otherwise relies on vegetation indices which are the primary values which define GDE health and any related impacts. Never-the-less data from groundwater monitoring will provide input into investigative action if required.

Table 5. Assessment parameters, application, and analysis.

Data collection method	Purpose	Analysis methods / metrics
Primary Parameter		
LAI	Primary parameter used to measure plant stress and vegetation response to decreasing groundwater.	Threshold to be set at the lower of the 10th percentile for all LAI data from the initial dry season survey of Billy's Gully and control site (or 0.5 from Doody et al 2015), triggered when: 1. T-test indicates significant differences between means of control and impact sites, and; 2. Impact site has a lower mean LAI value. The initial establishment of the trigger threshold will be undertaken in the dry season 2020 and relies on initial means between impact and control sites to be comparable.
Supporting Parameters		
LWP	A measurement of water availability to trees, which will provide an important correlate with LAI and a baseline dataset to support a future requirement for investigative action. Supporting data which can be used to determine if any future LAI threshold trigger events are related to plant water availability.	1. Pearson / Spearman's correlation to establish statistical relation between LAI and LWP as a basis for inclusion in investigative action, if required. 2. Application of a T-test to identify if significant differences between means of control and impact sites exist during the initial dry season assessment.
NDVI	A remotely sensed measurement of vegetation productivity that describes the greenness and the relative density / health of forest biomass.	Confirming the relationship between NDVI and LAI through application of Pearson's / Spearman's correlation. Longer term application to remotely monitor GDE health at completion of the 2yr baseline assessment.

Data collection method	Purpose	Analysis methods / metrics
Stable Isotopes of twig xylem, soil, groundwater and surface water.	Application as a tracer to identify the predominant sources of water utilised by trees. Useful to determine how tree / water interaction varies on a seasonal basis as groundwater levels fluctuate. Most applicable in the baseline characterisation phase though may be useful supporting information if investigative actions are initiated.	Biplot comparisons of stable isotope values (δ18O and δ2H) of tree xylem, groundwater and soil moisture to identify phase shifts.
Groundwater monitoring data	The purpose of monitoring groundwater in the alluvium at Billy's Gully is to: 1. Confirm linkages between recharge of the alluvial aquifer and surface flows. 2. Establish the period of saturation and seasonality. 3. Determine natural groundwater quality parameters. 4. Allow ecological response to aquifer recharge to be identified / quantified.	1. Installation of pressure transducers in the three alluvial monitoring bores to collect information on groundwater levels, fluctuation trends and water level response to rainfall. 2. Water quality measurement associated with routine water sampling schedules. 3. Analysis of water levels and water quality against vegetative indices including LAI and LWP through correlation testing (Pearson / Spearman's).

10.0 Potential Corrective Actions and Adaptive Management

Corrective actions that halt or reverse impacts to GDEs are not well developed in literature and the suggested measures will require trials to determine / confirm their effectiveness. As a starting point, where impacts to GDEs are identified that can be related to mining activities, corrective actions should be taken to ameliorate the source of impact. Where severe, these could include potentially limiting expansion of mining in the area that is contributing to impact whilst further investigation occurs. Corrective actions may include engineering solutions or re-design of surface water and sediment controls.

As the Billy's Gully GDE system is reliant on recharge from surface flows, the most relevant corrective actions will involve surface water management and enhancing its capacity to recharge the shallow alluvial aquifer. Possible mechanism might involve:

1. Minimise mine water catchments that would otherwise report to Billy's Gully
2. Maximising the diversion of clean water from clean water diversions to Billy's Gully. Infiltration may be enhanced by placement of temporary bunding to slow surface water flow.
3. Pumping sediment water from sediment ponds to Billy's Gully if water quality can meets standards to sustain ecosystem health, with salinity being a key driver.
4. Redirect any sediment dam overflows to Billy's Gully upstream of impact, if possible.
5. Direct injection of water, including sediment water that meets water quality objectives, into the rooting zone of trees where impacts are detected to provide site specific amelioration of impacts through increased water availability and /or dilution of groundwater salinity.

These techniques can be trialled in localised areas, most beneficially during a period of extended drought and seasonally dry conditions where impacts on LWP and LAI are likely to be most measurable. The release of water into Billy's Gully must be undertaken in compliance with the EA conditions for surface water release.

While there have been few case studies that have applied direct injection into the root zone, Behrens et al (2009) investigated direct injection of fresh water into a saline aquifer on the Murray and found that while the trial resulted in temporary freshening of the capillary fringe, it had limited influence on tree condition as the radial extent of freshening (approximately 10 m) did not intersect with the root zone of salinity stressed trees. Therefore, application of this technique is likely to be practical for localised areas where impacts are detected in scattered trees or scattered groups of trees rather than application in broader scale impact mitigation.

Forest red gum (*Eucalyptus tereticornis)* is one of the dominant groundwater dependent species occupying the Billy's Gully floodplain and is also the species that is most likely to demonstrate groundwater reliance. The species is ecologically adaptable, occurring on dry hillslopes as well as floodplains and is a significant plantation species. Malik and Sharma (2004) found that the species has a strong capacity to extract moisture from the shallow soil profile (0 – 150cm) in the 426mm rainfall belt and Kallarackel and Somen (1997) identified that growth rates are not necessarily limited

by water deficit. Trials using locally sourced forest red gum seedlings should be undertaken to determine:

1. If infill planting of forest red gum in canopy gaps has capacity to ameliorate impacts caused by potential tree dieback.
2. Whether trees that have been planted in dry soil regimes have greater capacity to withstand environmental stressors than older established trees that have adapted over long periods to specific ecological water requirements (EWRs).

It is recommended that small scale trials commence upon approval of the Extension, through planting of forest red gum seedlings into existing canopy gaps on Billy's Gully. This will require some maintenance through drier periods until seedlings have established. Trials do not need to be extensive and should focus on the capacity of the species to survive, through planting of scattered trees into existing canopy gaps. Plantings should be checked for disease and loss of vigour:

1. At least weekly for the first month including any watering requirements to aid establishment.
2. Monthly for the next 5 months, and;
3. Annually following the initial six months, in conjunction with the annual GDE monitoring program.

Where injection of fresh water into the tree root zone is applied as a management measure, the following approach to confirming the effectiveness of the measures should be considered:

4. Measurement of pre-impact LWP and LAI of trees where treatment is applied. Pre-impact canopy health can also be measured using NDVI imagery captured prior to treatment.
5. Repeat measurements for LAI and LWP to be taken at 1month, three months and six months following treatment to measure vegetative response.
6. Ongoing annual monitoring of crown health of individual trees using high resolution NDVI in accordance with annual monitoring program post baseline assessment.

In the absence of positive results from either of these trials, and degradation of GDE habitat on Billy's Gully that can be directly attributed to mining activity, despite implementation of mitigation measures, biodiversity offsets can be considered. Disturbance thresholds for habitat to listed species (identified as likely to occur by EcoSM, 2020) that trigger a requirement for biodiversity offsets should consider the following criteria to determine whether a significant impact has been incurred:

1. Death of dominant canopy trees, to the extent that habitat is converted from remnant to non-remnant vegetation cover as per definition under Queensland's Vegetation Management Act (1999) (i.e. loss of 50% of the original constituent trees or canopy cover).

2. *Loss of foraging resources* to the extent that a significant residual impact is incurred to a threatened species listed under the EPBC Act (as identified by EscoSM, 2020).

Relevant EPBC Act listed species are identified in the *Isaac Plains East Extension – Terrestrial Ecology Impact Assessment* and assessment of the significance of impact should be guided by the proposed habitat quality assessment

The decision-making process which determines the level of action required has been provided in **Figure 14**, which indicates ecological offset as a final measure applied to compensate habitat loss. The management framework is intended to be adaptive, with future capacity for update dependent on the ongoing results of the baseline assessment, and any information gaps identified.

11.0 References

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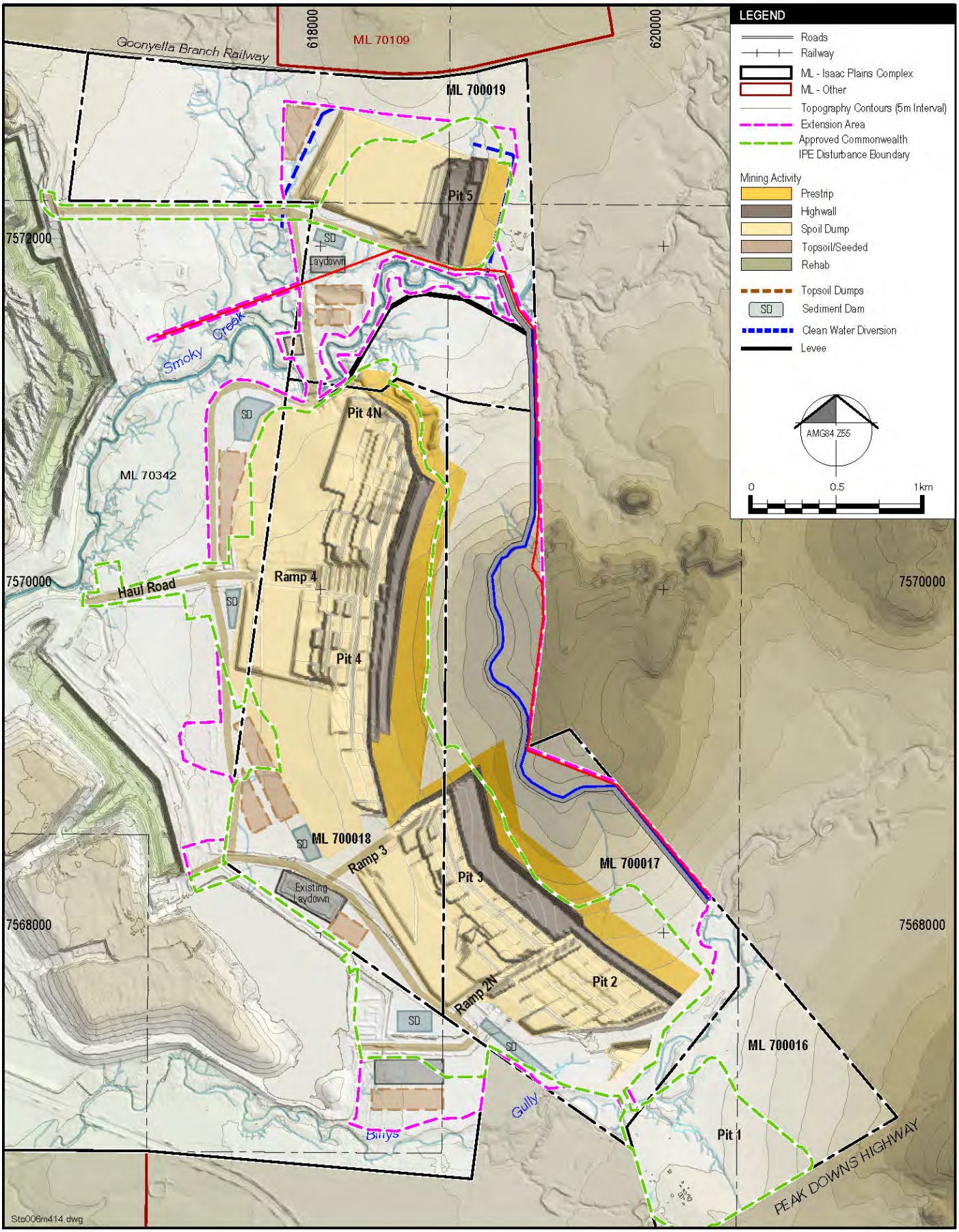
12.0 Appendices

Appendix A. Project Schedule and Timing

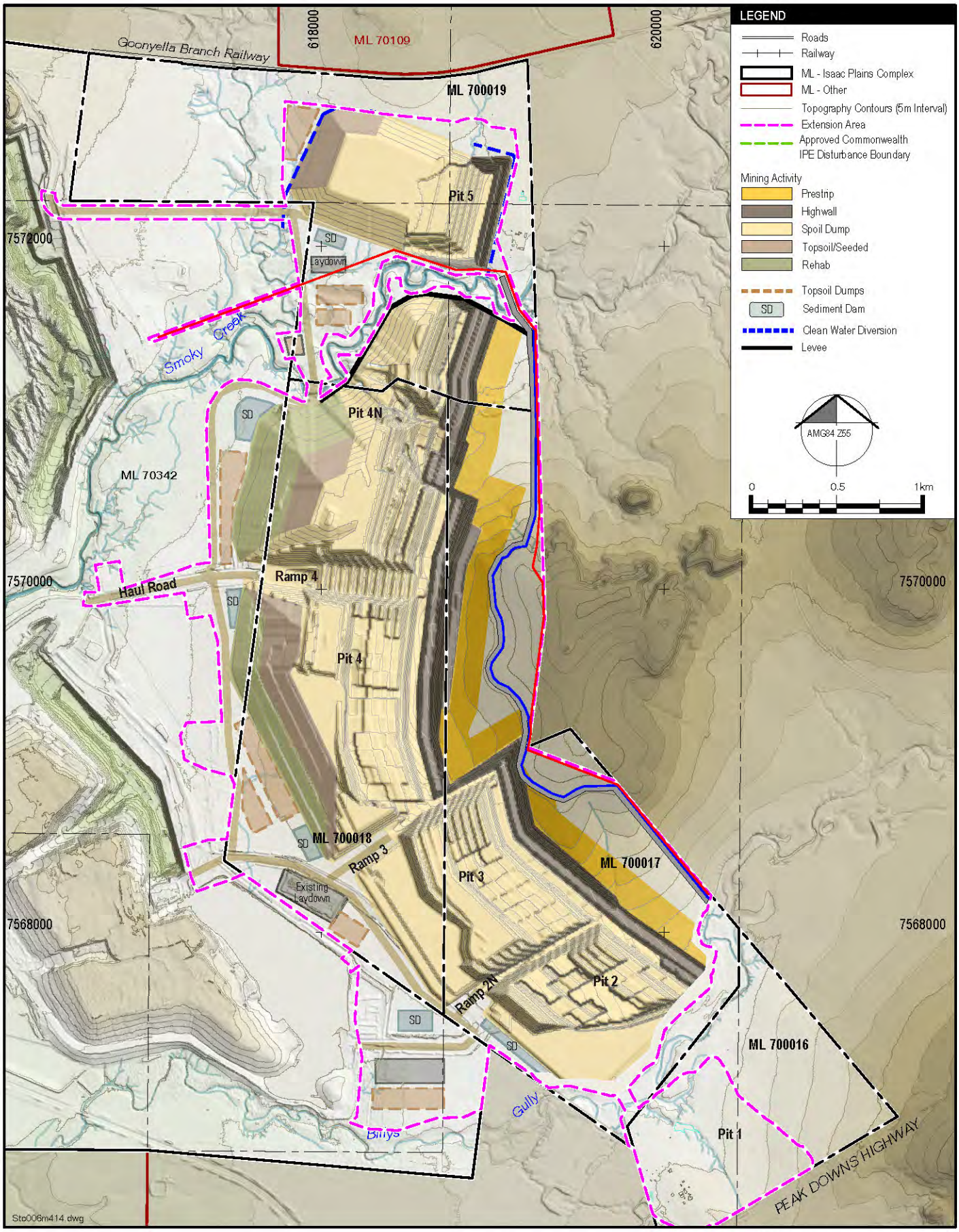


ISAAC PLAINS EAST EXTENSION

Stanmore IP Coal

Mine Stage Plan 2021

Figure 3-14

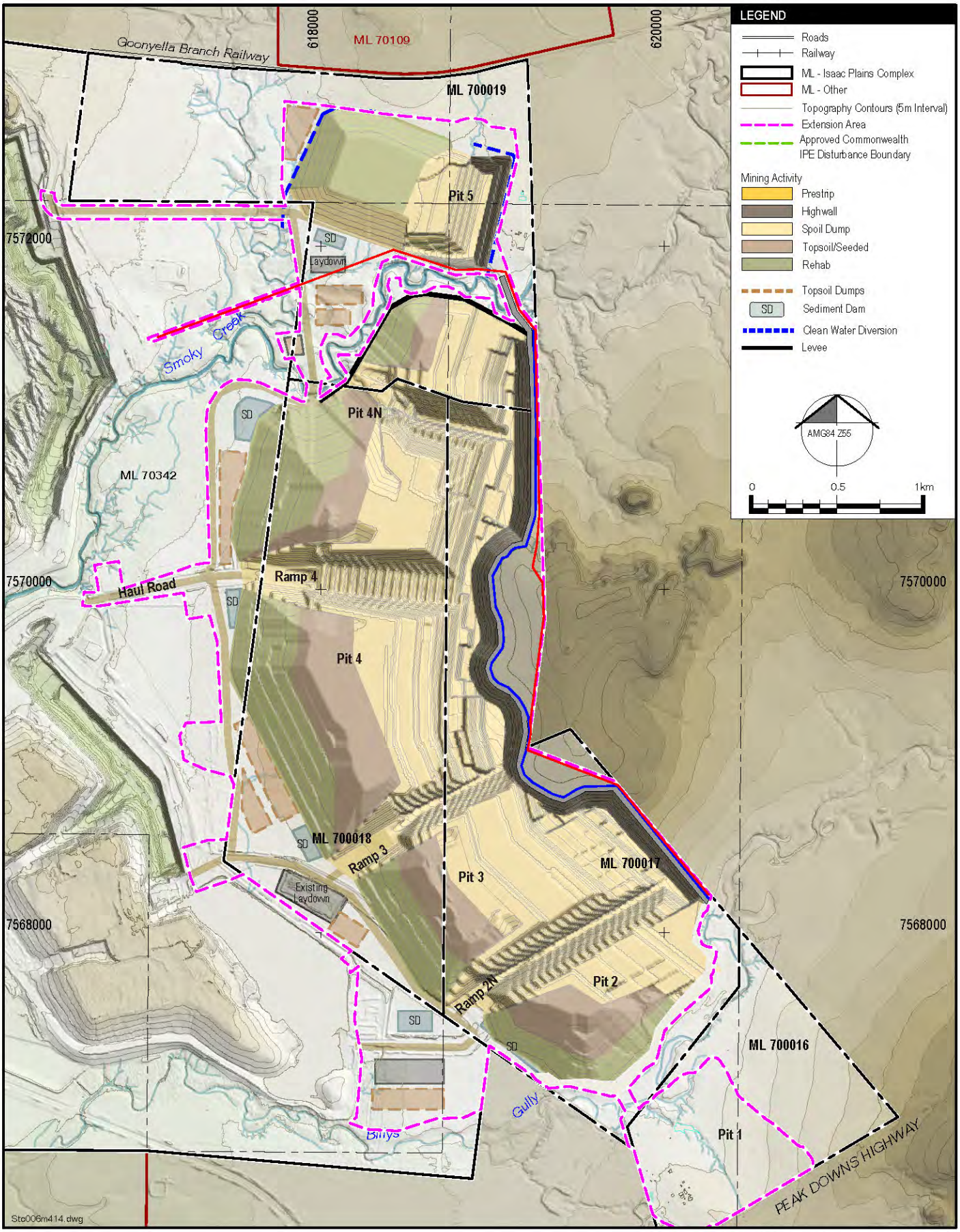


ISAAC PLAINS EAST EXTENSION

Stanmore IP Coal

Mine Stage Plan 2024

Figure 3-15

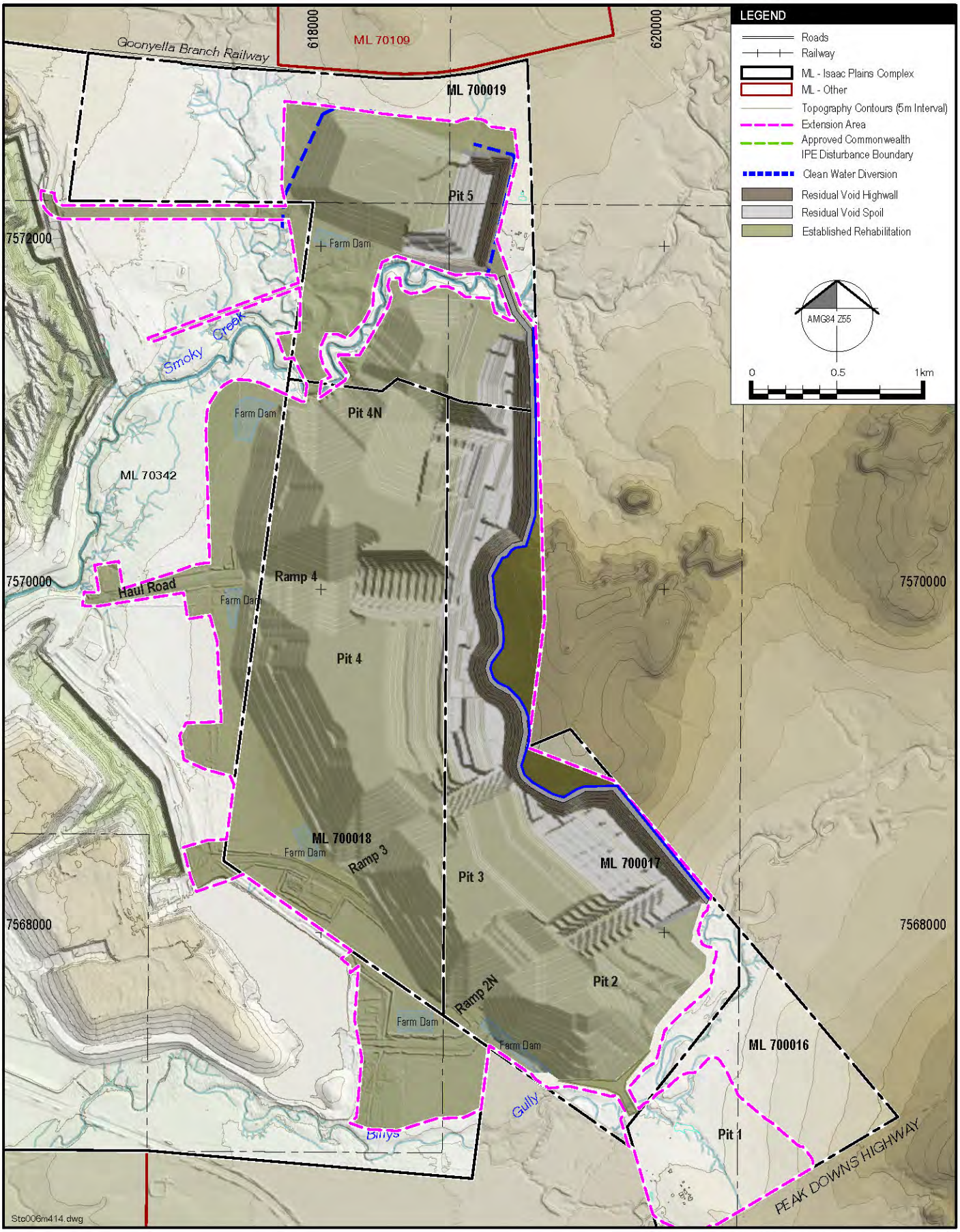


ISAAC PLAINS EAST EXTENSION

Stanmore IP Coal

Mine Stage Plan 2028

Figure 3.16



ISAAC PLAINS EAST EXTENSION

Stanmore IP Coal

IPE Extension Final Landform

Figure 3.17

Appendix B. Sampling Methods

B1. Leaf / Soil Moisture Potential

The measurement of leaf moisture potential will be targeted to specifically assess the interactions between tree roots and soil moisture / groundwater. These measurements will only be undertaken at the all chosen localities on selected trees (as per **Section 7.1.2**) placed specifically to assess for these interactions.

Rationale

Leaf water potential is the total potential for water in a leaf consisting of the balance between osmotic potential, turgor pressure and matric potential. It is defined as the amount of work that must be done per unit quantity of water to transport that water from the moisture held in soil to leaf stomata. It is a function of soil water availability, evaporative demand, and soil conductivity.

Measurement of leaf water potential is undertaken by collecting leaf samples at pre-dawn and using a Scholander pressure chamber (pressure bomb) to measure the pressure required to force water from the stem of the leaf. The results of the leaf water potential measurement are then compared to either the soil moisture potential at the same site collected at regular vertical intervals by drilling down to the water table and using a dewpoint potential meter.

It is assumed that trees will be using water from a source that requires the least energy (lowest water potential) to lift water from the soil, through plant xylem to the leaf for transpiration. This will be dependent to a large part on recent rainfall as well as the specific physical attributes of the soil that holds the rooting material. Heavy clays for example, may have a relatively high water content, although this water is hard to extract due to the cohesive forces of the fine particles which hold water very tightly. Clays will thus have a lower water potential than sand which has large pore spaces between the grains and much lower cohesive forces.

It is must also be recognised that trees at the chosen monitoring sites may not be accessing water from one specific source exclusively. Moisture from several horizons within the soil profile may be contributing to tree water requirements, and the predominant source of water may vary on a seasonal basis. To maximise the likelihood of identifying trees that are predominantly using groundwater, it is important that assessments be undertaken in the seasonally driest part of the year.

Methodology

Leaf water potential needs to be measured pre-dawn (prior to sunrise). The basis of this requirement is that pre-dawn measurement provides an estimate of the water potential of the wettest part of the soil profile that contains a significant amount of root matter (Eamus et al 2006a). It is assumed that pre-dawn leaf water potential will equilibrate overnight to the portion of the soil profile that has the highest water potential. Hence contemporaneous measurement of both pre-dawn leaf water potential from a canopy tree at a chosen monitoring locality and soil water potential from selected depth intervals down a co-located borehole will provide an indication of the predominant source of water (soil moisture or groundwater) being utilised by trees at the time of survey.

Measurement of Leaf Water Potential

Leaf water potential is measured pre-dawn (prior to 5.30 am in summer) using a Plant Water Potential Gauge (originally referred to as the Scholander pressure chamber or 'Pressure Bomb'). Measurement of leaf water potential requires:

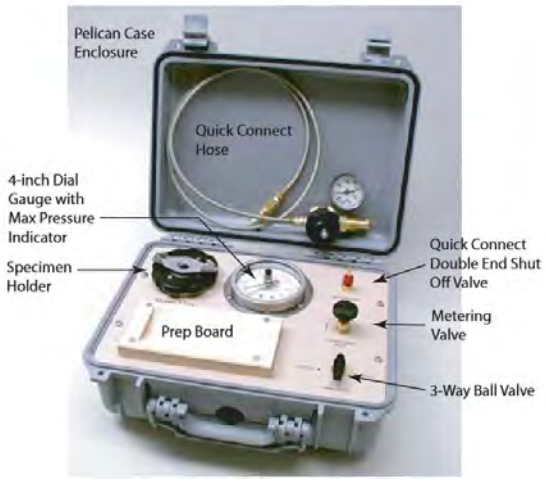
1. Collection of leaves from an accessible part of the tree crown.
2. Preparing of leaf material for insertion into the pressure bomb.
3. Measurement of Leaf Water Potential using the pressure bomb.

Collection of Leaf Material: Leaf material is to be collected from the highest accessible portion of the tree crown using an extension pole and attached lopper head (see **Section 8.5.2.2**). Leaf material should be selected that is disease free (as far as practical) and vigorous, preferably with indications of new leaf growth at the growing tips.

Preparation of Leaf Material: A representative sample of healthy leaf is removed from the collected material with sufficient leaf stem (petiole) to allow it to protrude outside the water potential meter (typically 1 to 2 cm). The stem is cut square with a sharp blade and immediately inserted into the water potential metre with the grommet sealed.

Use of the Plant Water Potential Gauge: The preferred Plant Water Potential gauge is the Model 3115 Plant Water Status Console due to its compactness and portability. The device is manufactured in USA (Soil Moisture Equipment Corp.) and distributed in Australia by ICT International (Armidale). The device fits into a 16 x 13 x 7inch Pelican Case and weighs approximately 11kgs which includes the compressed gas cylinder.

Additional Safety and Operational Measures: The Model 3115 console is accompanied with a detailed unit operation manual which describes in detail the required operational procedures. The unit operates on a compressed gas cylinder which should be professionally refilled with compressed N_2. As pressure is applied to the chamber, there is potential for the leaf petiole to be forcefully ejected from the chamber. Hence safety glasses will be required during unit operation.



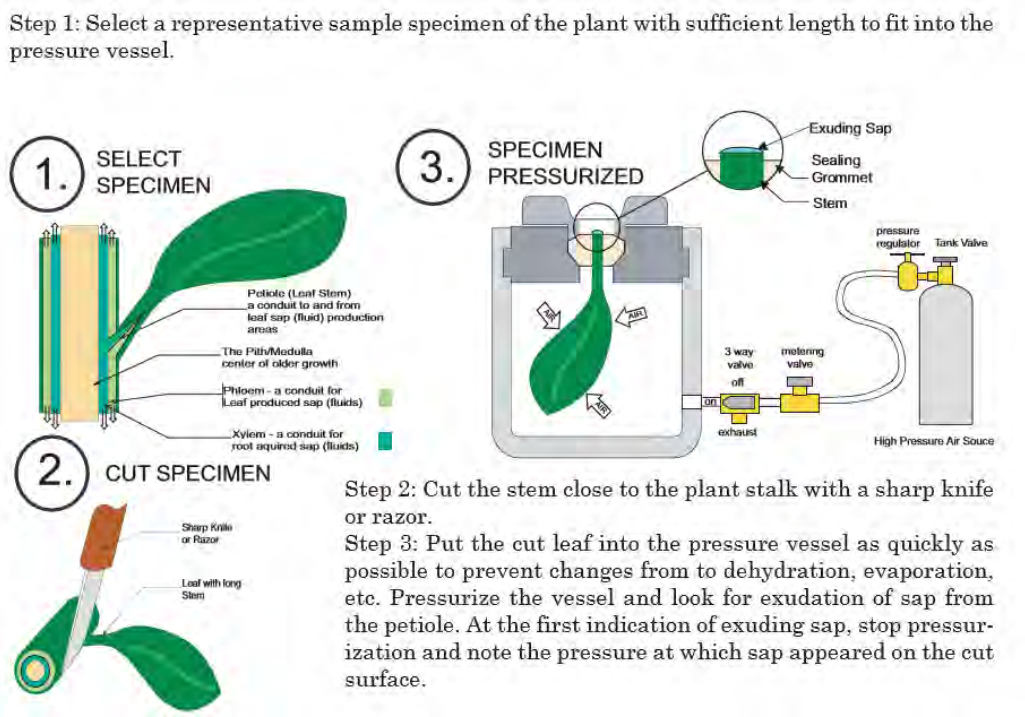
A1. Model 3115 Plant Water Status Console with parts description.

The Water Potential gauge measures leaf or stem water status by the following method:

1. A leaf or stem is collected from the tree that is targeted for assessment.

2. The petiole (leaf stem) is cut and placed in the pressure chamber with the cut stem protruding from the chamber at atmospheric pressure.
3. The vessel is sealed around the petiole and pressure applied via an external gas cylinder.
4. The protruding stem is observed and pressure readings recorded at the first point that water is noted to be exuding from the leaf.
5. The positive pressure applied to the leaf that forced water from the leaf stem is measured. This is the leaf water potential.

The process as supplied by Soil Moisture Equipment Corp (2006) is provided in **A2** below.



A2. Diagrammatic illustration of the use of the Pressure Bomb as per Soil Moisture Equipment Corp. (2006).

Measurement of Soil Water Potential

Soil moisture potential should be measured, utilising a soil auger, in specific cases where results of LWP analysis require additional explanation. This would occur primarily as result of unexpectedly high, or unexpectedly low LWP measurements that cannot be contextualised based on seasonal conditions. The same sampling protocols applied to soil sampling for stable isotopes should be applied to assessment of soil moisture potential. This includes:

1. An initial soil sample taken within the top 10cm of the soil profile.
2. Subsequent sampling at 0.5m intervals down borehole to the top of the Permian basements.
3. Additional measurements taken whenever there is a noted change is soil texture within the soil core (i.e change from clay to sandy clay / loam).

Sampling should be undertaken with a portable hand auger with a maximum expected depth of 5m (BGMB3 is 4.5m depth).

The most convenient method of measuring soil moisture potential is with a portable Dew Point PotentiaMeter which enables measurement to be taken directly on site. Portable devices such as the WP4C uses the chilled mirror dew point technique to measure water potential with the sample being equilibrated with the headspace of a sealed chamber that contains a mirror and a means of detecting condensation on the mirror.

A3. The WP4C Dew Point PotentiaMeter available for hire from ICT International Pty Ltd.

The following protocols are to be followed:

1. A 7ml soil sample is inserted into the sample draw of the potentiaMeter in a 15ml stainless steel sample cup.
2. A soil sample takes between 10 -15mins to analyse.
3. Faster settings (fast mode) should be used for samples with limited water holding capacity such as sand.

The WPC4 unit will require 12V power inverter that plugs into the 12V port of a vehicle if measurements are to be taken in the field. Alternatively, samples can be collected in a sealed sample bag (with air removed) and measurements taken in an office or other areas where there is a reliable power source. The inverter should have a continuous output of at least 140 Watts.

Outputs

The water potential assessments of both leaf (target tree at site) and soil (from soil core) will provided the following data outputs:

1. Pre-dawn leaf water potential measurements of canopy / sub-canopy leaf samples taken with the Pressure Bomb (3115 unit). The output unit will be provided in MPA.
2. Soil moisture potential taken with the portable WPC4 Potentiometer at standard intervals along the drillhole core. The unit output will be measured in MPA consistent with leaf moisture potential. The intervals for measurement will be:
    a. Top 10cm of the soil profile.
    b. At 0.5m intervals from the soil surface to the top of the phreatic zones.
    c. Where noticeable changes in soil texture or moisture content are noted during examination of the core.

The interval for measurement is purposefully coincident with the interval applied to soil sampling for stable isotopes. This will allow for more ready comparison of the results between differing sampling methods and applications.

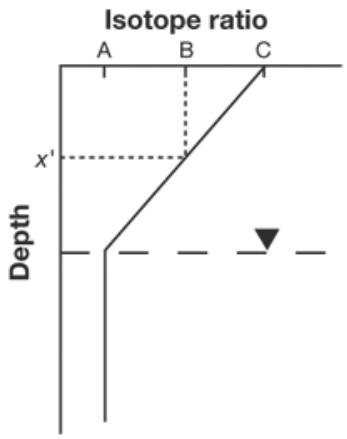
B2. Stable Isotope Analysis

The overarching aim of stable isotope analysis is to determine the degree to which trees utilise groundwater on either a permanent or seasonal basis. It will be applied during the initial phase of the baseline assessment to determine seasonal sources of moisture usage by selected trees, to be phased out once baseline water utilisation patterns are established (minimum of 2 years).

Rationale

Trees may utilise water from a range of sources including the phreatic zone, the vadose zone and surface water and the stable isotopes of water, oxygen 18 (18O) and deuterium (2H) may be a useful tool to help define the predominant source of water used by terrestrial vegetation. The method relies on a comparison between the stable isotope ratios of water contained in plant xylem (from a twig or xylem core) with concentrations in the various sources of water including potential artesian water sources, and shallow soil moisture. The heavier isotopes of 18O and 2H fractionate differently to the lighter isotopes equivalents (16O and 1H). Rainfall has a typically large δ18O and δ2H as it is formed through the process of condensation which concentrates heavier isotopes. Surface water may have an extremely high δ18O if it is subject to a period of strong evaporation, whilst isotopic composition of groundwater will vary dependent on the input source, although tends to be relatively stable as it is not exposed to processes of fractionation.

The isotopic signature of water measured in a trees xylem may result from a combination of sources with varying signatures. As per **A4** from Eamus et al (2006a) below, if an isotopic signature of 'A' is recorded, then water is being sourced from the phreatic zone, and for 'C' at the surface. If an isotopic signature of 'B' is recorded, this may represent water sourced from the middle of the vadose zone (at depth x), or may be a combination of water from a deeper phreatic source (A) or a shallow source (B). Hence there is potential for considerable uncertainty when mixed isotopic signatures occur and it may be necessary to apply a linear mixing model to aid the interpretation (as per Thorburn et al, 1993).



A4. Schematic representation of isotope ratios within soil and groundwater and application in identifying plant water sources (from Eamus et al. 2006a).

For a robust application of stable isotopes signatures obtained from plant xylem and soil pore spaces, the following general protocols should be observed:

1. Sampling of plant and soil material will need to be completed during a single sampling event to ensure the results are directly comparable.
2. Sampling of plant xylem material would be completed most effectively from twigs as leaves have tendency to concentrate isotopic concentrations during the process of transpiration and evaporation and hence should not be used. Twigs should be sampled during periods of active transpiration.
3. Persistence of groundwater dependency is best completed following a period of extended drought / dry conditions to maximise the potential that plants are utilising groundwater sources.
4. Sampling of soil pore water should be undertaken at consistent intervals throughout the vadose zone (the unsaturated zone above the groundwater table) down to the groundwater table. Soil samples are to be collected to the depth of the saturated zone or consolidated bedrock (whichever comes first). Sampling needs to extended beyond the saturated zone to consolidated bedrock in the case that a perched aquifer is identified.

Methodology

Sampling of Soil Pore Water for Stable Isotopes

Method: Soil sampling is to be undertaken at regular intervals along a retrieved soil core to capture signatures for possible isotopic end points (ground water and surface water) and a range of potential plant moisture sources within from the upper soil surface to the top of the phreatic zone. Mensforth et al (1994) completed soil sampling at 0.1m increments to 0.4m depth; 0.2m increments to 2m depth and 0.5m increments to the groundwater surface while others such as O'Grady et al (2006) applied sampling interval of 0.5m down the entire profile. The proposed sampling interval for this assessment is:

1. Initial soil sample taken within the top 10cm of the soil profile.
2. Subsequent soil sampled taken at 0.5m intervals down borehole to the top of the phreatic zone.
3. Additional soil samples take whenever there is a noted change is soil texture within the soil core (i.e change from clay to sandy clay / loam).

Soil sampling should be continued until either the unconfined groundwater table is intersected or the top of the Pleistocene surface halts auger penetration.

Soil sampling protocols: The following protocols for soil sampling are to be applied based on advice from ANU Stable Isotope Laboratory:

1. A minimum 50ml equivalent of soil is to be collected for each sample to be analysed.
2. Samples are to be immediately sealed to prevent evaporation in an airtight container (double bagging recommended).
3. Samples are to be labelled with the drill hole number and sampling depth / interval in a consistent format to aid data entry and recognition
4. Samples are to be kept on ice and transported to a freezer for temporary storage prior to dispatch to the laboratory (at the completion of each hole).
5. Frozen samples are to be dispatched in an a sealed (as airtight as possible) esky via overnight courier.

Equipment: The following equipment will be required by the site geologist / ecologist.

1. Stainless steel spatula for sample collection (paint scraper of putty knife sufficient).
2. Tape measure (15m extendable steel builders measure).
3. Sealable polypropylene containers (30 to 70ml adequate)
4. Permanent marking pens.
5. Esky for sample storage and dispatch.
6. A chest freezer will need to be accessed off site for storage.

Sampling of Xylem Water for Stable Isotopes

This will require twigs to be collected from the outer branches of mature Red Gum (or Poplar Box) trees that are the subject of the assessment. It is anticipated that up to 4 twig samples will be collected from individual trees directly adjacent to the assessment locality. At each site, the following sampling protocols should be observed:

1. Outer branches of up to four trees, including the central tree at the assessment locality plus three adjacent trees are to be harvested for twig material.
2. Trees subject to assessment are to be marked with a GPS.
3. Outer branches from each tree will be harvested using an extendable aluminium pole and lopping head. The longest commercially available extension pole is 7.5m giving a maximum reach of approximately 10m.
4. Stem material that is the equivalent to one joint length of the small finger should be sourced (based on advice from ANU). Hence collected branches should contain some stem diameters of at least 10mm.
5. Selected stems are to be cut into maximum 5cm lengths and the bark stripped. One to two stems of 10mm diameter stems will be sufficient although more material will be required for smaller diameter stems.
6. Stems are to be sealed in wide mouth sample containers with leakproof polypropylene closure.
7. Samples should be immediately labelled with the tree number and placed in an iced storage vessel before being transported to a freezer for temporary storage prior to dispatch to the laboratory (at the completion of each hole).
8. Frozen samples are to be dispatched in an a sealed (as airtight as possible) esky via overnight courier.

Equipment: The following equipment will be required by the site geologist / ecologist.

1. An extendable 7.5m aluminium pruning pole with an attached lopper head.
2. High quality secateurs for cutting stem material.
3. 125m wide mouth sample containers with a polypropylene seal cap (up to 16 required).
4. Permanent marking pens.
5. Esky for sample storage and dispatch. May be included with the frozen soil samples.
6. A chest freezer will need to be accessed off site for storage.

Groundwater sampling for stable isotopes

Method: Groundwater samples are to be collected from each groundwater monitoring bore using the low flow method. Groundwater sampling will follow methods described in the Geosciences Australia *Groundwater Sampling and Analysis – A Field Guide* (Sundaram, et al., 2009). Care should be taken not to oxygenate or agitate the sample during pumping or sample collection.

Samples for analysis of stable isotopes should be collected in laboratory prepared 28ml glass McCartney bottles or 15ml Vacutainers and kept cool during storage and transport.

Sample Despatch and personnel

Personnel: Samples are to be collected, bagged and stored by the supervising geologist / ecologist who will also be responsible for the sample dispatch to the receiving laboratory

Dispatch: Samples are to be dispatched directly to the ANU Stable Isotope Laboratory (address provided below).

Hilary Stuart-Williams
Stable Isotope Laboratory
Research School of Biology
R.N. Robertson Building (46)
The Australian National University Canberra ACT 0200 Australia

B3. Field Based Assessment of Leaf Area Index

Leaf Area Index (LAI) is a ratio of the total leaf area within a canopy to the ground area covered by the canopy. It is a measure of canopy vigour and the rationale applied is that plants with access to permanent sources of water (i.e. groundwater) will have greater vigour and hence LAI than vegetation that has only periodic access to groundwater resources (e.g. Zolfagher 2014). If a previous permanent groundwater resource is withdrawn (as might occur in a CSG operation), then leaf fall will occur, and LAI will decrease.

Measurement of LAI is typically completed with a hemispherical lens, is labour intensive and utilises specialised software to analyse foliage cover. The CI-110 Plant Canopy Analyzer provides a self-leveling, wide-angled lens to capture hemispherical photographs for the analysis of leaf area index (LAI) and gap fraction analysis and photosynthetically active radiation (PAR). This instrument is integrated with the corresponding software program, and a GPS, allowing for fast and simple analysis, with immediate data available on site including:

- Leaf area index (LAI)
- Leaf angle distribution
- Extinction coefficients
- PAR LAI

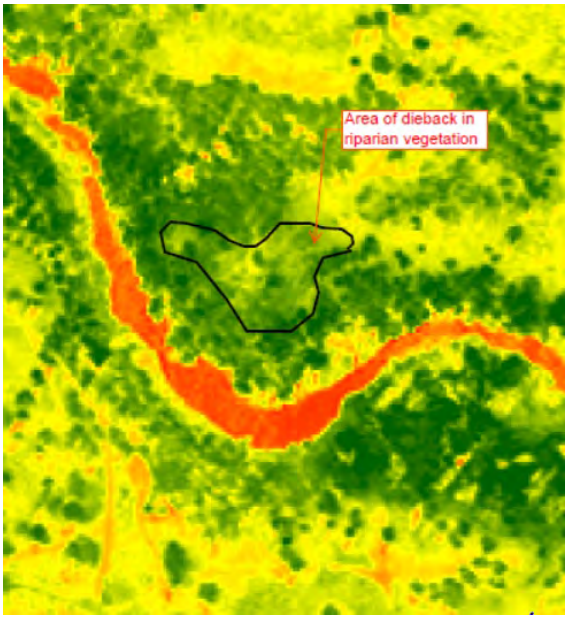
The units provides considerably greater accuracy in LAI measurement than standard hemispherical cameras and is time saving due to the immediate access of data.

The CI-110 Plant Canopy Analyzer is will be utilised during monitoring events which require calculation of LAI.

B4. Remote Sensing Methods

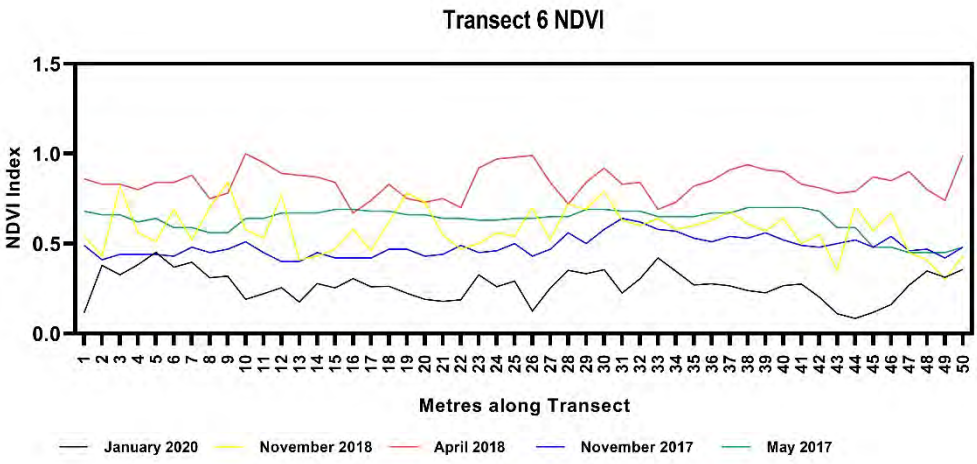
There are remote sensing based assessments used to calculate LAI (TERRA and AQUA satellites), although the spatial resolution of at 250 m x 250 m is not going be useful for the application, due to the fragmented nature of the landscape with large areas of clearing interspersed amongst native woodland.

Recent availability of high- resolution satellite imagery (WorldView-3/WorldView-2 and GeoEye-1; 0.5m Resolution 4-band Pan / WorldView 3 and WorldView 4 satellites; 0.3m resolution, 4 -16 band multispectral) provides an advanced capacity to monitor the health of individual trees if required. Assessment utilises the Normalised Difference Vegetation Index (NDVI) as a measure of canopy health and vigor. The strength of the assessment is that it enables the health of riparian (and other GDE) vegetation to be monitored across the entire landscape, rather than just a limited number of individual sites. The landscape-scale capability also has an ability to overcome issues surrounding a lack of site access and provides a long-term monitoring record of vegetation health that can be utilised as reference when a need arises. Capture can be undertaken reactively and can be tasked with a days' notice, providing weather, particularly cloud cover is amenable. An example of high resolution NDVI Imagery showing dieback in riparian vegetation is provided in **A7** (capture date May 2017).



A7. Healthy vegetation in bright green grading to bare ground and water in red. Area of recent canopy dieback is indicated (from Worldeye 1, 0.5m imagery).

Measurements of NDVI values at set intervals along permanently established transects also provides a quantifiable and easily rectifiable measure of vegetation productivity that can be undertaken on a seasonal basis. This would form a component of the baseline dataset against which trends in vegetation productivity and fluctuations in groundwater regime can be correlated to LAI. Figure A8 provides an example of a vegetation transect that that has been monitored for vegetation production for period of years, showing the strong decrease in vegetative productivity between May 2017 and January 2020.



A8. Seasonal variations in vegetation productivity, measured using NDVI, showing a decrease in vegetation health over a 2.5yr sampling period for a permanent monitoring transect in the Surat Basin.

B5. Groundwater Monitoring Bores

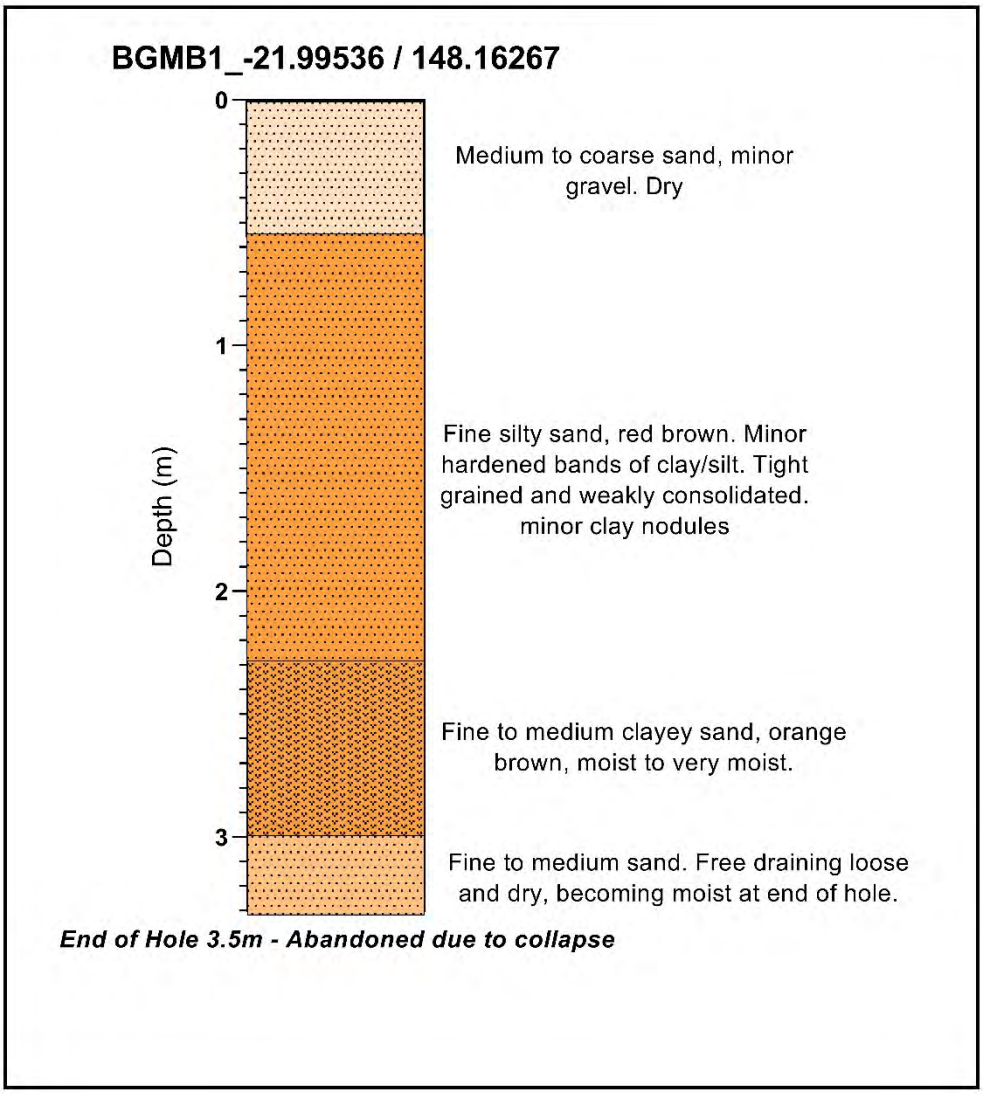
Drilling and construction of groundwater monitoring bores at a minimum of 3 selected localities and installation of pressure transducers to collect information on groundwater levels, fluctuation trends, water level response to rainfall and/or surface water recharge, hydrogeologic characteristics of shallow aquifers.

Installation of groundwater monitoring bores targeting shallow aquifers and screened across the water table, or level of the ephemeral water table will provide robust and site-specific data after a period of monitoring. To improve the robustness of this assessment method:

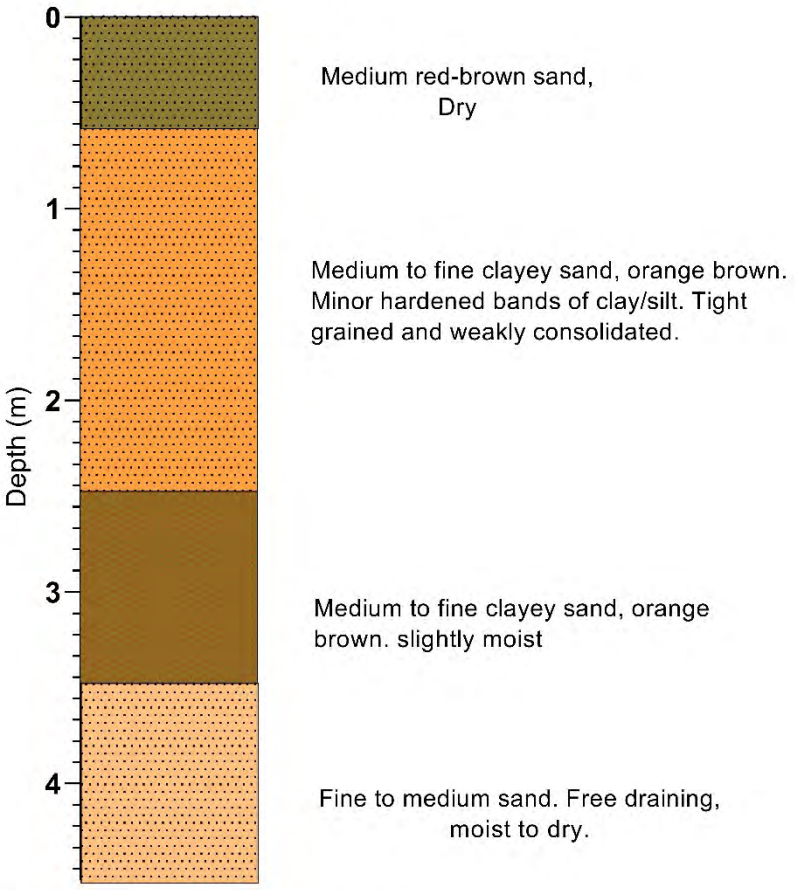
1. A barometric logger should be installed in the well, and weather recording stations should also be in proximity to assess daily and seasonal climate trends.
2. A survey should also be undertaken of ground level and top of monitoring bore casing levels at each monitoring site, preferably combined with levels of nearby surface water features and monitoring sites.

Diurnal changes in groundwater can provide an indication of groundwater use by vegetation accessing the capillary zone as identified by daily groundwater hydrographs. The method is only applicable in shallow unconfined aquifers. The seasonality of the unperched water table needs to be considered and there is likely to be a significant period when monitoring wells remains dry.

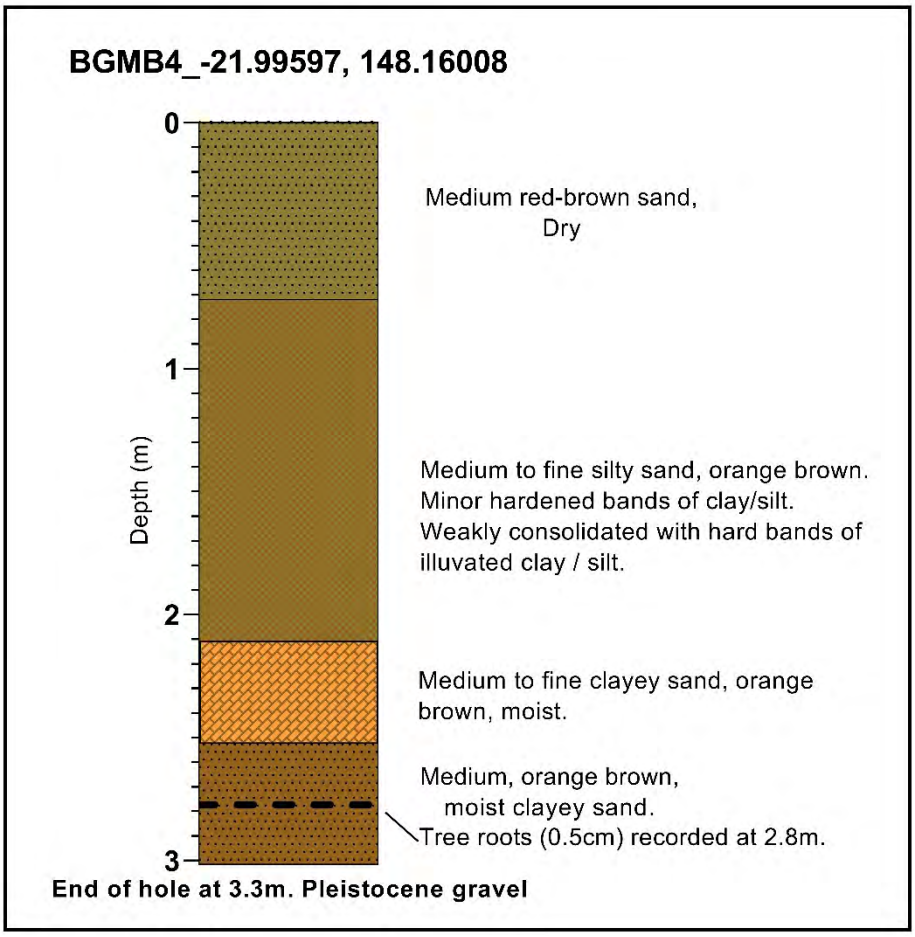
Logs from sites that were assessed for the suitability of groundwater monitoring bores in the Billy's Gully alluvium are provided.


BGMB1_-21.99536 / 148.16267
Depth (m)
0
1
2
3
Medium to coarse sand, minor gravel. Dry
Fine silty sand, red brown. Minor hardened bands of clay/silt. Tight grained and weakly consolidated. minor clay nodules
Fine to medium clayey sand, orange brown, moist to very moist.
Fine to medium sand. Free draining loose and dry, becoming moist at end of hole.
End of Hole 3.5m - Abandoned due to collapse

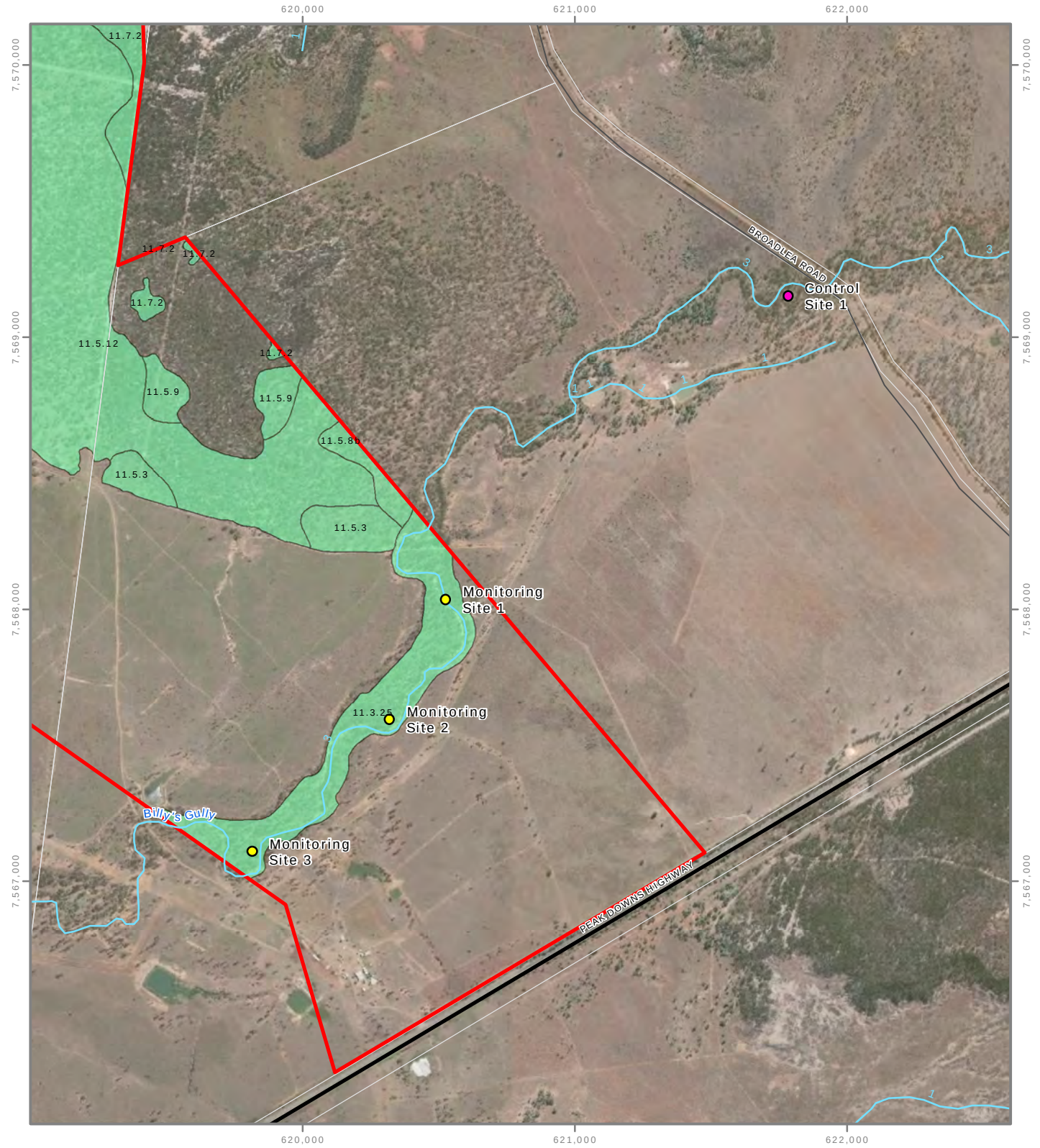
BGMB 3_- 21.98686, 148.16662



End of Hole 4.5m - Fine to medium sand. abandonded due to hole collapse


BGMB4_-21.99597, 148.16008
0
1
2
3
Depth (m)
Medium red-brown sand,
Dry
Medium to fine silty sand, orange brown.
Minor hardened bands of clay/silt.
Weakly consolidated with hard bands of
illuvated clay / silt.
Medium to fine clayey sand, orange
brown, moist.
Medium, orange brown,
moist clayey sand.
Tree roots (0.5cm) recorded at 2.8m.
End of hole at 3.3m. Pleistocene gravel

Appendix C. Proposed habitat quality monitoring sites proposed for the Billy's Gully GDE System.



Legend

- Project Site
- Highway
- Street/Local Road
- Vegetation Management Act Watercourse
- Cadastral Boundary

Field-validated Vegetation Mapping

Remnant Vegetation

- Least concern

Site Locations

- Monitoring Site
- Control Site

Figure 1 : Monitoring **site** locations

Isaac Plains East Project

Map Number: 20014_MPL_01_A
Date: 18 September 2020
Map Projection: GDA 1994 MGA Zone 55
Imagery: Digital Globe
Data: Roads, Watercourse, DCDB - (c)DNRM 2016

0 0.5 1
Kilometres

N

Appendix D. Suggested GDE Monitoring Program for Initial Two Years

Event	Timing	Areas for Monitoring	Parameters Measured	Additional Datasets / Techniques Recommended	Other Interacting Monitoring Datasets	Outputs
Monitoring Survey 1	Dry Season (October to December 2020)	• Billy's Gully GDE Assessment Area • Billy's Gully Control	• LWP • Stable isotopes (trees and selected auger sites if required). • Leaf Area Index	NDVI Imagery to coincide with the survey.	Groundwater monitoring data from shallow alluvium monitoring bores (water quality and data from pressure transducers). Rainfall and climate data from automated weather station.	GDE Monitoring Report- Monitoring Event 1.
Monitoring Survey 2	Wet Season (February to April 2021)	• Billy's Gully GDE Assessment Area • Billy's Gully Control	• LWP • Stable isotopes (trees and selected auger sites if required). • Leaf Area Index	NDVI Imagery to coincide with the survey	Groundwater monitoring data from shallow alluvium monitoring bores (water quality and data from pressure transducers). Rainfall and climate data from automated weather station.	GDE Monitoring Report- Monitoring Event 2.
Monitoring Survey 3	Dry Season (October to December 2021)	• Billy's Gully GDE Assessment Area • Billy's Gully Control	• LWP Stable Isotopes (Trees and Selected Auger Sites if required). • Leaf Area Index	NDVI Imagery to coincide with the survey	Groundwater monitoring data from shallow alluvium monitoring bores (water quality and data from pressure transducers). Rainfall and climate data from automated weather station.	GDE Monitoring Report- Monitoring Event 3.
Monitoring Survey 4	Wet Season (February to April 2022)	• Billy's Gully GDE Assessment Area • Billy's Gully Control	• LWP Stable Isotopes (Trees and Selected Auger Sites if required). • Leaf Area Index	NDVI Imagery to coincide with the survey	Groundwater monitoring data from shallow alluvium monitoring bores (water quality and data from pressure transducers). Rainfall and climate data from automated weather station.	GDE Monitoring Report- Monitoring Event 4.
2 Year GDE Monitoring Review						
2 Year Review - Baseline GDE Monitoring Assessment	At completion of Monitoring Survey 4	NA	NA	NA	NA	– Compilation of data from all surveys – Analysis of baseline ecohydrological function of

Event	Timing	Areas for Monitoring	Parameters Measured	Additional Datasets / Techniques Recommended	Other Interacting Monitoring Datasets	Outputs
						Billy's Gully GDE sites – Correlation between LAI and NDVI (plus other parameters) to provide a baseline for ongoing annual vegetation monitoring.

Appendix E. Raw Data from IPEE PER Assessment for Billy's Gully (LWP and Stable Isotopes)

Tree Number	Species	X	Y	Height (m)	DBH (cm)	LWP_Bar 1	LWP_Bar 2	LWP_Bar 3	LWP Mean Bar	LWP Mean MPa	Tree Water Availability	Notes
IP4_T1a	*Eucalyptus tereticornis*	-21.992389	148.164007	25	85	2	1.5		1.75	-0.175	Extremely High	On sandy flood plain adjacent to main drainage channel
IP4_T1	*Eucalyptus tereticornis*	-21.994953	148.163268	25	100	3	3		3	-0.3	Extremely High	On sandy flood plain adjacent to main drainage channel
IP4_T2	*Eucalyptus tereticornis*	-21.995026	148.163309	20	160	2	2		2	-0.2	Extremely High	On sandy flood plain adjacent to main drainage channel
IP4_T3	*Eucalyptus tereticornis*	-21.995529	148.162382	20	60	2	2		2	-0.2	Extremely High	On sandy flood plain adjacent to main drainage channel
IP4_T4	*Eucalyptus tereticornis*	-21.995801	148.161715	18	130	2	1.5		1.75	-0.175	Extremely High	On sandy flood plain adjacent to main drainage channel
IP4_T5	*Eucalyptus tereticornis*	-21.995883	148.161078	20	100	3	2		2.5	-0.25	Extremely High	On sandy flood plain adjacent to main drainage channel
IP4_T6	*Eucalyptus tereticornis*	-21.995791	148.159654	23	70	2	1.5		1.75	-0.175	Extremely High	On sandy flood plain adjacent to main drainage channel
IP4_T7	*Eucalyptus tereticornis*	-21.995607	148.159483	22	80	1.5	3	2	2.125	-0.2125	Extremely High	On sandy flood plain adjacent to main drainage channel
IP4_T8	*Eucalyptus tereticornis*	-21.995512	148.159073	20	70	2	2.5		2.25	-0.225	Extremely High	On sandy flood plain adjacent to main drainage channel
IP4_T9	*Eucalyptus tereticornis*	-21.995501	148.158623	25	55	2.5	3	3	2.75	-0.275	Extremely High	On sandy flood plain adjacent to main drainage channel

Sample 2	Site	Material	Depth	δ^2H	$\delta^{18}O$
IP4_AU1_0.1	IP4	soil	0.1	-31.97	-4.26
IP4_AU1_0.5	IP4	soil	0.5	-45.74	-7.23
IP4_AU1_1.0	IP4	soil	1	-42.52	-6.67
ip4 au1 1.35	IP4	soil	1.35	-37.95	-6.02
IP4_AU1_1.6	IP4	soil	1.6	-35.91	-5.53
IP4_AU1_1.75	IP4	soil	1.75	-33.25	-4.70
IP4_AU1_2.0	IP4	soil	2	-38.29	-6.32
IP4_AU2_0.1	IP4	soil	0.1	-40.98	-6.53
IP4_AU2_0.5	IP4	soil	0.5	-43.38	-7.89
IP4_AU2_0.5	IP4	soil	0.5	-41.61	-7.01
IP4_AU2_0.75	IP4	soil	0.75	-37.41	-5.64
IP4_AU2_1.0	IP4	soil	1	-43.96	-7.12
IP4_AU2_1.35	IP4	soil	1.35	-41.80	-6.91
IP4_AU2_1.75	IP4	soil	1.75	-36.30	-5.38
IP4_AU2_2.25	IP4	soil	2.25	-43.55	-6.54
IP4_T1	IP4	twig	NA	-25.48	-3.85
IP4_T2	IP4	twig	NA	-27.44	-4.37
IP4_T3	IP4	twig	NA	-35.38	-4.91
IP4_T4	IP4	twig	NA	-41.84	-4.65
IP4_T5	IP4	twig	NA	-28.85	-4.81
IP4_T6	IP4	twig	NA	-31.55	-4.37
IP4_T7	IP4	twig	NA	-28.63	-3.96
IP4_T8	IP4	twig	NA	-23.32	-2.33
IP4_T9	IP4	twig	NA	-34.80	-4.52
IP4_T1a	IP4	twig	NA	-26.31	-4.22
MB2		Groundwater	NA	-29.49	-5.11
BCB2		Groundwater	NA	-27.07	-4.41
MB10		Groundwater	NA	-37.38	-6.29
SB1		Groundwater	NA	-32.31	-5.53
MB4b		Groundwater	NA	-32.54	-5.11
MB1		Groundwater	NA	-34.20	-4.82
MB4a		Groundwater	NA	-26.24	-3.84

APPENDIX F GROUNDWATER REPORT (IPEE)

Klohn Crippen Berger

Stanmore IP Coal Pty Ltd

Isaac Plains East Extension Project

Groundwater Report

ISO 9001
ISO 14001
OHSAS 18001

D10175A08

September 2020

Stanmore IP Coal Pty Ltd

Isaac Plains East Extension Project

Groundwater Report

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1 INTRODUCTION

Klohn Crippen Berger Ltd (KCB) was commissioned by Stanmore IP Coal Pty Ltd (IP Coal), a wholly owned subsidiary of Stanmore Coal Limited (Stanmore) to complete a groundwater impact assessment for the Isaac Plains East (IPE) Extension (the 'project'); a proposed coal mine development in the Bowen Basin. The IPE Extension will be a development within the overall Isaac Plain Complex (IPC), comprising the Isaac Plains Mine (IPM) on mining lease (ML) 70342 and the Isaac Plains East (IPE) area on ML 700016, ML 700017, ML 700018 and ML 700019.

The objective of this assessment is to assess the potential impact to water resources and water-dependent assets under the *Environmental Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) (Commonwealth of Australia 2018) as a result of the proposed activities associated with the project.

The Referral for the project was subject to a controlled action decision by the Department of Agriculture, Water and the Environment (DAWE) on 31 January 2020 with the controlling provisions being:

- Listed threatened species and communities (sections 18 & 18A); and
- A water resource, in relation to coal seam gas development and large coal mining development (sections 24D & 24E) ('water resources trigger').

DAWE determined that the Referral for the Extension would be assessed by public environment report (PER).

This assessment is conducted with reference to the following guidelines:

- Department of Agriculture, Water and the Environment (DAWE) (formerly Department of the Environment and Energy (DoEE)) Significant Impact Criteria provided in 'Significant impact guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources' (DoEE 2013a) (Section 2.1);
- DoEE Significant Impact Guidelines 1.1 – Matters of National Environmental Significance (DoEE 2013b) (Section 2.1); and,
- The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the IESC) information guidelines (IESC 2018) (Section 1.2.1).
- Guidelines for the content of a draft Public Environment Report for the project ('PER Guideline').

This assessment was prepared to accompany IP Coal's draft PER for the IPE Extension Project to DAWE.

1.1 Project Overview

The IPC is an operating open cut mine located approximately 5 km northeast of Moranbah in Central Queensland (Figure 1). The IPC commenced operations in 2006 and produces primarily export coking coal. The IPC EA (EPML00932713) allows mining operations to occur within a defined area within the mining leases.

Open cut mining operations involve the removal of overburden by dragline, with truck and shovel pre-stripping. Coal is excavated from the active pits and hauled by truck to an on-site CHPP for washing and processing (Figure 2). Product coal is transported from the IPC, via an on-site rail loop and train load out facility (Figure 2). Product coal is railed to the Dalrymple Bay Coal Terminal, for export.

The project involves the extension of the Isaac Plains East (IPE) pits within the IPC by approximately 300 m to 600 m in an easterly direction. The project mining area and proposed extension is located within the existing IPC mining leases (MLs) and therefore a new ML will not be required for the project (Figure 2). The State Department of Environment and Science (DES) approved an environmental authority (EA) amendment for the MLs to include the Extension activities on 26/02/2020.

The project will use the existing IPC mine infrastructure, including the existing Coal Handling and Preparation Plant (CHPP) (Figure 2).

New infrastructure for the project includes:

- Haul roads and access roads, including connections to the existing IPE road network;
- Modular CHPP upgrade for operational flexibility
- Laydown areas, powerlines; and
- Stormwater drains, pit water pipelines, sediment dams and sediment control works.

1.2 Report Structure

This report has been prepared to accompany the IPEE *EPBC Act* Referral to be submitted to the DoEE, and the IESC. It is structured to include the following:

- Section 1: Introduction – provides an overview of the project, report purpose and structure;
- Section 2: Statutory Context – describes the regulatory setting, for both Queensland and Commonwealth legislation, relating to groundwater and the project;
- Section 3: Project Setting – describes the project location, including relevant land uses, local topography and drainage, climate and geology;
- Section 4: Assessment Methodology – describes the assessment method including the collection of relevant data and numerical groundwater modelling;
- Section 5: Existing Hydrogeology – describes the existing groundwater regime for the project mining area and its surrounds;
- Section 6: Impact Assessment – provides a detailed description and the predicted effects of the proposed mining on the local groundwater regime. This section also presents an assessment of the potential impacts on groundwater users and the sensitive environmental features;
- Section 7: Groundwater Monitoring Program – describes the proposed groundwater monitoring program for the project;

- Section 8: Risk Assessment – summarises the potential environmental risks to water resources and water-related assets and the application of management controls for risk reduction;
- Section 8: Conclusions; and
- Sections 9 to 11: References, abbreviations and a glossary.

Appendix I provides a compiled list of all groundwater bores within 5 km of the project mining area from which groundwater data has been sourced. This list comprises registered bores from the DNRME Groundwater Database (as discussed in Section 3.1).

A local and regional groundwater dataset was compiled for this assessment. This dataset was sourced from monitoring bores, operational mine monitoring, drilling and testing programs and surveys within the project mining area, its surrounds and the wider regional setting. A statistical analysis of the collated groundwater quality data is presented in Appendix II.

Groundwater level records from monitoring bores within the vicinity of the project have been compiled as hydrographs and are presented in Appendix III.

Appendix IV provides a detailed description of the numerical modelling conducted for the project, including details of model construction, calibration, predictive simulation and model sensitivity analysis.

Appendix V provides the Groundwater Monitoring and Management Plan (GMMP) for the IPC, which includes a monitoring network to assess potential impacts associated with the IPE Extension development.

Appendix VI is provides summary of site investigations to identify alluvium along Smoky Creek.

1.2.1 IESC Checklist

The Independent Expert Scientific Committee (IESC) is a statutory body under the *EPBC Act* (Commonwealth of Australia 2018). The IESC's key function in relation to this Project is to provide scientific advice to the Commonwealth Environment Minister and relevant state ministers in relation to CSG or large coal mining development proposals that are likely to have a significant impact on water resources.

As the controlling provisions for the project include the water resources trigger, the project will be referred to the IESC. It is noted that the Project is not predicted have significant residual impacts on groundwater resources (Refer to 8). Never-the-less, in accordance with the PER Guideline this report provides a checklist against the IESC Information Guidelines.

To allow the IESC to provide robust scientific advice to government regulators on water-related impacts of CSG and coal mining developments, an information guideline (IESC 2018) has been developed outlining the information considered necessary for the IESC to undertake the relevant assessment. Table 1.1: IESC Checklist and Section Addressed in this Report provides the information checklist for Groundwater and Surface Water in the IESC Information Guidelines, and the relevant sections of this report that addresses each checklist item. It should be noted that some items in the guideline are not required for this assessment, which includes: some information on final landform and voids – coal mines (captured in PER), Acid-forming materials and other contaminants of concern (captured in PER); and, Hydraulic stimulation – coal seam gas

(not relevant to the project). Furthermore, the surface water items of this checklist have not been addressed in this report. IP Coal has commissioned surface water specialist to address these items.

Table 1.1: IESC Checklist and Section Addressed in this Report

Checklist Title	Checklist Item	Section Addressed
Description of the Proposal		
Description of the Proposal	Provide a regional overview of the proposed project area including a description of the geological basin; coal resource; surface water catchments; groundwater systems; water-dependent assets; and past, present and reasonably foreseeable coal mining and CSG developments.	Section 1.1, Section 3
	Describe the proposal's location, purpose, scale, duration, disturbance area, and the means by which it is likely to have a significant impact on water resources and water-dependent assets.	Section 1.1, Section 3.1, Section 6.3
	Describe the statutory context, including information on the proposal's status within the regulatory assessment process and any applicable water management policies or regulations	Section 2
	Describe how impacted water resources are currently being regulated under state or Commonwealth law, including whether there are any applicable standard conditions.	Section 2
Risk Assessment	Identify and assess all potential environmental risks to water resources and water-related assets, and their possible impacts. In selecting a risk assessment approach consideration should be given to the complexity of the project, and the probability and potential consequences of risks.	Section 6 Section 8
	Incorporate causal mechanisms and pathways identified in the risk assessment in conceptual and numerical modelling. Use the results of these models to update the risk assessment.	
	Assess risks following the implementation of any proposed mitigation and management options to determine if these will reduce risks to an acceptable level based on the identified environmental objectives.	
	The risk assessment should include an assessment of: - all potential cumulative impacts which could affect water resources and water-related assets; and, - mitigation and management options which the proponent could implement to reduce these impacts.	
Groundwater		
Context and Conceptualisation	Describe and map geology at an appropriate level of horizontal and vertical resolution including: - definition of the geological sequence(s) in the area, with names and descriptions of the formations and accompanying surface geology, cross-sections and any relevant field data. - geological maps appropriately annotated with symbols that denote fault type, throw and the parts of sequences the faults intersect or displace.	Section 3.4
	Provide data to demonstrate the varying depths to the hydrogeological units and associated standing water levels or potentiometric heads, including direction of groundwater flow, contour maps, and hydrographs. All boreholes used to provide this data should have been surveyed.	Section 5
	Define and describe or characterise significant geological structures (e.g. faults, folds, intrusives) and associated fracturing in the area and their influence on groundwater – particularly groundwater flow, discharge or recharge. - Site-specific studies (e.g. geophysical, coring / wireline logging etc.) should give consideration to characterising and detailing the local stress regime and fault structure (e.g. damage zone size, open/closed along fault plane, presence of clay/shale smear, fault jogs or splays). - Discussion on how this fits into the fault's potential influence on regional-scale groundwater conditions should also be included.	Section 3.4 and Section 5.5
	Provide hydrochemical (e.g. acidity/alkalinity, electrical conductivity, metals, and major ions) and environmental tracer (e.g. stable isotopes of water, tritium, helium, strontium isotopes, etc.) characterisation to identify sources of water, recharge rates, transit times in aquifers, connectivity between geological units and groundwater discharge locations.	Section 5
	Provide site-specific values for hydraulic parameters (e.g. vertical and horizontal hydraulic conductivity and specific yield or specific storage characteristics including the data from which these parameters were derived) for each relevant hydrogeological unit. In situ observations of these parameters should be sufficient to characterise the heterogeneity of these properties for modelling.	Section 5.2.2, Section 5.3.2, Section 5.4.2, and Section 5.5.2
	Describe the likely recharge, discharge and flow pathways for all hydrogeological units likely to be impacted by the proposed development.	Section 5.2.3, Section 5.3.3, Section 5.4.3, and Section 5.5.3

Checklist Title	Checklist Item	Section Addressed
	Assess the frequency (and time lags if any), location, volume and direction of interactions between water resources, including surface water/groundwater connectivity, inter-aquifer connectivity and connectivity with sea water.	Section 5.2.3, Section 5.3.3, Section 5.4.3, and Section 5.5.3
Analytical and Numerical Modelling	Provide a detailed description of all analytical and/or numerical models used, and any methods and evidence (e.g. expert opinion, analogue sites) employed in addition to modelling.	Section 4.3 and Appendix IV
	Describe each hydrogeological unit as incorporated in the groundwater model, including the thickness, storage and hydraulic characteristics, and linkages between units, if any.	Section 5, Appendix IV
	Undertaken groundwater modelling in accordance with the *Australian Groundwater Modelling Guidelines* (Barnett et al. 2012), including independent peer review.	Section 4.3, Appendix IV
	Consider a variety of boundary conditions across the model domain, including constant head or general head boundaries, river cells and drains, to enable a comparison of groundwater model outputs to seasonal field observations.	Appendix IV Section 2.5
	Calibrate models with adequate monitoring data, ideally with calibration targets related to model prediction (e.g. use baseflow calibration targets where predicting changes to baseflow).	Appendix IV Section 2.7 to 2.10
	Undertake sensitivity analysis and uncertainty analysis of boundary conditions and hydraulic and storage parameters, and justify the conditions applied in the final groundwater model (see Middlemis and Peeters [in press]).	Appendix IV Section 3.3
	Provide an assessment of the quality of, and risks and uncertainty inherent in, the data used to establish baseline conditions and in modelling, particularly with respect to predicted potential impact scenarios.	Section 4.1, Section 4.2 and Section 5
	Describe the existing recharge/discharge pathways of the units and the changes that are predicted to occur upon commencement, throughout, and after completion of the proposed project.	Section 5 and Section 6.2
	Undertake an uncertainty analysis of model construction, data, conceptualisation and predictions (see Middlemis and Peeters [in press]).	Appendix IV Section 3.3
	Describe the various stages of the proposed project (construction, operation and rehabilitation) and their incorporation into the groundwater model. Provide predictions of water level and/or pressure declines and recovery in each hydrogeological unit for the life of the project and beyond, including surface contour maps for all hydrogeological units.	Section 6.1 and Section 6.2
	Provide a program for review and update of models as more data and information become available, including reporting requirements.	Captured as part of State Regulatory requirements under current EA requirements for annual review of Groundwater Monitoring and Management Plan; and Associated Water License annual reporting requirements. See Appendix V.
	Identify the volumes of water predicted to be taken annually with an indication of the proportion supplied from each hydrogeological unit.	Section 6.2.2; Appendix IV Section 3.3.2
	Provide information on the magnitude and time for maximum drawdown and post-development drawdown equilibrium to be reached.	Section 6.2

Checklist Title	Checklist Item	Section Addressed
	Undertake model verification with past and/or existing site monitoring data.	Appendix IV Sections 2.7 to 2.11
Impacts to Water Resources and Water-Dependent Assets	Provide an assessment of the potential impacts of the proposal, including how impacts are predicted to change over time and any residual long-term impacts. Consider and describe: - any hydrogeological units that will be directly or indirectly dewatered or depressurised, including the extent of impact on hydrological interactions between water resources, surface water/groundwater connectivity, inter-aquifer connectivity and connectivity with sea water. - the effects of dewatering and depressurisation (including lateral effects) on water resources, water-dependent assets, groundwater, flow direction and surface topography, including resultant impacts on the groundwater balance. - the potential impacts on hydraulic and storage properties of hydrogeological units, including changes in storage, potential for physical transmission of water within and between units, and estimates of likelihood of leakage of contaminants through hydrogeological units. - the possible fracturing of and other damage to confining layers. - for each relevant hydrogeological unit, the proportional increase in groundwater use and impacts as a consequence of the proposed project, including an assessment of any consequential increase in demand for groundwater from towns or other industries resulting from associated population or economic growth due to the proposal.	- Section 6.3.1 and Section 6.3.3 - Section 6.3.1 and Section 6.3.3 - Section 6.3.1 and Section 6.3.3 - Not Applicable - Section 6.3.2
	Describe the water resources and water-dependent assets that will be directly impacted by mining or CSG operations, including hydrogeological units that will be exposed/partially removed by open cut mining and/or underground mining.	Section 6.3
	For each potentially impacted water resource, provide a clear description of the impact to the resource, the resultant impact to any water-dependent assets dependent on the resource, and the consequence or significance of the impact.	Section 6.3
	Describe existing water quality guidelines, environmental flow objectives and other requirements (e.g. water planning rules) for the groundwater basin(s) within which the development proposal is based.	Section 2; Appendix V
	Provide an assessment of the cumulative impact of the proposal on groundwater when all developments (past, present and/or reasonably foreseeable) are considered in combination	Section 6.5
	Provide a description and assessment of the adequacy of proposed measures to prevent/minimise impacts on water resources and water-dependent assets.	Section 7
Data and Monitoring	Provide sufficient data on physical aquifer parameters and hydrogeochemistry to establish pre-development conditions, including fluctuations in groundwater levels at time intervals relevant to aquifer processes.	Section 5, Appendix II and Appendix III
	Provide long-term groundwater monitoring data, including a comprehensive assessment of all relevant chemical parameters to inform changes in groundwater quality and detect potential contamination events.	Appendix II and Appendix III
	Develop and describe a robust groundwater monitoring program using dedicated groundwater monitoring wells – including nested arrays where there may be connectivity between hydrogeological units – and targeting specific aquifers, providing an understanding of the groundwater regime, recharge and discharge processes and identifying changes over time.	Sections 4.1.2 and 7; Appendix V
	Ensure water quality monitoring complies with relevant National Water Quality Management Strategy (NWQMS) guidelines (ANZECC/ARMCANZ 2000) and relevant legislated state protocols (e.g. QLD Government 2013).	Sections 4.1.2, Section 7, Appendix V
	Develop and describe proposed targeted field programs to address key areas of uncertainty, such as the hydraulic connectivity between geological formations, the sources of groundwater sustaining Groundwater Dependent Ecosystem (GDEs), the hydraulic properties of significant faults, fracture networks and aquitards in the impacted system, etc., where appropriate.	Section 7 and Appendix V
Surface Water		

Checklist Title	Checklist Item	Section Addressed
Context and Conceptualisation	Describe the hydrological regime of all watercourses, standing waters and springs across the site including: -geomorphology, including drainage patterns, sediment regime and floodplain features; -spatial, temporal and seasonal trends in streamflow and/or standing water levels; -spatial, temporal and seasonal trends in water quality data (such as turbidity, acidity, salinity, relevant organic chemicals, metals, metalloids and radionuclides); -current stressors on watercourses, including impacts from any currently approved projects.	Section 3.5 and addressed in other technical reports for the PER.
	Describe the existing flood regime, including flood volume, depth, duration, extent and velocity for a range of annual exceedance probabilities. Provide flood hydrographs and maps identifying peak flood extent, depth and velocity. This assessment should be informed by topographic data that has been acquired using lidar or other reliable survey methods with accuracy stated.	
	Provide an assessment of the frequency, volume, seasonal variability and direction of interactions between water resources, including surface water/ groundwater connectivity and connectivity with sea water.	
Analytical and Numerical Modelling	Provide conceptual models at an appropriate scale, including water quality, stores, flows and use of water by ecosystems.	Addressed in other technical reports for the PER.
	Describe and justify model assumptions and limitations and calibrate with appropriate surface water monitoring data.	
	Use methods in accordance with the most recent publication of *Australian Rainfall and Runoff* (Ball et al. 2016).	
	Provide an assessment of the risks and uncertainty inherent in the data used in the modelling, particularly with respect to predicted scenarios.	
	Develop and describe a program for review and update of the models as more data and information becomes available.	
	Provide a detailed description of any methods and evidence (e.g. expert opinion, analogue sites) employed in addition to modelling.	
Impacts to Water Resources and Water-Dependent Assets	Describe all potential impacts of the proposed project on surface waters. Include a clear description of the impact to the resource, the resultant impact to any assets dependent on the resource (including water-dependent ecosystems such as riparian zones and floodplains), and the consequence or significance of the impact. Consider: -impacts on streamflow under the full range of flow conditions. -impacts associated with surface water diversions. -impacts to water quality, including consideration of mixing zones. -the quality, quantity and ecotoxicological effects of operational discharges of water (including saline water), including potential emergency discharges, and the likely impacts on water resources and water-dependent assets. -landscape modifications such as subsidence, voids, post rehabilitation landform collapses, on-site earthworks (including disturbance of acid-forming or sodic soils, roadway and pipeline networks) and how these could affect surface water flow, surface water quality, erosion, sedimentation and habitat fragmentation of water-dependent species and communities.	Section 6.2 and addressed in other technical reports for the PER.
	Discuss existing water quality guidelines, environmental flow objectives and requirements for the surface water catchment(s) within which the development proposal is based.	Addressed in other technical reports for the PER.
	Identify processes to determine surface water quality guidelines and quantity thresholds which incorporate seasonal variation but provide early indication of potential impacts to assets.	Addressed in other technical reports for the PER.
	Propose mitigation actions for each identified significant impact.	
	Describe the adequacy of proposed measures to prevent or minimise impacts on water resources and water-dependent assets.	
	Describe the cumulative impact of the proposal on surface water resources and water-dependent assets when all developments (past, present and reasonably foreseeable) are considered in combination.	
	Provide an assessment of the risks of flooding (including channel form and stability, water level, depth, extent, velocity, shear stress and stream power), and impacts to ecosystems, project infrastructure and the final project landform.	
Data and Monitoring	Identify monitoring sites representative of the diversity of potentially affected water-dependent assets and the nature and scale of potential impacts, and match with suitable replicated control and reference sites (BACI design) to enable detection and monitoring of potential impacts.	

Checklist Title	Checklist Item	Section Addressed
	Develop and describe a surface water monitoring program that will collect sufficient data to detect and identify the cause of any changes from established baseline conditions and assess the effectiveness of mitigation and management measures. The program will: include baseline monitoring data for physico-chemical parameters, as well as contaminants (e.g. metals); comparison of physico-chemical data to national/regional guidelines or to site-specific guidelines derived from reference condition monitoring if available; and, identify baseline contaminant concentrations and compare these to national guidelines, allowing for local background correction if required.	
	Ensure water quality monitoring complies with relevant National Water Quality Management Strategy (NWQMS) guidelines (ANZECC/ARMCANZ 2000) and relevant legislated state protocols (e.g. QLD Government 2013).	
	Describe the rationale for selected monitoring parameters, duration, frequency and methods, including the use of satellite or aerial imagery to identify and monitor large-scale impacts.	
	Identify data sources, including streamflow data, proximity to rainfall stations, data record duration and describe data methods, including whether missing data have been patched.	
	Develop and describe a plan for ongoing ecotoxicological monitoring, including direct toxicity assessment of discharges to surface waters where appropriate.	
	Identify dedicated sites to monitor hydrology, water quality, and channel and floodplain geomorphology throughout the life of the proposed project and beyond.	
Water-Dependent Assets		
Context and conceptualisation	Identify water-dependent assets, including: - water-dependent fauna and flora and provide surveys of habitat, flora and fauna (including stygofauna) (see Doody et al. [in press]). - public health, recreation, amenity, Indigenous, tourism or agricultural values for each water resource.	Section 3.5
	Estimate the ecological water requirements of identified GDEs and other water-dependent assets (see Doody et al. [in press]).	Section 3.5
	Identify the hydrogeological units on which any identified GDEs are dependent (see Doody et al. [in press]).	Section 3.5
	Identify GDEs in accordance with the method outlined by Eamus et al. (2006). Information from the GDE Toolbox (Richardson et al. 2011) and GDE Atlas (CoA 2017a) may assist in identification of GDEs (see Doody et al. [in press]).	Section 3.5
	Provide an outline of the water-dependent assets and associated environmental objectives and the modelling approach to assess impacts to the assets.	Section 6.3.4
	Describe the conceptualisation and rationale for likely water-dependence, impact pathways, tolerance and resilience of water-dependent assets. Examples of ecological conceptual models can be found in Commonwealth of Australia (2015).	Section 3.5
	Describe the process employed to determine water quality and quantity triggers and impact thresholds for water-dependent assets (e.g. threshold at which a significant impact on an asset may occur).	Appendix V
Impacts, Risk Assessment and Management of Risks	Provide an assessment of direct and indirect impacts on water-dependent assets, including ecological assets such as flora and fauna dependent on surface water and groundwater, springs and other GDEs (see Doody et al. [in press]).	- Section 6.3.4 and addressed in other technical reports for the PER - Addressed in other technical reports for the PER - Section 6.3.2 - Section 8 and addressed in other technical reports for the PER
	Provide estimates of the volume, beneficial uses and impact of operational discharges of water (particularly saline water), including potential emergency discharges due to unusual events, on water-dependent assets and ecological processes.	
	Describe the potential range of drawdown at each affected bore, and clearly articulate of the scale of impacts to other water users.	
	Assess the overall level of risk to water-dependent assets through combining probability of occurrence with severity of impact.	
	Indicate the vulnerability to contamination (e.g. from salt production and salinity) and the likely impacts of contamination on the identified water-dependent assets and ecological processes.	
	Identify the proposed acceptable level of impact for each water-dependent asset based on leading-practice science and site-specific data, and ideally developed in conjunction with stakeholders.	
	Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion and habitat fragmentation of water-dependent species and communities.	
	Propose mitigation actions for each identified impact, including a description of the adequacy of the proposed measures and how these will be assessed.	

Checklist Title	Checklist Item	Section Addressed
		- Addressed in other technical reports for the PER - Addressed in other technical reports for the PER - Addressed in other technical reports for the PER - Section 8 and addressed in other technical reports for the PER
Data and Monitoring	Identify an appropriate sampling frequency and spatial coverage of monitoring sites to establish pre-development (baseline) conditions and test potential responses to impacts of the proposal (see Doody et al. [in press]).	Appendix V
	Develop and describe a monitoring program that identifies impacts, evaluates the effectiveness of impact prevention or mitigation strategies, measures trends in ecological responses and detects whether ecological responses are within identified thresholds of acceptable change (see Doody et al. [in press]).	Appendix V and addressed in other technical reports for the PER
	Consider concurrent baseline monitoring from unimpacted control and reference sites to distinguish impacts from background variation in the region (e.g. BACI design, see Doody et al. [in press]).	Appendix V and addressed in other technical reports for the PER
	Describe the proposed process for regular reporting, review and revisions to the monitoring program.	Appendix V
	Ensure ecological monitoring complies with relevant state or national monitoring guidelines (e.g. the DSITI guideline for sampling stygofauna (QLD Government 2015)).	Addressed in other technical reports for the PER
Water and salt balance, and water quality		
Water and Salt Balance, and Water Quality	Provide a quantitative site water balance model describing the total water supply and demand under a range of rainfall conditions and allocation of water for mining activities (e.g. dust suppression, coal washing etc.), including all sources and uses.	Addressed in other technical reports for the PER
	Provide estimates of the quality and quantity of operational discharges under dry, median and wet conditions, potential emergency discharges due to unusual events and the likely impacts on water-dependent assets.	
	Describe the water requirements and on-site water management infrastructure, including modelling to demonstrate adequacy under a range of potential climatic conditions.	
	Provide salt balance modelling that includes stores and the movement of salt between stores and takes into account seasonal and long-term variation.	
Cumulative Impacts		
Context and Conceptualisation	Provide cumulative impact analysis with sufficient geographic and temporal boundaries to include all potentially significant water-related impacts.	Section 6.5 and Appendix IV
	Consider all past, present and reasonably foreseeable actions, including development proposals, programs and policies that are likely to impact on the water resources of concern in the cumulative impact analysis. Where a proposed project is located within the area of a bioregional assessment consider the results of the bioregional assessment.	Section 3.1 and Section 6.5

Checklist Title	Checklist Item	Section Addressed
Impacts	Provide an assessment of the condition of affected water resources which includes: -identification of all water resources likely to be cumulatively impacted by the proposed development; -a description of the current condition and quality of water resources and information on condition trends; -identification of ecological characteristics, processes, conditions, trends and values of water resources; -adequate water and salt balances; and, -identification of potential thresholds for each water resource and its likely response to change and capacity to withstand adverse impacts (e.g. altered water quality, drawdown).	- Section 6.5 - Section 5, Appendix II, Appendix III and addressed in other technical reports for the PER - Section 2.2 and addressed in other technical reports for the PER - Addressed in other technical reports for the PER - Appendix V
	Assess the cumulative impacts to water resources considering: -the full extent of potential impacts from the proposed project, (including whether there are alternative options for infrastructure and mine configurations which could reduce impacts), and encompassing all linkages, including both direct and indirect links, operating upstream, downstream, vertically and laterally; -all stages of the development, including exploration, operations and post closure / decommissioning; -appropriately robust, repeatable and transparent methods; -the likely spatial magnitude and timeframe over which impacts will occur, and significance of cumulative impacts; and, opportunities to work with other water users to avoid, minimise or mitigate potential cumulative impacts.	- All bullets addressed under Section 6.5
Mitigation, Monitoring and Management	Identify modifications or alternatives to avoid, minimise or mitigate potential cumulative impacts. Evidence of the likely success of these measures (e.g. case studies) should be provided.	Section 7
	Identify cumulative impact environmental objectives.	Addressed in other technical reports for the PER
	Identify measures to detect and monitor cumulative impacts, pre and post development, and assess the success of mitigation strategies.	Section 7; Appendix V
	Describe appropriate reporting mechanisms	Appendix V
	Propose adaptive management measures and management responses.	Appendix V
Subsidence – underground coal mines and coal seam gas		
Subsidence – Underground Coal Mines and Coal Seam Gas	Provide predictions of subsidence impact on surface topography, water-dependent assets, groundwater (including enhanced connectivity between aquifers) and the movement of water across the landscape (See CoA 2014b; CoA 2014c). Consider multiple methods of predictions and apply the most appropriate method. Consider the limitations of each method including the adequacy of empirical data and site-specific geological conditions and justify the selected method.	Not applicable
	Describe subsidence monitoring methods, including the use of remote or on-ground techniques and explain the predicted accuracy of such techniques.	
	Provide an assessment of both conventional and unconventional subsidence. For project expansions, an evaluation of past or current effects of geological structures on subsidence and implications for water resources and water-dependent assets should be provided.	
	Consider geological strata and their properties (strength/hardness/fracture propagation) in the subsidence analysis and/or modelling. Anomalous and near-surface ground movements with implications for water resources and compaction of unconsolidated sediment should also be considered.	
Final landform and voids – coal mines		

Checklist Title	Checklist Item	Section Addressed
Final Landform and Void – Coal Mine	Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion, sedimentation and habitat fragmentation of water-dependent species and communities.	Addressed in other technical reports for the PER
	Assess the adequacy of modelling, including surface water and groundwater quantity and quality, lake behaviour, timeframes and calibration.	Section 6.2.3 and addressed in other technical reports for the PER
	Provide an evaluation of stability of void slopes where failure during extreme events or over the long term (for example due to aquifer recovery causing geological heave and landform failure) may have implications for water quality.	Addressed in other technical reports for the PER
	Provide an assessment of the long-term impacts to water resources and water-dependent assets posed by various options for the final landform design, including complete or partial backfilling of mining voids. Assessment of the final landform for which approval is being sought should consider: - groundwater behaviour – sink or lateral flow from void. - water level recovery – rate, depth, and stabilisation point (e.g. timeframe and level in relation to existing groundwater level, surface elevation). - seepage – geochemistry and potential impacts. - long-term water quality, including salinity, pH, metals and toxicity. - measures to prevent migration of void water off-site. For other final landform options considered sufficient detail of potential impacts should be provided to clearly justify the proposed option.	Section 6.2.3 and addressed in other technical reports for the PER
	Evaluate mitigating inflows of saline groundwater by planning for partial backfilling of final voids.	Section 6.2.3 presents a post-closure scenario that manages groundwater inflow into the pit voids
	Assess the probability of overtopping of final voids with variable climate extremes, and management mitigations.	Section 6.2.3 and addressed in other technical reports for the PER

2 STATUTORY CONTEXT

This report has been prepared with consideration to key policies and legislation from the Commonwealth of Australia and the State of Queensland. This section provides an overview of key legislation / policies relevant to this assessment.

2.1 Commonwealth Legislation

2.1.1 Environment Protection and Conservation Act 1999

The *Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)* (Commonwealth of Australia 2018) is the central piece of environmental legislation at the Commonwealth level. It provides for the protection of environmental values, including matters of national environmental significance (MNES). Actions that are likely to have a significant impact on MNES are subject to the assessment and approval process under this Act. Amendments to the *EPBC Act* have resulted in water resources being a MNES in relation to large coal mining and CSG development projects.

The regulatory guideline relevant to this project, developed from the amendment to the EPBC Act identifying water resources as being a MNES, is the *Significant impact guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources* (DoEE 2013a).

Significant Impact Guidelines 1.3: Coal Seam Gas and Large Coal Mining Developments

The *'Significant impact guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources'* (DoEE 2013a) identify a 'significant impact' as *'an impact which is important, notable, or of consequence, having regard to its context or intensity'*.

Section 5.2 and 5.3 of the guidelines, identify that for a water resource a 'significant impact' may occur where, as a result of the action, one of the following changes to the hydrological characteristics of a water resource are of a sufficient scale or intensity to significantly reduce the current or future utility of the water resource for third party users, including environmental and other public benefit outcomes:

a. changes in the water quantity, including the timing of variations in water quantity;

b. changes in the integrity of hydrological or hydrogeological connections, including substantial structural damage (e.g. large scale subsidence); and

c. changes in the area or extent of a water resource.

DAWE have identified the following aspects that may need to be considered when assessing the above hydrological characteristics:

- flow regimes (volume, timing, duration and frequency of surface water flows);
- recharge rates to groundwater;
- aquifer pressure or pressure relationships between aquifers;
- groundwater table and potentiometric surface levels;
- groundwater-surface water interactions;
- river-floodplain connectivity;

- inter-aquifer connectivity; and
- coastal processes including changes to sediment movement or accretion, water circulation patterns, permanent alterations in tidal patterns, or substantial changes to water flows or water quality in estuaries.

The Significant impact guidelines 1.3, section 5.4, provide guidance on changes to water quality which state that a significant impact on a water resource may occur where, as a result of the action:

- there is a risk that the ability to achieve relevant local or regional water quality objectives would be materially compromised, and as a result the action:
  - creates risks to human or animal health or to the condition of the natural environment as a result of the change in water quality;
  - substantially reduces the amount of water available for human consumptive uses or for other uses, including environmental uses, which are dependent on water of the appropriate quality;
  - causes persistent organic chemicals, heavy metals, salt or other potentially harmful substances to accumulate in the environment;
  - seriously affects the habitat or lifecycle of a native species dependent on a water resource; or,
  - causes the establishment of an invasive species (or the spread of an existing invasive species) that is harmful to the ecosystem function of the water resource; or
- there is a significant worsening of local water quality (where current local water quality is superior to local or regional water quality objectives); or,
- high quality water is released into an ecosystem which is adapted to a lower quality of water.

Both changes to the hydrological characteristics and water quality as a result of the proposed activities have been assessed as part of this assessment for the identification of potential impacts.

2.2 Queensland Legislation

The Queensland *Mineral Resources Act 1989* (MR Act) (State of Queensland 2019a) entitles the holder of a mining lease to take or interfere with underground water (i.e. groundwater) as part of approved mining operations. This entitlement is termed the mining lease holder's 'underground water rights'. Groundwater that is taken or interfered with while exercising the underground water rights is termed 'associated water'. The holder of the mining lease is entitled to use associated water for any purpose.

Section 227AA of the Queensland *Environmental Protection Act 1994* (EP Act) (State of Queensland 2019b) requires that an EA amendment application that involves a change to the exercise of underground water rights must be supported by the following information:

- A statement describing the proposed exercise of underground water rights and a description of the timing and location of the proposed activities;
- A description of each aquifer and the movement of water within each aquifer affected by the proposed activities;
- An assessment of the extent of depressurisation in each aquifer due to the proposed activities;
- The predicted quantity of associated water taken from each aquifer during the proposed activities;
- A description of the impacts of the proposed activities on environmental values;
- A description of the effects of the proposed activities on groundwater quality; and
- A description of any strategies to avoid, manage or mitigate the impacts of the proposed activities.

The supporting information required under the EP Act is provided in this report, and this information was used in support of the EA amendment for the project, approved by DES in February 2020. The proposed exercise of underground water rights is discussed in Section 6. The conceptual groundwater regime, including relevant aquifers and the movement of groundwater is discussed in Section 5. The predicted effects of the project including groundwater take and changes in groundwater levels and quality are discussed in Section 6.2 and Section 6.3.4.2. The predicted impacts of the project on groundwater users and sensitive environmental features is also addressed in Section 6.3. Groundwater monitoring and management is discussed in Section 7.

The proponent will not require a separate approval (e.g. an associated water license under the parallel provisions of the Water Act) in order to exercise its underground water rights. The proponent already holds an associated water license for the project's mining leases, which includes the Extension areas. This assessment will be used to support conditions of the associated water license requiring an update to groundwater modelling and assessment if there are any landholder bores for which make good agreements are required.

Other relevant groundwater legislation considered in this assessment includes:

- The Environmental Protection (Water) Policy (EPP Water) provides a framework to protect and/or enhance the suitability of Queensland waters for various beneficial uses (State of Queensland 2016a). Groundwater resources within the project lie within the Isaac River catchment as listed in Schedule 1 of the EPP Water. The EPP states that the environmental values for groundwaters within the Isaac River catchment may include aquatic ecosystems, irrigation, farm supply, stock water, primary recreation, drinking water and cultural and spiritual values. The EPP provides water quality objectives (WQOs) to support and protect the various environmental values identified for waters within the Isaac River catchment. The groundwater WQOs for the Isaac River catchment are provided in the *Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin* (DES 2011) according to their chemistry zone and depth category. Groundwater within the vicinity of the project mining area is classified as 'shallow' and 'deep' under chemistry zone 34, a brackish (Na-Cl) type water. Section 4.2.2 presents the groundwater quality data relevant to the project setting. Appendix II

compares groundwater quality at monitoring bores to the *Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin.*

- The water resource planning process under the Water Act provides a framework for the development of catchment specific Water Plans (State of Queensland 2016b). A Water Plan, along with Water Management Protocols, Resource Operations Licences and associated operations manuals, provides a management framework for water resources in a plan area, and includes outcomes, objectives and strategies for maintaining balanced and sustainable water use in that area. The project mining area is located in the Isaac Connors Groundwater Management Area (GMA) under Schedule 3 of the Water Plan (Fitzroy Basin) 2011 area (Figure 3). The Isaac Connors GMA comprises two groundwater units, namely:
  - the Isaac Connors Groundwater Unit 1, containing the aquifers of the Quaternary alluvium associated with the Isaac River channel; and
  - the Isaac Connors Groundwater Unit 2, containing all sub-artesian aquifers within the Isaac Connors GMA other than the aquifers included in Isaac Connors Groundwater Unit 1.

The potential project impacts on these groundwater resources are addressed in Section 6.

3 PROJECT SETTING

3.1 Land Use

The project mining area has been extensively cleared in the past for cattle grazing. More recently, vegetation has been cleared for seismic surveys and open cut mining as part of the approved IPC open cut mining operations.

There are a number of coal mines and coal projects that are approved in the region of the IPC and the project mining area, as shown in Figure 1, including:

- The existing and future mining areas at the IPC adjoining the project mining area;
- The Grosvenor Mine adjacent to the IPC;
- The Moranbah North Mine located northwest of the project mining area;
- The Burton, Broadlea and Ironbark No. 1 Mines located north of the project mining area;
- Carborough Downs Mine located east of the project mining area;
- Millennium and Poitrel Mines located southeast of the project mining area; and
- The Moranbah South Project and Caval Ridge Mine located southwest of the project mining area.

The Moranbah Gas Project, which is one of Australia's largest operating CSG projects, also extends over the Grosvenor Mine, Moranbah North Mine and surrounding areas. The Moranbah Gas Project is a joint venture between Arrow Energy and AGL.

In addition to the above resource development mines/projects surrounding the project area, a subsidiary of Stanmore, Stanmore IP South, is in the process of developing the Isaac Downs Project. The Isaac Downs Project is proposed to comprise the development of open cut pits for the mining of the coal associated with the Rangal Coal Measures; and is located approximately 5 km south of the project. Conceptually, the Isaac Downs Project has been assessed as part of the potential cumulative impacts to the groundwater system (Section 6.5).

Other non-approved projects that are in the process of being developed, within the vicinity of the project area include:

- The Winchester South Project, located approximately 30 km south of the project area, to be developed by Whitehaven Coal;
- The Olive Downs Project, located approximately 40 km south of the project area, to be developed by Pembroke Resources; and
- The Eagle Downs Project, located approximately 30 km southeast of the project area, to be developed by South32.

The potential for cumulative groundwater impacts due to the project and the surrounding land uses is assessed in Section 6.5.

3.2 Topography and Drainage

The project mining area is traversed by Smoky Creek, its northern tributary; and Billy's Gully (Figure 4). Smoky Creek and its northern tributary converge to the west of the northern extent of the project mining area. Surface water flow within Smoky Creek is towards the southwest and joins the Isaac River approximately 7 km downstream of the project mining area boundary. Smoky Creek separates the approved Pit 4 (south of Smoky Creek) and Pit 5 (north of Smoky Creek) of IPE. Billy's Gully flows towards the west-southwest and is located adjacent to the southern extent of the project mining area (Figure 4). The Billy's Gully drainage line separates the approved Pit 1 (south of Billy's Gully) and Pit 2 (north of Billy's Gully) of IPE.

The project mining area comprises undulating terrain (Figure 4). In the northern part of the project mining area, the land slopes towards creek channels. The remainder of the project mining area slopes to the west.

The Isaac River, Smoky Creek, Billy's Gully and their tributaries are ephemeral and characterised by short-duration surface water flows that are typically restricted to periods during and immediately after rainfall events. Creek flows exhibit naturally elevated suspended sediment loads and the channels show extensive sediment deposition.

3.3 Climate

The climate at the project mining area is sub-tropical continental, characterised by high variability in rainfall, temperature and evaporation, typical of the regional Central Queensland area.

Climate data has been collected from two Bureau of Meteorology (BoM) weather stations within the vicinity of the project mining area (BOM 2019b; 2019a). These include:

- Moranbah Water Treatment Plant (Station 034038) – now decommissioned, operating from 1972 to March 2012. This monitoring station is located approximately 12 km west of the project mining area (Figure 4).
- Moranbah Airport (Station 034035) – operational, operating from March 2012 to present. This monitoring station is located approximately 12.5 km south west of the project mining area (Figure 4).

A summary of average temperatures, rainfall and evaporation from the Moranbah Water Treatment Plant station is presented in Table 3.1, while a summary of average temperatures and rainfall from the Moranbah Airport station is presented in Table 3.2.

Table 3.1: Climate Averages – Moranbah Water Treatment Plant (Station 034038)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean max temp (^{0}C)*	33.8	33.1	32.1	29.5	26.5	23.7	23.7	25.5	29.2	32.3	33.1	34.0	29.7
Mean min temp (^{0}C)*	21.9	21.8	20.2	17.6	14.2	11.2	9.9	11.1	14.1	17.6	19.4	21.1	16.7
Mean rainfall (mm)*	103.8	100.7	55.4	36.4	34.5	22.1	18.0	25.0	9.1	35.7	69.3	103.9	614.2
Mean daily evaporation (mm)**	8.0	7.4	6.8	5.7	4.3	3.5	3.7	4.9	6.6	8.0	8.5	8.5	6.3

* Data record from 1972 to 2012
** Data record from 1986 to 2012

Table 3.2: Climate Averages – Moranbah Airport (Station 034035)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean max temp (^{0}C)	35.0	33.4	32.3	29.8	27.0	24.3	24.7	26.9	30.4	32.8	34.7	35.1	30.8
Mean min temp (^{0}C)	21.3	21.1	20.2	16.5	13.0	9.6	8.6	8.3	12.5	15.8	18.8	20.3	21.3
Mean rainfall (mm)	86.2	103.6	97.7	26.2	27.4	16.3	32.1	8.7	8.4	26.3	46.2	63.3	563.4

Data record from 2012 to June 2019

Available climate data highlights distinct cycles of above average and below average rainfall. The Moranbah area has experienced below average rainfall between 2001 and 2006, and 2008 to 2010; with above average rainfall in 2007, and between 2010 and 2012. Rainfall from 2012 to present day has been consistent with the long-term average, except for 2016 where above average rainfall occurred.

Evaporation rates have been recorded at the Moranbah Water Treatment Plant station between 1986 and 2012. Monthly evaporation rates exceed monthly rainfall for all months of the year, highlighting a net evaporative loss over a year.

3.4 Geology

The project mining area is located on the northwestern flank of the Bowen Basin, a sedimentary basin comprising Permian to Triassic age geology (Figure 5). A veneer of more recent basalt and weathered sediments typically overlies the Bowen Basin strata (Figure 6).

The ground-truthed surface geology relevant to the project mining area is shown in Figure 6, and includes:

- Thin deposits of alluvium within, and immediately adjacent to, the drainage channel of Billy's Gully;
- A veneer of recent weathered sediments comprising the Suttor Formation and associated colluvium and regolith;
- Localised Tertiary basalt deposits;
- Triassic sediments of the Rewan Group; and
- Permian sediments of the Rangal Coal Measures (including the target Leichardt seam) and the deeper Fort Cooper Coal Measures and Moranbah Coal Measures.

KCB field investigations completed in 2018 identified limited Quaternary alluvium within the vicinity of Smoky Creek, in comparison to surrounding larger water courses (e.g. Isaac River), with the alluvium constrained to within the Smoky Creek water course by the adjacent banks. A summary of this field investigation in provided in Appendix VI. Field investigations completed by 3D Environmental in 2020, as part of a GDE study at IPC (3D Environmental 2020), identified thin (~2 m) localised deposits of alluvium within and adjacent to the drainage channel of Billy's Gully.

Broader and thicker deposits of Quaternary alluvium, are mapped adjacent to the Isaac River, located approximately 6.5 km southwest of the project mining area.

The Tertiary sediments comprise a heterogeneous profile of semi-consolidated sandstone, mudstone and other minor sediments associated with the Tertiary Suttor Formation, duricrusted

palaeosols at the top of deep weathering profiles, colluvium and regolith (Figure 6). Published geological mapping confirms that the colluvium deposits transition to Suttor Formation sediments, indicating that these materials are frequently indistinguishable due to lithological similarities. These materials are therefore considered to form a single unit, hereafter referred to as the Tertiary sediments, which are widely distributed over the project mining area and its surrounds. These sediments are up to approximately 15 m thick in the west and south of the project mining area and are thin or absent elsewhere.

The Tertiary basalt comprises a heterogeneous profile of vesicular and massive basaltic lavas, with minor tuff and ash. The upper basalt profile is highly weathered forming a basaltic clay. The distribution of Tertiary basalt is confined to a paleochannel that is incised into the Permian sediments. The project mining area is located to the west of the main basalt paleochannel, however, the northern extent of the project mining area does intersect a western extension of basalt away from the main basalt paleochannel. The basalt reaches a maximum thickness of approximately 15 m within the project mining area.

The Triassic Rewan Group overlies the Permian sediments within and to the east of the project mining area and consists of fine/medium grained sandstones, siltstones and shale. The upper profile of the Permian sediments has been extensively weathered forming a clay. The Rewan Group sub-crops beneath the Tertiary sediments and basalt within the project mining area and thickens as it dips to the east.

The Permian sediments include the Rangal Coal Measures and the underlying Fort Cooper Coal Measures and Moranbah Coal Measures. These units comprise a sedimentary sequence with interbedded coal seams, including the target Leichardt Seam, which is approximately 3.2 to 4.4 m thick in the project mining area. The upper profile of the Permian sediments has been extensively weathered forming a clay. The weathered Permian sediments outcrop at the ground surface across much of the IPC mining area and much of the surrounding area to the west (Figure 6). In the remainder of the project mining area, the weathered Permian sediments sub-crop under the Tertiary sediments and basalt and dip towards the east (Figure 7). As the Permian sediments dip to the east, the depth of cover above the coal seam being mined generally increases from approximately 80 m in the west of the project mining area to approximately 140 m in the east (Figure 8).

The Permian sediments (including the Leichardt Seam) and the Rewan Group are faulted to the west of the project mining area (Figure 7). The fault dips gently to the east in the northern part of the IPC. In this area, the downthrust and upthrust Leichardt Seam (located west and east of the fault, respectively) overlap (Figure 7). Open cut mining in the project area will target the upthrust coal seam (Figure 7). The fault is sub-vertical in the southern part of the IPC and there is negligible overlap in the Leichardt Seam in this area.

3.5 Groundwater Dependent Assets

3.5.1 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) are defined by DoEE (2015) as "*Natural ecosystems which require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services* (Richardson et al. 2011)."

The potential for the presence of GDEs has been determined through a desktop search of the Queensland Springs Database and the Bureau of Meteorology's (GDE) Atlas; and field investigations comprising a project-specific GDE assessment and groundwater field investigations (3D Environmental 2020).

The desktop investigations concluded that:

- There is an absence of spring wetlands in the vicinity of the project mining area in the Queensland Springs Database; and
- BoM GDE mapping identifies Smoky Creek and its northern tributary as areas with moderate potential for GDEs to occur which are reliant on surface expression of groundwater.

The project-specific GDE assessment identified:

- Riparian vegetation on Smoky Creek is supported by ephemeral flows that saturate in-channel alluvial sands and clays in the stream bank and floor. There is no indication that this vegetation is utilising shallow groundwater resources, therefore it is not considered to represent a GDE.
- Mature vegetation within Billy's Gully is being sustained by a shallow groundwater system associated with the alluvium within, and adjacent to, the water course. The condition of the vegetation suggests that the vegetation are not utilising saline groundwater (groundwater within the underlying Tertiary sediments).

Further discussion regarding the groundwater flow conditions associated with the Billy's Gully alluvium is provided in Section 5.1. An assessment of potential impacts to GDEs as a result of the project is provided in Section 6.3.4.

3.5.2 Stygofauna

Stygofauna are aquatic animals (generally invertebrates such as crustaceans) that are between 0.3 mm and 15 mm in length (Humphreys 2006). They are predominantly found in aquifers with large (mm or greater) pore spaces, especially alluvial, karstic and some fractured rock aquifers (Hose et al. 2015). The size of the pore spaces is a key determinant of the suitability of an aquifer as stygofauna habitat.

A stygofauna pilot study of the IPEE was undertaken (frc environmental 2020) which involved a desktop review, a field survey, an assessment of environmental value and an impact assessment and mitigation strategy development. The study comprised the collection of 10 representative groundwater samples, which were analysed for stygofauna. Results on the analyses identified only a single *stygoxene* taxon from two bores. Based on this result (i.e. limited occurrence), and the

characteristics of the groundwater regime, the stygofauna community for the Project area was assessed as having low environmental value.

4 METHODOLOGY

4.1 Desktop Study

4.1.1 Database Searches

A search of relevant Australian and Queensland databases was undertaken. The purpose of this search was to identify the presence of current and historical groundwater bores and collate drilling records and groundwater level, yield and quality data from relevant bores.

The database search area included the project mining area and its surrounds within a 5 km radius. The search radius was considered representative of the geological and hydrogeological setting of the area.

The following databases and mapping were searched:

- The DNRME Groundwater Database of registered water bore data from private water bores and Queensland Government groundwater investigation and monitoring bores (Appendix I). Sourced data includes bore location, groundwater levels, construction details, stratigraphic logs, available hydrogeological testing and available groundwater quality.
- The Queensland Spatial Catalogue (QSpatial), via Queensland Globe. Records of petroleum and coal seam gas (CSG) exploration, production and monitoring wells are contained within this database.

The IPC groundwater database was also searched to identify any unregistered groundwater bores.

These searches identified 47 groundwater bores (44 registered and 3 unregistered) within 5 km of the project mining area (Figure 9), including:

- 11 bores (MB1 to MB5, MB8 to MB11, Swamp Bore 2[1] and Burton Coal Bore 2) comprising the existing IPC EA groundwater monitoring network described in Section 4.1.2;
- 6 bores (Smoky Creek Bore, BC095, 240P/AC1, MB4b, MB06 and MB07) that are historical IPC groundwater monitoring bores;
- 24 water supply and monitoring bores that form part of the Broadlea water supply borefield, located approximately 4 km northeast of the project mining area and targeting the Tertiary basalt aquifer;
- 1 operating landholder water supply (Swamp Bore 1); and
- 5 groundwater bores (Burton Coal Bore 1, MGC Wotonga 1, MGC Moranbah 1, GW23, and 141C) that are predominantly historical and existing monitoring bores associated with local mining and gas operations.

The database information on these bores has been tabulated in Appendix I. A detailed assessment of Swamp Bore 1 and 2 (described in Section 4.1.2) has shown that Swamp Bore 2 is the EA

[1] Swamp Bore 2 is identified as Swamp Bore 1 in the existing IPC EA groundwater monitoring network.

monitoring bore while Swamp Bore 1 is the landholder water supply bore, hence these bore names have been transposed in the public records. The corrected naming convention has been used above and throughout this report. The potential impacts of the project on Swamp Bore 1 are discussed in Section 6.3.2.

A total of 21 QSpatial-registered gas production wells were identified within 5 km of the project mining area. Of these wells, 19 have either been plugged or abandoned or suspended and capped and therefore not shown in the report figures. The remaining two registered CSG wells include Sapphire 4 and M348A (Figure 9). The former is an appraisal well which occurs within the project mining area and the latter is a development well to the west of the Isaac Plains Mining Lease. Both wells target the Moranbah Coal Measures and are therefore not in hydraulic connection with the formations associated with the project.

The relevant reliable data collected from these and surrounding CSG wells was used to inform the conceptual understanding of the groundwater regime and the numerical groundwater model. The specific use of each groundwater bore in this study was dependent on the type and quality of information available (i.e. bores with reliable water levels were used to establish the groundwater flow regime and calibrate the groundwater model, bores with reliable salinity data were used in the groundwater quality assessment, bores with reliable hydraulic data were used to confirm the groundwater regime and establish suitable model parameters). Stratigraphic information from the remaining bores was used to confirm the geology setting, relevant lithology and construct the model geology.

4.1.2 Isaac Plains Complex Groundwater Monitoring Network

IP Coal maintains the IPC groundwater monitoring network in accordance with the EA. The IPC EA groundwater monitoring network currently comprises 11 monitoring bores as shown on Figure 9, including:

- 2 bores (Burton Coal Bore 2 and Swamp Bore 2) that have been monitored since 2010;
- Dedicated groundwater monitoring bores (MB01 to MB04a and MB04b) installed in 2016 as part of the IPE Project groundwater assessment; and
- Bores (MB8 to MB11) installed in mid-2018 to fulfil the monitoring requirements of the IPC EA.

The proponent has also historically monitored an additional 7 bores (Smoky Creek Bore, BC095, 240P (also called AC1), MB4b, MB05, MB06 (note, MB05 and MB06 has now been decommissioned as a result of mining activities)and MB07) (Figure 9).

Bore lithology, depth to water strike, bore construction details, screened lithology and hydraulic conductivity testing results have been collected for each bore along with groundwater level and quality data from 2007 to 2019, where available.

4.1.3 Literature Review and Previous Groundwater Studies

A review of available groundwater reports, literature and relevant groundwater studies was undertaken to support and refine the conceptual understanding of the local and regional groundwater regime.

The review included the following groundwater studies undertaken within the vicinity of the project mining area and within comparable geological and environmental settings:

- Smoky Creek Alluvium Site Investigation Report (Appendix VI). This report provides a factual site investigation report for the Smoky Creek alluvium reconnaissance completed in 2008.
- The Isaac Plains East Project Groundwater Report (KCB 2016). This report includes groundwater levels and quality data from six groundwater monitoring bores (MB01 to MB06) installed as part of the IPE Project groundwater field investigation program in 2016. This report also includes pumping test data has been collected from three production wells associated with the Broadlea Mine;
- The Integrated Isaac Plains Project EIS groundwater study (Matrix Plus Consulting 2009). This report includes information on 13 groundwater monitoring bores installed at six locations (i.e. multiple clustered bores targeting various hydrogeological units at each location). A total of 55 water level measurements and 30 water quality samples were collected. Hydraulic testing was also undertaken in the alluvium and the Rangal Coal Measures (including the Leichardt and Vermont seams and the Permian interbeds);
- The Grosvenor Project EIS (JBT Consulting 2010). This report includes extensive field investigation data from the Grosvenor Mine ML, including data collected from Anglo's regional network of 220 exploration and monitoring bores located on the Grosvenor Mine ML, the Moranbah North Mine ML and the surrounding area. Groundwater level and quality data spanning an 11 year period was reviewed;
- The Moranbah South Project (AGE 2013). This report includes field investigation data that was collected from the installation of 14 monitoring bores (two in the alluvium, six in the Tertiary basalt / sediments, three in the Fort Cooper Coal Measures, three in the Moranbah Coal Measures), the installation of 16 vibrating wire piezometers across four locations targeting the coal seams and falling-head testing on 13 monitoring bores (three in the Fort Cooper Coal Measures, three in the Moranbah Coal Measures, five in the Tertiary basalt, two in the alluvium) to obtain hydraulic conductivity values of the target hydrogeological units; and
- The Moranbah Gas Project Underground Water Impact Report (Arrow Energy 2016). This report includes monitoring data collected from the coal seams and overlying strata to the west of the project mining area and provides information on the response of groundwater levels to dewatering of the coal seams during CSG production.
- Isaac Plains East Extension Project Groundwater Dependent Ecosystem Assessment Report – Draft (3D Environmental 2020). This report includes the mapping and augering of alluvium within Billy's Gully, logs of the augered holes, identification of water/degree of saturation within the augered holes and groundwater sampling for laboratory testing.

4.1.4 Bore Census

A bore census carried out in 2015 as part of the IPE Project groundwater assessment identified Smoky Creek Bore, Burton Coal Bore 1 and Swamp Bore 2 as inactive water supply bores surrounding the IPC.

The bore census confirmed that Smoky Creek Bore is located on the Broadlea property and the leaseholder of this property has access to an alternative water supply and therefore this bore has not been used as a water supply. This bore is part of the historical IPC groundwater monitoring network.

In mid-2018 a detailed bore assessment was undertaken to confirm the status of Burton Coal Bore 1 and Swamp Bore 2. In addition, the bore assessment investigated Burton Coal Bore 2, Swamp Bore 1 and Smoky Creek Bore. The bore assessment concluded that:

- Burton Coal Bore 1 is damaged and inaccessible. No pumping equipment is installed in this bore.
- Burton Coal Bore 2 and Swamp Bore 2 are EA groundwater monitoring bores. These bores are not installed with pumping equipment and are not used for water supply.
- Swamp Bore 1 is an operating water supply bore located approximately 2 km east of the project mining area. This bore is screened in the Rewan Group.
- Smoky Creek Bore was unable to be located during the detail bore assessment. However, signage located adjacent to the Burton Coal Bores identified the bores as Smoky Creek Bore. Therefore, it is interpreted that there has been confusion regarding the bore IDs for Smoky Creek Bore, Burton Coal Bore 1 and Burton Coal Bore 2, and that Smoky Creek Bore is interpreted to be an incorrect reference to one of the Burton Coal Bores. To avoid confusion, the Smoky Creek Bore ID is not referenced in the remainder of this report.

The potential impacts of the project on Swamp Bore 1 are discussed in Section 6.3.2.

4.2 Data Analysis and Conceptualisation

Data collected from the desktop study was collated and screened. The relevant local data was analysed in detail to develop a conceptual understanding of the groundwater regime in the project mining area and its immediate surrounds (Section 5).

The collated local groundwater dataset includes the following relevant measurements:

- Geological data collected from the proponent's geology database of over 200 exploration drill holes within the project mining area and its surrounds, lithological logs from 41 DNRME-registered and unregistered bores.
- Groundwater level data collected from 33 bores screened across the main stratigraphic units within the project area and its surrounds. This includes manual and automated logger groundwater level data from the IPC groundwater monitoring bores and adjacent landholder bores.
- Hydraulic testing results collected from 14 rising/falling head tests conducted on the IPC groundwater monitoring bores and adjacent landholder bores. This includes hydraulic testing results for each of the main stratigraphic units within the project mining area and its surrounds (Figure 10).
- Groundwater quality data collected from 14 bores, including detailed field measurements and laboratory results for each of the main stratigraphic units within and surrounding the project area.

4.2.1 Groundwater Flow

Spatially distributed groundwater level data were used to characterise groundwater flow directions, gradients and velocities. In addition, time variant groundwater level fluctuations were used to interpret the rate and distribution of recharge/discharge, depressurisation influence from surrounding mining activities and pre-development/seasonal variability in groundwater levels. Groundwater levels were recorded from an established groundwater monitoring bore network at the project site, which is summarised in Table 4.1.

Table 4.1 Summary of IPC Groundwater Monitoring Bore Network

Monitoring Bore	Location[a]		Surface RL	Total Depth	Screen Interval	Screened Unit	Monitoring Frequency	Status
	Easting	Northing						
Burton Coal Bore 2	620383	7573599	240.8	37.0	30.3 – 34.6	Rewan Group	Quarterly	Existing
Swamp Bore 2[b]	621518	7568790	245.9	55.0	24 – 55.1	Rewan Group	Quarterly	Existing
MB1	618793	7572214	236.4	29.2	22.5 – 28.4	Rangal Coal Measures	Quarterly	To be decommissioned and replaced
MB2	619074	7573137	242.7	51.9	48.7 – 51.6	Rangal Coal Measures	Quarterly	Existing
MB3	619047	7568473	253.0	52.6	49.7 – 52.6	Rangal Coal Measures	Quarterly	Decommissioned. Replaced by MB9
MB4a	620351	7567479	237.6	11.0	7.8 – 10.7	Tertiary sediments	Quarterly	To be decommissioned, replaced by MB4b.
MB4b	619740	7567253	233.9	12.4	9.4 – 12.4			To be decommissioned and replaced
MB5	618507	7570878	235.7	39.4	36.4 – 39.3	Rangal Coal Measures	Quarterly	Destroyed. Replaced by MB8.
MB8	619105	7571149	245.9	126.3	117.3 – 120.3	Rangal Coal Measures	Quarterly	To be decommissioned and replaced
MB9	620368	7568049	239.5	80.5	77.5 – 80.5	Rangal Coal Measures	Quarterly	To be decommissioned and replaced
MB10	620368	7568046	239.5	27.0	21.0 – 27.0	Tertiary basalt	Quarterly	To be decommissioned and replaced
MB11	618832	7571924	232.3	5.0	3.0 – 4.0	Tertiary sediments	Quarterly	Existing, Dry.

Groundwater level hydrographs from monitoring bores installed across the project area and screened across the various hydrostratigraphic units are presented in Appendix III. These hydrographs were used for the transient calibration of the numerical model (Section 4.3).

4.2.2 Groundwater Quality

Groundwater quality data provides useful information on the hydrogeological regime, as it is influenced by interaction with the aquifer matrix, and groundwater recharge/discharge processes. A statistical summary of the groundwater quality data from historical groundwater records from bores across the project site is provided in Appendix II. A comparison of the groundwater quality concentrations for each of the hydrostratigraphic units against the Lower Isaac Zone 34 Water

Quality Objectives (WQOs); and/or the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018), has been provided in Appendix II.

Salinity is a key constraint to the usability of groundwater resources for productive applications such as potable supply, irrigation, stock watering and industrial applications. If groundwater with elevated salinity levels are used for incompatible purposes or applications it may result in impacts to agricultural productivity, health and the environment.

A categorisation scheme for salinity proposed by (FAO 1992) is presented in Table 4.2. Table 4.2 also categorises the groundwater salinity collected from laboratory analysis at the current and historical IPC groundwater monitoring bores. The dataset collected from these bores represents the most relevant and comprehensive, long-term record of groundwater quality within the vicinity of the project. There are no records indicating that 'fresh' groundwater has been encountered near the project mining area. Note that bore MB11 is dry and has never contained water.

Table 4.2: Salinity Classification Scale

Salinity	Range (TDS mg/L)	Groundwater Salinity in IPC Monitoring Bores (Average TDS mg/L)
Fresh	< 500	Nil
Brackish	500 – 1,500	Nil
Moderately saline	1,500 – 7,000	MB10 – 3,121 Swamp Bore 2 – 6,203 Burton Coal Bore 2 – 3,077 MB01 – 2,154 MB02 – 4,778 MB09 – 6,943
Saline	7,000 – 15,000	MB08 – 7,710 MB07 – 13,683 MB03 – 13,210
Highly saline	15,000 – 35,000	MB05 – 16,210 MB04b – 19,500
Brine	> 35,000	MB04a – 38,158

A piper plot of the collated groundwater samples was undertaken to understand the major ionic proportions of the groundwater regime. Piper plots are useful for assessing groundwater mixing and evolution (e.g. through water-rock interaction) and identifying potential zones of groundwater recharge and discharge. Figure 11 provides a piper diagram of groundwater ionic proportions collected from the bores listed in Table 4.2. This diagram shows data from 2010 to April 2020.

Collectively, the compiled water quality data represents all reliable data on groundwater ion composition within 5 km of the project mining area. Figure 11 clearly demonstrates that the ionic composition of groundwater is consistent across all measured bores, and was used to further support the assessment that the groundwater regime is generally consistent at a local and regional scale.

4.3 Numerical Modelling

A 3D numerical groundwater flow model was developed from the collated dataset (described in Sections 4.1 to 4.2) using MODFLOW software to represent the conceptual groundwater regime

described in Section 5. A detailed description of the modelling methodology is provided in Appendix IV.

The model represented the key geological units using 17 model layers and extends 48 km north-south and 27 km east-west. The project mining area is located in the centre of the model domain.

The physical structure of the groundwater model was based on the detailed geological model developed by Stanmore and a numerical groundwater model developed for the Isaac Plains Complex, inclusive of the potential, future Isaac Plains Underground (IPU) Project (KCB 2019), which has been deferred. Model development was supplemented by published geological maps, digital geology surfaces and information from mining operations near the project mining area and data from the DNRME groundwater database.

The Australian Groundwater Modelling Guidelines (Barnett et al. 2012) were used to frame the calibration process. A detailed description of the calibration method is provided in Appendix IV. The groundwater model was initially calibrated to 5,858 reliable groundwater levels records from 15 monitoring bores screened across a variety of aquifers and aquitards. Groundwater inflow data and transient level data from existing mining and coal seam gas operations was also used as a target for model calibration.

The groundwater regime near the project mining area has varied over time due to the influence of historic and current mining activities. For this assessment, it was necessary to perform a transient (time-variant) calibration which considered the change in groundwater levels and flow from pre-mining conditions up to November 2018.

The transient calibration achieved an RMS of 3.8 m and a scaled RMS error of 4.0 %, which is an acceptable calibration metric as recommended by the Australian Groundwater Modelling Guidelines (Barnett et al. 2012). Furthermore, the calibrated groundwater levels, vertical gradients, flow patterns and mine inflows replicate measured data and groundwater trends. The model calibration is therefore considered robust. Further details of the transient calibration are provided in Appendix IV, however, the following key points summarises the calibration results and confirms the adequacy of the calibration:

- Calibration was undertaken using transient groundwater level records from monitoring bores screened across a range of hydrostratigraphic units within the vicinity of the project;
- Monitoring bore locations for bores used for the transient calibration are distributed across the project area; and due to the screened intervals of these bores being across various hydrostratigraphic units, the monitoring records used for the model calibration are distributed across the project area both laterally and vertically; and
- Groundwater level trends observed in the monitoring records (e.g. drawdown influences, seasonal variability) were replicated by the simulated groundwater level as part of the calibration simulation.

5 EXISTING HYDROGEOLOGY

The relevant hydrogeological units of the project mining area and its surrounds broadly comprise:

- Localised thin deposits of alluvium within and immediately adjacent to the watercourse of Billy's Gully;
- A shallow, highly weathered veneer of low permeability Tertiary sediments;
- Tertiary basalt comprising highly weathered, low permeability basaltic clay and a relatively permeably basalt aquifer;
- Low permeability Rewan Group sediments; and
- Permian sediments comprising low permeability sediments and relatively permeable coal seams.

The main groundwater-bearing formations are the fresh Tertiary basalt and the coal seams of the Permian sediments. These formations have been significantly depressurised and impacted by mining and gas production activities at nearby operations. The Rewan Group is a low permeability formation that is a regionally recognised aquitard. The Tertiary sediments do not form a permanent, saturated aquifer, and persistent groundwater occurs only where these sediments extend below the regional water table. The alluvium associated with Billy's Gully is an ephemeral perched aquifer located above the regional groundwater system that develops following rainfall and associated runoff events.

Recharge predominantly occurs via direct and diffuse rainfall to the weathered surface sediments (i.e. Tertiary sediments and basalt) and outcropping weathered Permian and Rewan Group sediments. A portion of the rainfall moves downwards to the groundwater table then moves through the system following the hydraulic gradient. Recharge to the Permian sediments and Rewan Group will occur where these units sub-crop below the Tertiary sediments and basalt.

The regional groundwater flow is generally from elevated areas in the northeast to lower lying areas in the southwest (i.e. the Isaac River). However, groundwater flow has been significantly altered by mining operations in the vicinity of the project mining area. A zone of depressurisation exists above and around the surrounding mines and gas production wells. This zone locally influences groundwater flow directions and results in groundwater flowing towards these mines and gas production activities.

Groundwater flow in the Billy's Gully alluvium occurs during and immediately following rainfall/runoff events, with the flow direction parallel with the water course. The duration of flow within this alluvium is anticipated to be minimal as the relatively high hydraulic conductivity of this unit results in the quick drain-down of the saturated profile following a recharge event.

The Tertiary sediments and upper weathered profile of the Tertiary basalt, Rewan Group and Permian sediments are predominantly unsaturated in the vicinity of the project mining area, therefore, interpolated groundwater surfaces for these units are unable to be produced.

The ephemeral nature of groundwater in the alluvium associated with Billy's Gully also highlights the predominantly unsaturated characteristics of this unit.

The depth to groundwater following mining at IPM, based on available data, is presented in Figure 12.

All formations within the project mining area and its surrounds have a relatively low hydraulic conductivity (Figure 10), with the exception of the Quaternary alluvium identified in Billy's Gully.

Figure 7 shows a conceptual cross-section of the geology and groundwater regime within the project mining area and its surrounds.

Regional groundwater quality within the project mining area and its surrounds ranges from moderately saline to brine. Local groundwater is therefore generally unsuitable for potable, irrigation or stock watering uses. There are no current groundwater users in the project mining area or its surrounds.

5.1 Quaternary Alluvium

Quaternary alluvium occurs within, and adjacent to, the water course of Billy's Gully. Field investigations completed in 2020 (3D Environmental 2020) identified the alluvium to be up to ~150 m wide across the water course with a maximum thickness of ~2 m. The alluvium comprises coarse sands with minor clays and intermittent lenses of gravel. The lithology underlying the alluvium comprises highly plastic clay with mottled clay features and weather sandstone. Both of these lithologies are representative of weathered residual bedrock of the Tertiary Sediments and/or the Rewan Group. A conceptual model of the Billy's Gully alluvium system is provided in the GDE Assessment report (3D Environmental 2020).

Field investigation completed in March 2020 (3D Environmental) identified a shallow saturated zone at the based on the alluvium, above the residual bedrock, of approximately 0.2 m (i.e. water level at ~1.8 mbGL). This zone of saturation is interpreted to be perched on the low permeability residual bedrock and has resulted from recent rainfall and runoff recharge to the alluvium. Considering the field investigation along Billy's Gully was completed late in the wet season, the relatively shallow height of the saturated zone in the alluvium indicates that groundwater in the alluvium has a short residence time and drains away down-gradient (towards the Isaac River) relatively quickly following recharge events.

In comparison to the water levels recorded from other hydrostratigraphic units within the vicinity of the Billy's Gully alluvium, the water level in the alluvium (230.3 mAHD) is ~8 m higher than the water level in the underlying Tertiary Sediments (MB4b) (see Appendix III); indicating that the alluvium is not in hydraulic connection with the Tertiary Sediments. As a result of the difference in water levels between the alluvium and the Tertiary Sediments, the alluvium in Billy's Gully is identified as a perched ephemeral aquifer that is not in connection with the regional groundwater system.

The relatively thin deposits of alluvium in Billy's Gully and the ephemeral nature of groundwater within the alluvium indicates that this unit is relatively insignificant. Furthermore, considering the groundwater in the alluvium is not in hydraulic connection with the regional groundwater system, this unit has not been simulated in the numerical groundwater model.

5.2 Tertiary Sediments

5.2.1 Groundwater Distribution

The Tertiary sediments comprise a heterogeneous profile of semi-consolidated sandstone, mudstone and other minor sediments. The Tertiary sediments are widely distributed over the project mining area and its surrounds (Figure 6) where they form undulating sandy plains. The Tertiary sediments have been extensively weathered resulting in the formation of a heterogeneous layer of residual soils and weathered clays.

The Tertiary sediments are up to 10 m thick within the project mining area and its surrounds. The limited thickness and low primary porosity of these sediments results in limited capacity for groundwater storage and movement.

The Tertiary sediments are typically located above the regional groundwater table and are therefore generally dry and unsaturated in the vicinity of the project mining area. Where saturated, the groundwater within the Tertiary sediments is in direct hydraulic connection with the underlying Triassic Rewan Group or Permian sediments. The saturated thickness and extent of the Tertiary sediments is shown in Figure 13.

The Tertiary sediments are not a significant aquifer.

5.2.2 Hydraulic Parameters

Hydraulic testing data indicates the Tertiary sediments have a low to moderately low hydraulic conductivity, ranging from approximately 7.0×10^{-4} to 0.04 m/d. The hydraulic conductivity of this unit is within the range exhibited by the Triassic Rewan Group and Permian sediments. This supports the assessment that these sediments are not a significant aquifer.

5.2.3 Potentiometric Surface, Recharge, Flow and Discharge

The Tertiary sediments are recharged by direct infiltration from rainfall where these sediments are present at the surface. The Tertiary sediments are also recharged by the underlying groundwater regime where they are hydraulically connected.

Groundwater flows in the Tertiary sediments are towards the southwest and are locally influenced by dewatering of the Tertiary basalt at the Broadlea water supply borefield and mining operations.

Discharge predominantly occurs as seepage to the underlying Permo-Triassic groundwater regime.

Due to the depth of groundwater in the Tertiary sediments, there is no significant interaction with surface waters within the vicinity of the project area.

5.2.4 Groundwater Quality

Groundwater quality in the Tertiary sediments at the IPC (MB4a and MB4b) has the TDS concentration representative of highly saline water (e.g. mean TDS of 38,689 mg/L in MB4a and 19,467 mg/L in MB4b). The elevated salinity reflects the degree of connectivity with the

underlying low permeability Permian sediments and the long groundwater residency times of groundwater in this formation.

5.2.5 Yield and Use

Groundwater yields are expected to be low (less than 1 L/s). No groundwater supply bores are located in the Tertiary sediments within 5 km of the project area due to the general lack of saturation or reliable water supply in these sediments.

5.3 Tertiary Basalt

5.3.1 Distribution

The Tertiary basalt underlies the Tertiary sediments and overlies weathered Permo-Triassic strata at the project mining area and typically occurs as a single composite unit comprising massive and vesicular lava, tuff and ash flows.

Regionally, the Tertiary basalt occurs within paleo-channels incised into the underlying Permo-Triassic bedrock. Paleo-channels with associated basalt flows are located to the north, east and south of the project mining area. The regional basalt flows have a saturated thickness of up to approximately 50 m in the centre of the paleo-channels (Figure 14).

The basalt extends into the northern parts of the project mining area from the main paleo-channel to the east. The local distribution of the Tertiary basalt is shown in Figure 6. Basalt within the project mining area is typically dry or has a limited saturated profile of less than 5 m (Figure 14). The saturated profile thickens to the east of the project mining area (i.e. towards the regional paleo-channel).

5.3.2 Hydraulic Parameters

The basalt exhibits highly variable hydraulic properties due to its complex lithology. Groundwater storage and flow is dominated by localised vesicular and fractured zones.

Fractured and vesicular basalt zones are compartmentalised by zones of massive basalt that is not significantly fractured or vesicular. In addition, the shallow highly weathered basalt also forms a very low hydraulic conductivity clay. Therefore, massive basalt and shallow highly-weathered basalt do not generally contain significant groundwater and can act as barriers to flow.

The hydraulic conductivity of the Tertiary basalt in the project mining area and its surrounds ranges from 4.0×10^{-3} to 6.5 m/d, reflecting the variability in the basalt characteristics. Higher hydraulic conductivity values are generally associated with the fractured / vesicular basalt within the centre of the basalt paleo-channel approximately 5 km east of the project mining area. Lower hydraulic conductivity values are typically associated with massive basalt along the lateral extents of the paleo-channel, and as minor limbs of the paleo-channel. The limbs of the paleo-channel within the project mining area are characterised by low permeability massive basalt.

5.3.3 Potentiometric Surface, Recharge, Flow and Discharge

Recharge to the Tertiary basalt occurs via direct rainfall infiltration in areas where the Tertiary basalt outcrops and via seepage from the overlying Tertiary sediments where present.

Regional groundwater flow in the Tertiary basalt is typically parallel with the orientation of the paleo-channels. Within the project mining area and its local surrounds the paleo-channel and groundwater flow are towards the southeast (i.e. towards the centre of the paleo-channel). Flows are locally influenced by mining and water abstraction from the Broadlea water supply borefield.

Discharge occurs as seepage to underlying Permo-Triassic geology and licensed dewatering from the Broadlea water supply borefield.

5.3.4 Groundwater Quality

Groundwater in the Tertiary basalt at the project mining area and its surrounds is of variable quality. Groundwater is typically moderately saline with an average TDS of 1,519 mg/L (MB10).

The salinity of groundwater in the Tertiary basalt is due to solute dissolution into the groundwater as a result of weathering of the rock structure and lengthy residence times. Weathering profiles in the Tertiary basalt may contribute to the salinity at various depths within the basalt. This is further confirmed by stratification of groundwater quality within the Tertiary basalt, supporting the concept that groundwater in the basalt occurs within discrete zone of fractured / vesicular basalt.

5.3.5 Yield and Use

Groundwater yield from the Tertiary basalt in the project mining area and its surrounds is very low (9.0×10^{-3} L/s). This is due to the basalt within the project mining area being dominated by low permeability, low yielding massive basalt (i.e. competent rock with negligible structure or defects that containing groundwater).

The Broadlea water supply borefield targets vesicular/fractured basalts approximately 4 km northeast of the project mining area. The impact of the project on the Broadlea water supply borefield is addressed in Section 6.3.2.

5.4 Triassic Rewan Group

5.4.1 Distribution

The Rewan Group is a thinly interbedded sequence of siltstone, claystone and minor fine-grained sandstone. This unit sub-crops and outcrops across the project mining area where it overlies the Rangal Coal Measures (Figure 6 and Figure 7). The Rewan Group is faulted in the north of the project mining area.

The Rewan Group is uniformly saturated at depth, and may become unsaturated where it outcrops or subcrops above the regional groundwater table east of the project mining area.

5.4.2 Hydraulic Parameters

The measured hydraulic conductivity of the Rewan Group ranges from 1.0×10^{-3} to 1 m/d.

The Rewan Group is recognised as a regional aquitard and acts as a confining unit overlying the Permian sediments. This unit is characterised by low primary porosity and as a result, groundwater movement is controlled by local fracture sets. Where fractures are intersected, this unit shows slightly higher permeability, and conversely, where limited fractures are intersected this unit shows lower permeability associated with the primary porosity. Bulk permeability of this

unit is therefore constrained by the degree of connection between localised fractures. This means that at the regional scale the representative average hydraulic conductivity is expected to be towards the lower end of the values measured by field testing.

5.4.3 Potentiometric Surface, Recharge, Flow and Discharge

The Rewan Group is recharged via direct rainfall infiltration in outcropping areas and via seepage from overlying units (including the Tertiary sediments and Tertiary basalt).

Groundwater flow is towards the southwest and is a subdued reflection of the topography and surface water catchments. Discharge into the underlying Permian sediments is the main discharge mechanism. However, discharge volumes are very low due to the very low rates of groundwater recharge.

5.4.4 Groundwater Quality

Groundwater quality within the Rewan Group at the project mining area and its surrounds is moderately saline (bordering on saline) with an average TDS ranging from 3,381 to 6,061 mg/L (Burton Coal Bore 2 and Swamp Bore 2, respectively). The salinity of groundwater from the Rewan Group reflects the low hydraulic conductivity of this unit, which results in solute contribution from the rock mass to the groundwater due to the longer residence time of groundwater.

5.4.5 Yield and Use

Groundwater yields from the Rewan Group are typically very low. Slightly higher yields can occur where localised fractures are intersected by drilling. Water supply bores tend to have targeted these localised fractures.

A bore census conducted in 2018 confirmed the presence of a single active water supply bore (Swamp Bore 1) screened in the Rewan Group within 5 km of the project mining area (KCB 2018b). The highest recorded yield from this bore is approximately 1.13 L/s (i.e. low yield). The impact of the project on this bore is addressed in Section 6.3.2.

5.5 Permian Sediments

5.5.1 Distribution

The Permian sediments include the Rangal Coal Measures, the Fort Cooper Coal Measures (FCCM) and the Moranbah Coal Measures (Figure 5 and Figure 7). They comprise alternating layers of fine to medium grained sandstone, siltstone and coal, including the target Leichardt seam. The upper profile of the sub-cropping coal measures have been extensively weathered forming a clay cap.

Individual coal seams form the principal water-bearing strata within the coal measures and are therefore typically saturated throughout their full thickness, but may become unsaturated where they outcrop or subcrop above the regional groundwater table. Groundwater storage and movement occurs within the coal seam cleats and fissures and within open fractures that intersect the seams.

The overburden and interburden sediments of the coal measures (above and between the coal seams) comprise hydraulically “tight” and hence very low yielding sediments. These sediments form thick confining aquitards within the coal measures.

The Permian coal measures at the project mining area are fault bound by the Isaac Thrust Fault and the associated fault splay. Faulted strata can exhibit a range of hydraulic characteristics, and in extreme circumstances can act as either a barrier or a conduit to groundwater flow. In this setting, the faults are likely to restrict groundwater flow in the horizontal direction, compared to un-faulted areas for the following reasons:

- Fractures associated with the faults in the vicinity of the project are typically sealed by mineralisation and precipitation.
- The high clay content of the Permian coal measures means that there is a significant likelihood of clay smearing across the fault plane that is likely to reduce the fault permeability by several orders of magnitude compared to the un-faulted areas.
- The coal seams are thin (up to 4.4 m) and represent an extremely small proportion of the overall thickness of the Permo-Triassic sediments (i.e. less than 1 %). There is therefore a greater than 99 % probability that fault displacement has resulted in a coal seam being juxtaposed with less permeable Permian interburden or Rewan Group sediments on the other side of the fault.
- Previous mining experience in the Bowen Basin indicates that coal seams are typically highly compartmentalised by faulting.

The low permeability of the fault zones is therefore likely to restrict groundwater flow, compared to un-faulted areas (OGIA 2016).

The Rangal Coal Measures is underlain by the FCCM. The FCCM is a sequence of sandstone, carbonanceous mudstone, coal and tuffaceous material and is recognised as a regional aquitard.

The FCCM separates the Rangal Coal Measures from the MCM. The FCCM therefore acts to limit the hydraulic interaction between the overlying Rangal Coal Measures and the underlying MCM (and associated coal seams).

5.5.2 Hydrogeological Parameters

Hydraulic conductivity within the Permian sediments is typically associated with secondary porosity through fractures and cleats within the coal seams. The spacing and nature of cleating are the primary controls on hydraulic conductivity within the coal seams. The thick sequences of siltstone and sandstone interburden form confining aquitards within the coal measures.

The hydraulic conductivity of the Leichardt seam ranges from 0.07 to 2.3 m/d, while the other seams in the Permian sediments range from 1.0×10^{-5} to 2 m/d.

The hydraulic conductivity of the Permian sediments overburden/interburden range from 2.0×10^{-5} to 2 m/d. The hydraulic conductivity range in the interburden reflects the high degree of variability in the interburden strata, and includes measurements collected from very tight mudstones and extensively fractured horizons.

Hydraulic conductivity of the Permian sediments also reduces with increasing depth, as a result of increasing lithostatic pressure causing compression of the strata. Regionally, the measured ranges of hydraulic conductivity therefore reflect the depth at which measurements were collected. The regional and local dataset contains a high proportion of relatively shallow measurements due to the practical limitations of collecting deeper measurements.

5.5.3 Recharge, Flow and Discharge

Recharge occurs via rainfall infiltration on localised outcrops of Permian sediments within and to the west of the project mining area, and slow downward seepage from overlying strata. As a result, the groundwater recharge to the Permian sediments is typically very low. Locally, seepage is enhanced by the storage of water within open cut pit voids west of the project mining area. The rate of recharge may also be enhanced where the Permian sediments subcrop against the overlying strata, although the clayey nature of this weathered material will also limit recharge. Overall, the rate of recharge remains very low.

Conceptually, the undisturbed groundwater flow direction in the Permian sediments is towards the southwest.

However, coal mining at surrounding mining operations and CSG production at the Moranbah Gas Project have reduced groundwater pressures in the surrounding coal measures, creating a zone of depressurisation that gradually diminishes with distance from these operations. The project mining area lies within the zone of depressurisation associated with the existing and approved Isaac Plains Complex mining activities. Depressurisation of the coal measures has reduced the potentiometric groundwater surface creating a hydraulic gradient towards the open cut pits. Groundwater movement in the vicinity of the project mining area is therefore a reflection of the depressurisation within the coal measures (i.e. towards these pits).

Groundwater discharge within the vicinity of the project mining area is therefore dominated by groundwater drainage associated with the IPC open cut mine pits. Groundwater discharge into overlying formations is negligible in the vicinity of the project mining area.

5.5.4 Groundwater Quality

Groundwater within the Permian sediments at the project area and its surrounds is moderately saline to (more typically) highly saline, with an average TDS ranging from 2,121 (MB1) to 15,986 mg/L (MB5), reflecting the long groundwater residency times and low permeability of this formation.

5.5.5 Groundwater Yields and Use

Groundwater yields from the Permian sediments are typically low, with a median yield of less than 0.5 L/s.

At the project mining area, yields from the target Leichardt seam and fractured overburden are very low (< 0.5 L/s).

There are no water supply bores targeting the Permian coal measures within 5 km of the project mining area due to the typically low yields and therefore lack of reliable water supply in these sediments.

6 IMPACT ASSESSMENT

6.1 Introduction

The project involves the extension of the approved IPE open cut pits towards the east by approximately 300 m to 600 m (Figure 2). Open cut mining will involve the dewatering of the open cut workings which will result in depressurisation of surrounding strata. The project involves the following activities that have the potential to impact the groundwater regime:

- The extraction of coal through the extension of the already approved IPE open cut pits, with associated depressurisation of the surrounding strata from the proposed extension; and
- Use of hydrocarbons and chemicals which may result in groundwater contamination.

Appendix IV describes how open cut mining, and specifically, the open cut mining associated with the project (i.e. extension of the IPE open cut pits) was represented in the numerical groundwater model.

The following sections provides a detailed assessment of these potential impacts and is structured as follows:

- Section 6.2 presents the predictions of the groundwater modelling, including changes in groundwater levels during mining operations, groundwater take from the surrounding formations and recovery of groundwater levels following mine closure;
- Section 6.3 describes potential impacts to groundwater users and the environment;
- Section 6.4 describes the potential impacts on groundwater quality; and
- Section 6.5 outlines potential cumulative impacts with the adjacent mines and CSG production activities.

6.2 Groundwater Modelling Predictions

6.2.1 Drawdown and Depressurisation During Mining Operations

Figure 15 shows the predicted maximum depressurisation within the target Leichardt seam due to the project development (i.e. extension of IPE open cut pits). The project will locally depressurise the Leichardt seam within the project mining area and its surrounds by up to approximately 100 m (Figure 15). Depressurisation is greatest in the northeastern part of the project mining area, corresponding to the maximum depth of mining (approximately 148 m below ground level), and therefore where the groundwater pressure is greatest.

Depressurisation of the Leichardt seam is generally constrained to the project mining area. The maximum zone of depressurisation in the Leichardt seam is predicted to extend approximately 1.4 km northeast, 1 km southeast, and up to 1.9 km to the east of the project mining area. Along the eastern margin of Pit 4 extension, depressurisation is approximately 100 m within the Leichardt seam. This decreases to 10 m of depressurisation approximately 810 m to the northeast. At the southern project mining area boundary, on the eastern margin of Pit 2, the depressurisation is approximately 70 m, decreasing to 10 m approximately 550 m to the southeast and east.

Depressurisation is generally constrained to the coal seam but is predicted to extend to the upper weathered profile of the Permian and Rewan Group, predominantly in the south of the project mining area. The weathered profile (comprising weathered sediments (colluvium (Qr), distal alluvium (TQa), Suttor Formation (Tu), duricrust: ferricrete (Td/f), shallow weathered Rewan Group (Rr) and shallow weathered Permian sediments (Pwj, Pwt))) is predicted to experience minor localised depressurisation of up to approximately 8 m at the southern project extension mining area boundary and up to 4 m of depressurisation to the west of Pit 4 (Figure 16).

Minor localised depressurisation (up to 4 m) of the Tertiary basalt is predicted to the northeast of the project mining area (Figure 17).

No depressurisation is predicted to occur in the Tertiary sediments or the distant Isaac River alluvium as a result of mining in the project mining area.

6.2.2 Groundwater Take

Modelled groundwater take from the proposed extension to IPE open cut pits is presented in Figure 18.

The modelled rate of groundwater take is controlled by factors such as mining depth and extent, the thickness and hydraulic conductivity of mined and overlying strata, the hydraulic gradients induced by depressurisation and drawdown from nearby mines.

The modelled groundwater take from the project mining area gradually increases as mining progresses east and the Leichardt seam becomes deeper. The modelled groundwater take peaks at approximately 19 L/s (0.6 GL per annum) at the end of mining operations.

The modelled groundwater take represents the theoretical volume of groundwater that could be removed from the groundwater regime. The actual volume of groundwater pumped from the mining area will be less than that predicted by the numerical model, as a component of the groundwater will be lost to wetting of surfaces, evaporation from the pit wall surfaces and retained moisture within the coal. The groundwater take presented in Figure 18 does not account for the above mentioned losses that will occur when converting groundwater take to mine dewatering rates.

6.2.3 Post-Closure Groundwater Recovery

The recovery of groundwater levels after the cessation of mining was also predicted by the model. Appendix IV outlines the development of the post mining groundwater modelling. The post-closure simulation of groundwater levels is based on the recovery of groundwater levels following the development of the IPU. IPU is scheduled to commence development following the development of the project (i.e. it is currently deferred), and is anticipated to take nine years to complete. The IPU has been included in the post-closure simulation of groundwater conditions for the project because the IPU development will influence the starting condition of post-closure groundwater level across the project area.

The modelling results indicate that mined areas will gradually fill, reducing the hydraulic gradient and magnitude of depressurisation immediately surrounding the project. Steady-state water level conditions is predicted to be established after approximately 500 (N1 pit and S2 pit) to 700 years

(E5 pit, E4/4N pit and E2/3 pit) following the cessation of mining. Figure 19 presents the post-closure water level within each of the pit voids overtime.

Due to the varying sizes of the pit voids across the IPC, the evaporation rates from the different pit voids will vary; and along with the hydraulic connection between the various pit voids through the hydrostratigraphic units, a range of final steady-state pit void water level elevations across the various pit voids is predicted. These elevations are summarised in Table 6.1.

An assessment of the source / sink trigger elevation for each of the pit void was undertaken. This trigger elevation represents the "spill point" for each pit void, where any water level elevation above the trigger elevation represented discharge from the pit void to the downstream environment, while any water level elevation below the trigger elevation resulted in localised groundwater flow towards the pit void. These predicted source / sink trigger elevations for each pit void are also provided in Table 6.1.

Table 6.1: Post-Closure Steady-State Pit Void Water Levels

Pit Void	Post-Closure Steady-State Void Water Elevation		Pit Void Source / Sink Trigger Elevation
	Base Case Climate Scenario	Climate Change Climate Scenario	
N1	173 mAHD	170 mAHD	217.0 mAHD
S2	174 mAHD	170 mAHD	213.8 mAHD
2/3	191 mAHD	189 mAHD	232.0 mAHD
4/4N	191 mAHD	188 mAHD	229.6 mAHD
5	191 mAHD	187mAHD	228.5 mAHD

Although the post-closure steady-state pit void water levels in Table 6.1 range from 173 to 191 mAHD, these levels are all below the predicted pit void source / sink trigger elevations, therefore, the area within the vicinity of the IPC pits would act as a regional groundwater sink, with regional groundwater flows towards the IPC. Locally, groundwater flow between pits would occur predominantly from the eastern pit voids (E2/3, E4, E5) to the western pit voids (S2, N1) as steady-state pit void water level elevations in the western pits are approximately 17.5 m lower than the eastern pit voids. Post-closure groundwater level contours within the vicinity of the pit voids, after 854 years since the cessation of mining, are presented in Figure 20 and highlight regional groundwater sink within the vicinity of IPC and the localised groundwater gradient from the eastern pit voids to the western pit voids. The transfer of water between the pits is not considered to have any discernible impacts on groundwater receptors within the vicinity of the project as the steady-state pit water elevations are predicted to be below the source / sink trigger elevations of the pit voids (between 37.5 m to 44 m below source / sink trigger), and therefore, groundwater migration away from the IPC area is not predicted.

The rainfall and evaporation patterns for a future climate scenario, representative of a predicted change in climate patterns (WRM 2020), was simulated for the IPEE post-closure groundwater level recovery. The predicted change in climate patterns represent a decrease in rainfall and an increase in evaporation. Model results for the climate change scenario are provided in Table 6.1 The incorporation of these climate patterns into the post-closure simulation indicates that the groundwater system will display similar characteristics to the base case post-closure simulation (i.e. regional groundwater sink within the vicinity of the IPC). However, due to the higher

evaporation rates and lower rainfall rates associated with the predicted climate change patterns, the steady-state pit void water elevations are predicted to be lower than the predicted base case scenario levels.

6.3 Project Impacts

This section describes the operational and post closure impacts of the project on:

- Groundwater resources;
- Groundwater users; and
- Surface water features.

Prediction and assessment of cumulative impacts is included in Section 6.5.

The groundwater assessment also investigated potential impacts on groundwater quality due to the use of hydrocarbons and chemicals. These potential impacts are discussed in Section 6.3.4.2.

6.3.1 Impacts on Groundwater Resources

As discussed in Section 2.2, groundwater resources within the project mining area and its surrounds are located within the Isaac Connors GMA. The Isaac Connors GMA is managed under the Water Plan (Fitzroy Basin) and comprises two groundwater units. Groundwater Unit 1 includes alluvial aquifers and Groundwater Unit 2 comprises all other sub-artesian aquifers.

As discussed in Sections 3.4 and 4.2, there is limited alluvium in the vicinity of the project mining area (constrained to the water course and adjacent edges of Billy's Gully), however, the groundwater associated with this alluvium is identified to be a perched system and therefore not connected to the regional groundwater system. Beyond the alluvium in Billy's Gully, the next closest alluvium is in the Isaac River, approximately 6.5 km to the southwest. There is no drawdown within alluvium as a result of the project. There will be no groundwater take from alluvium (i.e. Groundwater Unit 1) and therefore, the project will not impact on this groundwater resource.

Groundwater depressurisation is limited to the Permian sediments (and to a lesser extent the Rewan Group aquitard and Tertiary basalt), which form part of Groundwater Unit 2. Figure 18 shows the predicted groundwater take associated with the project, and hence, Groundwater Unit 2. The project is predicted to result in a total groundwater take of up to approximately 1,959 ML from Groundwater Unit 2 over the life of the project.

6.3.2 Impacts on Groundwater Users

A bore census was carried out in 2018 to identify water supply bores surrounding the IPC that could potentially be impacted by the project (KCB 2018b). The census drew upon information gathered through consultation with surrounding landholders as part of the IPE Project groundwater assessment, advice from the proponent, a search of the DNRME groundwater database and a recent detailed bore assessment.

The bore census was targeted towards bores and properties that could potentially be impacted due to their proximity to mining activities. The local hydrogeology was also taken into account in

planning the bore census. The bore census included a conservative search radius of 5 km beyond the boundary of the project mining area.

The bore census indicated that groundwater use is typically opportunistic and dispersed over a wide area due to the generally low yields and access to alternative supplies (i.e. water supply pipelines). Water quality is variable, but can be suitable for stock watering.

The bore census confirmed the presence of one water supply bore (Swamp Bore 1) (Figure 9). Swamp Bore 1, located approximately 2 km east of the project mining area, is screened in the Rewan Group. As discussed in Section 6.2.1, the project is not predicted to result in any depressurisation of the Rewan Group in the vicinity of Swamp Bore 1. As a result, this bore is unlikely to be affected by the project.

The proponent currently holds a make good agreement with the landholder of this property as part of the approval of the existing mining tenure. The potential impacts to the water supply bore are managed under this agreement.

The Broadlea water supply borefield is located to the northeast of the project mining area and targets the Tertiary basalt aquifer. As shown in Figure 17, the project is not predicted to result in any depressurisation of the Tertiary basalt in the vicinity of these bores and therefore the Broadlea water supply borefield is unlikely to be affected by the project.

6.3.3 Impacts on Surface Drainage

Figure 4 shows the drainage setting of the project.

The project mining area is bounded by Smoky Creek to the north and Billy's Gully to the south. These creeks are ephemeral and are characterised by short duration, surface water flows that are typically restricted to periods during and immediately after rainfall events. This is consistent with observations made during field investigations in 2018 (Appendix VI). This is also supported by the surface water assessment completed as part of this PER (WRM 2020), which indicates no perennial flows in the vicinity of the project mining area.

The groundwater table is currently located approximately 10 m to 15 m below the bed of Smoky Creek to the north of the project mining area, and approximately 10 m below the bed of Billy's Gully to the south (Figure 12). Further to the east along Smoky Creek, groundwater rises to approximately 5 m below the bed of Smoky Creek. Further to the west down Smoky Creek, and adjacent to the existing IPM open cut pits, groundwater deepens to approximately 50 m below the bed of Smoky Creek and approximately 25 m below the bed of Billy's Gully. Existing open cut pits have therefore reduced the elevation of the groundwater table by approximately 35 m and 15 m in these areas, respectively. In addition, stable isotope analysis completed as part of GDE study across the project area (3D Environmental 2020) identified "there is no linkage between groundwater and surface water in the stream channel and baseflow is not supported".

The separating depth between the bed of these creeks and the groundwater table means that there is no direct interconnection between the groundwater table and surface water flows in this area. Groundwater does not provide baseflow to surface waters in the vicinity of the project mining area.

Drawdown on the groundwater table will therefore not impact the overlying surface drainage features.

6.3.4 Impacts on Groundwater Dependent Assets

6.3.4.1 Groundwater Dependent Ecosystems

A GDE assessment was completed across the project area (3D Environmental 2020) (Section 3.5.1), which identified no GDEs across the majority of the project area, including along Smoky Creek, but some GDEs along Billy's Gully. In addition, minor alluvium was also identified within and adjacent to the Billy's Gully water course, which was identified to be the water source to the GDE.

The groundwater identified within the alluvium of Billy's Gully is not considered to be a significant aquifer due to the ephemeral nature of this groundwater and the system being perched above the regional groundwater system. Groundwater bores located within the vicinity of the Billy's Gully alluvium (MB4a and MB4b) are screened across the Tertiary sediments, which are stratigraphically underlying the alluvium. Groundwater level records from these bores identify the water levels to be 8 to 10 m below the base of the alluvium, which groundwater level hydrographs showing limited variability to seasonal fluctuations (Appendix III). These water level records / trends support the interpretation of the alluvium as a localised perched ephemeral groundwater system.

Groundwater quality records from groundwater sourced from the Tertiary sediments, within the vicinity of Billy's Gully, indicate the groundwater to be highly saline to brine (Table 4.2). The GDE assessment (3D Environmental 2020) identified that the condition of the vegetation in Billy's Gully suggests that the GDEs are not utilising the saline groundwater from the Tertiary sediments, and are therefore utilising water from the perched alluvium, which is not in hydraulic connection with the underlying regional groundwater system.

The GDEs in Billy's Gully are sourcing water from the perched groundwater in the alluvium which is identified to be not in connection with the regional groundwater system; therefore, any drawdown in the underlying regional groundwater system as a result of the IPEE development will not results in drawdown in groundwater in the alluvium. Therefore, no discernible impact to the GDEs in Billy's Gully is predicted as a result of the project development. Nevertheless, annual monitoring of riparian vegetation within the project area will be conducted to assess vegetation health.

6.3.4.2 Impacts on Stygofauna

A stygofauna pilot study of the IPEE (frc environmental 2020) identified a single *stygoxene* taxon from two bores. This study interpreted that based on the identify stygofauna community this, and the characteristics of the groundwater regime, the stygofauna community for the Project area was assessed as having low environmental value.

Taking this assessment environmental value into account, a risk-based impact assessment on the stygofauna community, as a result of the IPEE development, was undertaken. The assessment include the risks associated with a number of potential sources of impacts, which identified a low risk for each of these.

6.4 Impacts on Groundwater Quality

The project is an extension of the existing IPE mining area that will be operated as part of the approved IPC. There is some additional linear infrastructure associated with the extension (e.g. haul roads, powerline, clean water diversion), sediment dams, laydown areas and a modular extension to the existing CHPP. The project will utilise existing, approved infrastructure at the IPC for coal haulage, mine water management, processing coal by the CHPP and the storage of rejects associated with coal processing within an existing void at IPM. There will be no changes to other existing, approved infrastructure at IPC as a result of the extension. IPC conducts activities in accordance with management plans required under the approved environmental authority and associated water licence, as well as site environmental management practices to prevent contamination of groundwater, or to manage contamination (e.g. from accidental releases of contaminants) should this occur.

The storage of hydrocarbon and chemicals will continue to be managed in accordance with the existing IPC management practices, including the use of bunding and immediate clean-up of spills which are standard practice and a legislated requirement at mine sites that will prevent the contamination of the groundwater regime.

Given the limited activities proposed as part of the extension, and the controls that will be adopted, the project has a very limited potential to give rise to groundwater contamination as a result of hydrocarbon and chemical contamination. Therefore, the potential for the operational extension activities to impact on groundwater quality is therefore limited to accidental releases of hydrocarbons or chemicals during operations.

At the cessation of mining, groundwater and surface water inflow into the pit voids will result in the collection of water within the voids. The water levels within the pit voids will equilibrate over time at an elevation below the source / sink trigger elevation for each pit void (Section 6.2.3). Therefore, the regional groundwater flow will be towards the IPC pit voids, driven by evaporation from the pit void water level surface. This evaporation will result in the increase in salinity of water within the pit voids over time, details of which are provided in the surface water assessment report for the PER (WRM 2020). However, due to the predicted post-closure pit void water level elevations, the saline water within the pit voids will be contained within the IPC area and will not migrate away from the project. Locally, the transfer of water from the eastern pit voids to the western pit voids will occur due to the hydraulic gradient difference between the pit voids (Section 6.2.3). However, as the predicted equilibrated water level within the western pit voids will be the lowest groundwater elevation in the region, migration of the saline water away from the pit voids is not predicted to occur. Therefore, no discernible impacts on groundwater quality are predicted as a result of the post-closure condition of the project.

6.5 Cumulative Impacts

The existing and approved future mines and CSG operations in the vicinity of the project mining area are shown on Figure 1 and include:

- The existing and approved future open cut mining areas at the IPC adjoining the project mining area;
- The Grosvenor Mine adjacent to the IPC;

- The Moranbah North Mine located northwest of the project mining area;
- The Burton, Broadlea and Ironbark No. 1 Mines located north of the project mining area;
- Carborough Downs Mine located east of the project mining area;
- Millennium and Poitrel Mines located southeast of the project mining area;
- The Moranbah South Project and Caval Ridge Mine located southwest of the project mining area; and
- The Moranbah Gas Project.

The potential impacts of these operations on the groundwater environment in the region has been considered as part of the numerical groundwater model prediction in relation to potential cumulative impacts they may have with the project.

The numerical groundwater model considered all approved future mining activities at the IPC, Grosvenor Mine, Moranbah North Mine, Burton Mine, Broadlea Mine, Carborough Mine, Poitrel Mine and Millennium Mine, Moranbah South Project, Caval Ridge Mine as well as Arrow Energy's CSG production activities. These are the nearest significant operations or projects to the project mining area and include all operations which could potentially have cumulative drawdown impacts with the project.

Ironbark No.1 Mine and Caval Ridge Mine are located at significant distances from the project mining area and well beyond limit of predicted depressurisation from the project. These distant and hydraulically disconnected operations are unlikely to add any significant depressurisation to the extensively depressurised groundwater regime at the project mining area. Ironbark No.1 Mine and Caval Ridge Mine are therefore unlikely to give rise to cumulative impacts with the project.

The numerical groundwater model was used to assess the cumulative groundwater impacts associated with the project during mining and post closure. The maximum predicted extents of depressurisation for the project and the relevant operations were compared in order to determine whether any areas could potentially be cumulatively impacted. The extent of cumulative impacts will be less than this extent at all other times during and post-mining and this approach therefore provides a conservative assessment of the potential worst-case cumulative groundwater impacts.

The project will not result in drawdown in the Isaac River alluvium or Tertiary sediments and therefore will not contribute to cumulative impacts in these formations.

Figure 21 to **Figure 23** show the maximum predicted extent of the cumulative groundwater depressurisation (i.e. the area where depressurisation due the project could overlap with depressurisation from other relevant operations) within the extent of drawdown associated with the project for the Leichardt seam, Tertiary basalt and weathered Permo-Triassic sediments. Figure 21 to **Figure 23** also show the percentage of cumulative depressurisation that is attributable to the project. Total cumulative drawdown, based on development of the project and surrounding approved mining and CSG projects, for the Leichardt seam, Tertiary basalt and weathered sediments (comprising colluvium (Qr), distal alluvium (TQa), Suttor Formation (Tu), duricrust: ferricrete (Td/f), shallow weathered Rewan Group (Rr) and shallow weathered Permian sediments (Pwj, Pwt)) are provided in Figure 24 to Figure 26. These predicted cumulative drawdown results indicate that the cumulative drawdown within the vicinity of IPC, for each of

the presented hydrostratigraphic units, is a result of the existing, approved and proposed (i.e. the Extension) mining activities at IPC. Limited contribution to cumulative drawdown within these units from surrounding projects/mines (e.g. Moranbah North, Carborough Downs) is predicted due to these projects/mines targeting deeper coal seams (e.g. Moranbah Coal Measures) or being a large distance away such that contribution to cumulative drawdown is not discernible.

In the Leichardt seam, the project contributes up to 88 % of the total cumulative depressurisation within the extent of the project mining area and its surrounds to the north, east and south (Figure 21). In these areas, the project mining area is located at a greater depth than the surrounding open cut mining operations of the IPC. To the west of the project mining area, the project is responsible for less than 25 % of the total depressurisation in the Leichardt seam due to the depressurisation contribution from the approved IPE open cut pits (Pits 1 to 5).

In the upper weathered profile (includes Tertiary sediments, weathered Tertiary basalt, weathered Rewan Group, weathered Permian sediment), the project contributes to approximately 66 % of the total cumulative depressurisation within a localised zone at the southern extent of the project mining area (Figure 22). To the north and south of the project mining area, the project contribution to the total cumulative depressurisation is approximately 30 %.

In the Tertiary basalt, the project contributes up to approximately 63 % of the total cumulative depressurisation to the east of Pit 4 adjacent to the project mining area (**Figure 23**). The zone of predicted cumulative depressurisation associated with the project does not include any groundwater users, including the Broadlea Borefield located to the east of the project area.

The cumulative depressurisation within the weathered profile is predicted to extend below Smoky Creek, with the project contribution of approximately 35% of the cumulative depressurisation. In Billy's Gully the cumulative depressurisation contribution from the project in the weathered profile is approximately 15%. However, it has been previously identified that due to the depth of separation between the groundwater table and the bed of Smoky Creek and Billy's Gully there is not hydraulic connection between the groundwater and surface water systems (Section 6.3.3 and 6.3.4). Therefore, the project is not predicted to contribute to cumulative impacts on these creeks. Furthermore, it has been previously identified that the perched ephemeral groundwater in the Billy's Gully alluvium is not hydraulically connected with the regional groundwater system, therefore, there is no discernible cumulative impacts predicted for this perched groundwater system or the associated GDEs.

In addition to the above operations that were captured in the cumulative impacts prediction of the numerical groundwater model, other future operations within the wider vicinity of the project area that are not approved or are distant (i.e. Isaac Downs, Winchester South, Olive Downs and Eagle Downs) may potentially contribute to the cumulative impacts on the groundwater system. Conceptually, should these operations contribute to the cumulative drawdown across the project area, the incremental project drawdown (i.e. drawdown as a result of the IPEE only), and the contribution of the project drawdown to the cumulative drawdown, would be less in comparison to what has been provided in this report (Figures 15, 16, 17, 21, 22 and 23). Therefore, the project drawdown impacts on the groundwater system, and the contribution of project drawdown to the cumulative drawdown, provided in this assessment is considered conservative.

7 GROUNDWATER MONITORING AND MANAGEMENT

The IPC operates an extensive groundwater monitoring network in accordance with the Isaac Plains Complex EA. The EA groundwater monitoring network comprises 11 monitoring bores located on the IPC MLs and its immediate surrounds (**Figure 27**). A groundwater monitoring and management plan for this network is included in Appendix IV.

The purpose of the EA groundwater monitoring network is to monitor groundwater levels and quality in the Permian sediments, Rewan Group, Tertiary basalt, and Tertiary sediments in response to mining. The existing EA groundwater monitoring network includes four bores (MB1, MB3, MB4B and MB5) within the existing IPE project mining area. Three monitoring bores will also be decommissioned with the extension to IPE (MB8, MB9, and MB10).

To ensure that the existing groundwater monitoring network is suitable for monitoring the effects of the project on the groundwater regime throughout the life of the project, replacement monitoring bore locations have been selected to monitor key formations. The status of bores within the existing groundwater and location of proposed replacement monitoring bore locations is summarised in Table 7.1 and shown in **Figure 27**.

Table 7.1: IPC Groundwater Monitoring Network – Bore Status and Replacement Sites

ID	Easting (GDA94 Z55)	Northing (GDA94 Z55)	Screened Lithology	Status
MB1	618793	7572214	Rangal Coal Measures	Decommissioned
MB2	619074	7573137	Rangal Coal Measures	Existing
MB3	619047	7568473	Rangal Coal Measures	Decommissioned
MB4B	619740	7567253	Tertiary Sediments	To be decommissioned, previous MB4a replacement
MB5	618507	7570878	Rangal Coal Measures	Decommissioned
MB8	619105	7571149	Rangal Coal Measures	To be decommissioned, previous MB5 replacement
MB9	620368	7568049	Basalt and Rangal Coal Measures	To be decommissioned, previous MB3 replacement
MB10	620368	7568046	Basalt	To be decommissioned
MB11	618832	7571924	Tertiary Sediments	Existing, Dry
Swamp Bore 2	621518	7568790	Rewan Group	Existing
Burton Coal Bore 2	620383	7573599	Rewan Group	Existing
MB12	619210	7572000	Rangal Coal Measures	Replace MB1
MB13	619367	7571035	Rangal Coal Measures	Replace MB8
MB14	620263	7571132	Tertiary Basalt	Replace MB10
MB15	620633	7568080	Rangal Coal Measures	Replace MB9
MB16	620670	7568599	Tertiary Sediments	Replace MB4B

In accordance with the requirements of the IPC EA, the following monitoring will be undertaken at the EA groundwater monitoring bores:

- Groundwater levels will be recorded on a quarterly basis, which will enable natural groundwater level fluctuations (such as seasonal responses to rainfall) to be distinguished from potential water level impacts due to depressurisation resulting from mining activities; and
- Groundwater quality monitoring will be undertaken on a quarterly basis to enhance the existing baseline dataset available prior to commencement of the project. This will be used to detect any changes in groundwater quality during- and post-mining. Water quality

samples will be analysed for physico-chemical parameters including pH, electrical conductivity, total dissolved solids, total suspended solids, alkalinity, hardness, major ions (Ca, Mg, Na, K, Cl and SO_4), metals and metalloids (Al, Ag, As, Fe, Hg, Mo, Sb Se, Cu, Cd, Pb, Ni and Zn) and total petroleum hydrocarbons.

The groundwater monitoring data will be reviewed annually, and the groundwater monitoring program revised, as necessary.

8 RISK ASSESSMENT

An environmental risk assessment has been conducted for the proposed project activities in relation to potential impacts on groundwater resources. Using the information presented in previous sections, and the likelihood of occurrence and the consequence of risk tables presented below (Table 8.1 and Table 8.2), the significance of the risks was identified using Table 8.3. This approach is consistent with AS/NZS 4360:2004: Risk Management and AS/NZS ISO 31000:2009 Risk Management – Principals and Guidelines (AS/NZS 2009; 2004), with environmental consequence adapted from Ford et al. (2016). The significance of the risks is described below:

- **High significance:** Significant risk with high likelihood of impact. The risk is considered unacceptable or intolerable and may be irreversible or persistent;
- **Moderate significance:** Level of risk is not acceptable with moderate severity with impacts persisting over time but that can be mitigated;
- **Low significance:** The risk is low with any impacts short in duration and reversible; and
- **Insignificant:** An insignificant risk and any potential impacts are acceptable, and no risk treatment is necessary with the impact restricted to the immediate area of activity.

Table 8.1: Likelihood of Risk (Criteria)

Rank	Likelihood	Description
1	Highly unlikely	An event that has not previously been experienced in the industry but may occur in exceptional circumstances
2	Unlikely	An event not likely to occur in the industry over 10 years
3	Possible	An event that may occur in the industry over 10 years
4	Likely	An event likely to occur more than once a year in the industry
5	Very likely	A common event that is likely to occur in the industry many times per year

Table 8.2: Consequence of Risk (Criteria)

Magnitude	Description
Negligible	Minimal impact on ecosystem; contained on mining lease, and / or reversible in 1 year
Low	Moderate impact on ecosystem; contained on mining lease, and/ or reversible in 1 to 5 years
Moderate	Significant impact on ecosystem; impact contained on mining lease, and /or reversible in ~10 years
High	Significant harm or irreversible impact (for example to World Heritage area); widespread, catchment area, long term, greater than 10 years
Severe	Incident(s) due to unforeseen circumstances causing significant harm or irreversible impact (for example to World Heritage area); widespread, long term

Table 8.3: Significance of Risk (Criteria)

		Likelihood				
		Highly Unlikely (1)	Unlikely (2)	Possible (3)	Likely (4)	Highly Likely (5)
Consequence	Severe	Insignificant	Low	High	High	High
	High	Insignificant	Low	Moderate	High	High
	Moderate	Insignificant	Low	Moderate	Moderate	Moderate
	Low	Insignificant	Low	Low	Low	Low
	Negligible	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant

The results of the risk assessment are detailed in Table 8.4.

Table 8.4: Environmental Risk Assessment – Key Potential Impacts (Groundwater)

Issue	Potential Impact	Pre-Mitigated Risk Rating			Management Controls	Residual Risk Rating		
		Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
Aquifer depressurisation due to coal extraction and overburden removal	Could lead to a decline in groundwater level / pressure at water bores, reducing water availability and potentially impacting groundwater water supply bores	2	High	Low	▪ Numerical groundwater modelling predicts potential drawdown impacts and allows for the establishment of monitoring bores as an early warning / trigger system ▪ All groundwater inflows managed within mine water system, approved under EA (refer to surface water assessment report (WRM 2020)) ▪ Final void water levels will not exceed pit void source / sink trigger elevations ▪ Agreement in place with local landholder for the provision of water as a result of impacted bore ▪ Groundwater at IPC will continue to be monitored and managed in accordance with the approved GMMP ▪ IPC Waste Management Plan, spill response procedure, Water Management Plan	2	Low	Low
	Reduction in groundwater head resulting in a reduction of groundwater availability, potentially causing degradation of GDEs	2	High	Low		1	High	Insignificant
	Reduction in groundwater head resulting in a reduction of groundwater availability, or overburden removal, potentially impacting stygofauna	3	Low	Low		3	Low	Low
	Reduction of baseflow to Smoky Creek and Billy's Gully, potentially affecting downstream users	1	Moderate	Insignificant		1	Moderate	Insignificant
Operational and construction activities	Localised incidental mining activities have the potential to impact shallow groundwater systems, such as fuel spills or improper storage of chemicals	2	Moderate	Low		2	Low	Low

Issue	Potential Impact	Pre-Mitigated Risk Rating			Management Controls	Residual Risk Rating		
		Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
	Groundwater recharge from final voids	1	High	Insignificant		1	High	Insignificant
	Post-closure intra-pit void flux transfer impacts water resources	1	Moderate	Insignificant		1	Moderate	Insignificant

9 CONCLUSIONS

The key conclusions of the groundwater assessment are as follows:

- Approved mining operations in the region have resulted in extensive regional depressurisation within the Permo-Triassic sediments, Tertiary basalt and Tertiary sediments and the project has negligible potential for additional significant impact on the groundwater regime.
- The project will not impact surface waters or alluvial aquifers because:
  - There is limited alluvium present in the vicinity of the project mining area, and the identified alluvium is not in hydraulic connection with the regional groundwater system.
  - There is no groundwater contribution to surface water flows in creeks within the project mining area and its surrounds.
- There are no groundwater users predicted to be affected by groundwater depressurisation and therefore no significant impacts on groundwater users are predicted.
- Potential GDEs are interpreted to be sourcing water from shallow, perched ephemeral groundwater associated with Billy's Gully. This groundwater is not in hydraulic connection with the regional groundwater system and therefore no significant impacts on these receptors are predicted.
- The zone of predicted cumulative depressurisation does not include any groundwater users or other features impacted by the project.
- There is a very low potential for groundwater contamination as a result of the project.

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11 ABBREVIATIONS

BoM: Bureau of Meteorology

DES: Department of Environment and Science

CHPP: Coal Handling and Preparation Plant DNRME: Department of Natural Resources, Mines and Energy

EA: Environmental Authority

EAR: Environmental Assessment Report

EC: Electrical Conductivity

EIS: Environmental Impact Statement

EPP Water: Environmental Protection (Water) Policy 2009

GMA: Groundwater Management Area

IESC: Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development

Kh: lateral hydraulic conductivity

Kv: vertical hydraulic conductivity

mAHD: Metres (above) Australian Height Datum

mbGL: Metres below ground level

Mtpa: Million tonnes per annum

ROM: Run of Mine

RMS: Root Mean Squared

TDS: Total Dissolved solids

The Project: Isaac Plains East Extension

Water Act: *Water Act 2000*

12 GLOSSARY

Alluvium: Unconsolidated sediments (gravel/sand/silt/clay) transported by water (i.e. deposits within a stream channel or floodplain).

Aquifer: Permeable earth material such as porous sediments or fractured hard rock, saturated with groundwater. The permeability should be such that it is capable of conducting and yielding usable quantities of groundwater to a borehole(s) and / or springs. An aquifer is 'a geological formation which has structures or textures that hold water or permit appreciable water movement through them'.

Aquitard: A confining bed that retards, but does not completely stop the flow of water to or from an adjacent aquifer. Although it does not readily release water to boreholes or springs, it may function as a storage chamber for groundwater.

Calibration: The process by which independent variables (e.g. hydraulic conductivity) within a model are varied in order to match a dependent variable (e.g. measured groundwater level within a monitoring bore).

Confined aquifer: An aquifer which is overlain by a confining layer of low permeability. The groundwater is confined under pressure greater than atmospheric pressure such that if the aquifer is penetrated the water level may rise above the top of the aquifer.

Confining layer/unit: Geologic material with little permeability or hydraulic conductivity.

Contamination: The introduction into the environment of any substance by the action of man.

Dewatering: The process of removing water from an open pit or underground mine, or from the surrounding rock or non-lithified materials.

Drawdown: Lowering of the water table within an unconfined aquifer, or the potentiometric surface within a confined aquifer caused by an induced stress on the groundwater system (e.g. pumping).

Geology: The study of the earth, its history and the changes that have occurred or are occurring and the rocks and non-lithified materials of which it is composed and their mode of formation and transformation.

Groundwater: The water in the aquifer; saturated zone below the water table.

Hydraulic conductivity: Describes the ease with which water can move through pore spaces or fractures. It depends on the intrinsic permeability of the material and on the degree of saturation. Saturated hydraulic conductivity, Ksat, describes water movement through saturated media.

Hydraulic gradient: The change in hydraulic head or water level over a distance.

Hydraulic head: The height above a datum (such as sea level) of the column of water that can be supported by the hydraulic pressure at a given point in a groundwater system.

Lithology: The systematic description of sediment and rocks, in terms of composition, texture and internal structure.

Model: A formalised expression of a theory, event, object, process or system used for prediction or control; an experimental design based on a casual situation that generates observed data. A model can be viewed as a selective approximation which by the elimination of incidental detail, allows some fundamental, relevant or interesting aspect of the real world to appear in a generalised form.

pH: The negative logarithm to the base 10 of the hydrogen ion activity [H^+] in solution.

Recharge: The addition of water to the saturated zone, either by the downward percolation of precipitation or surface water and/or the lateral migration of groundwater from adjacent aquifers.

Saturated zone: The part of the geological stratum in which all the voids are filled with water under pressure greater than that of the atmosphere.

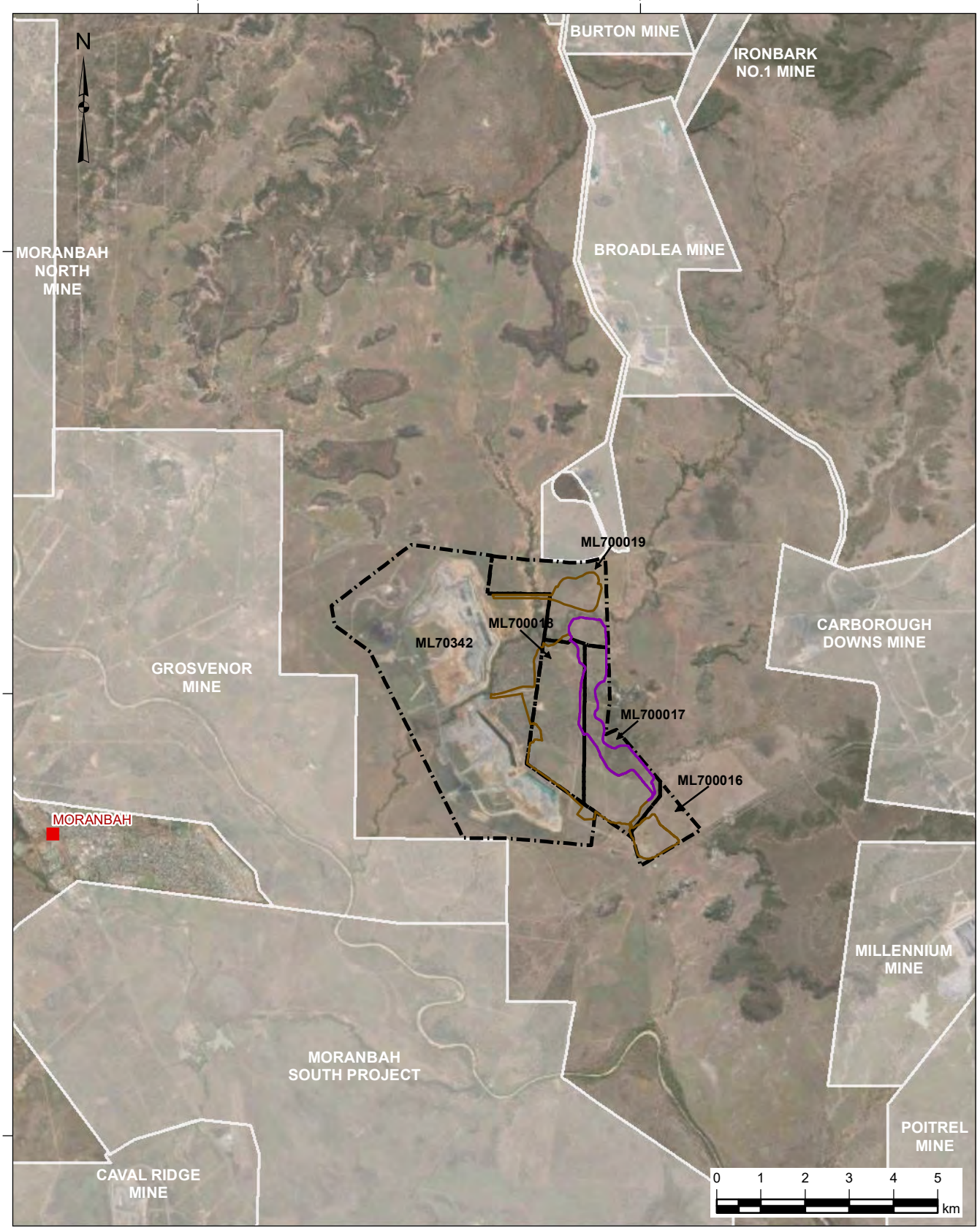
Specific Storage: Volume of water released form storage from a unit volume of aquifer, per unit decline in hydraulic head.

Specific Yield: The ratio of the volume of water a rock or spoil will yield by gravity drainage to the volume of the rock or soil. The upper bound of a specific yield value for a given material is equal to its porosity.

Storativity: The storage coefficient or storativity is a measure of the volume of water per volume of aquifer released as a result of a change in head. For confined aquifers, the storage coefficient is equal to the product of the specific storage and aquifer thickness.

Unconfined aquifer: An aquifer whose upper surface (water table) is free to fluctuate.

Water Table: The top of an unconfined aquifer, where the aquifer is fully saturated and the water pressure is equal to atmospheric pressure. Usually measured in metres below ground level or below top of casing.



Legend

- Town
- Isaac Plains Complex Mining Lease
- Approved IPE Outline
- IPE Pit Extension

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:125,000

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL

Klohn Crippen Berger

PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
PROJECT SETTING

PROJECT No. D10175A08

FIG No. FIGURE 1

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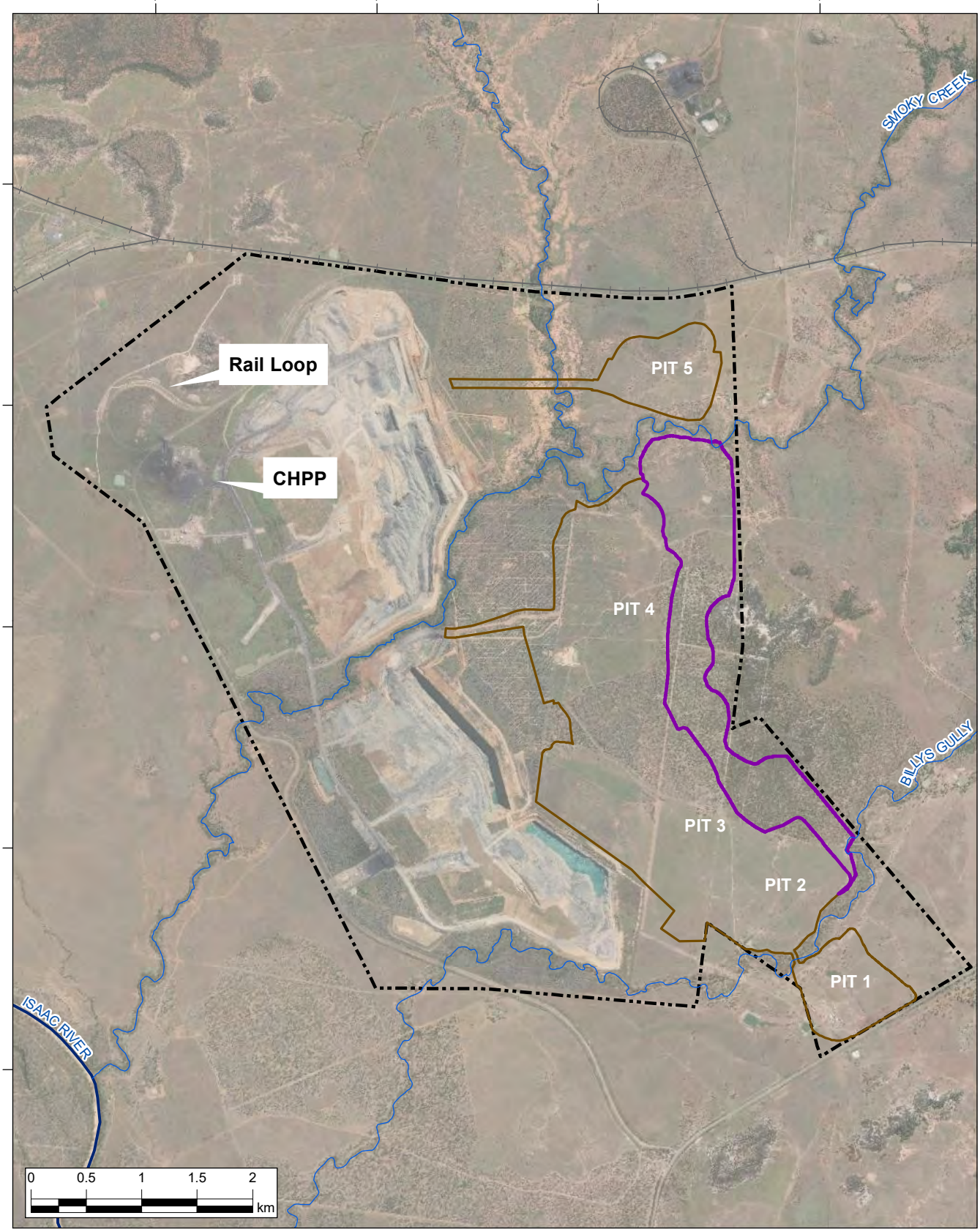

Legend

- River
- Creek
- Railways
- Isaac Plains Complex Mining Lease
- Approved IPE Outline
- IPE Pit Extension

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:50,000

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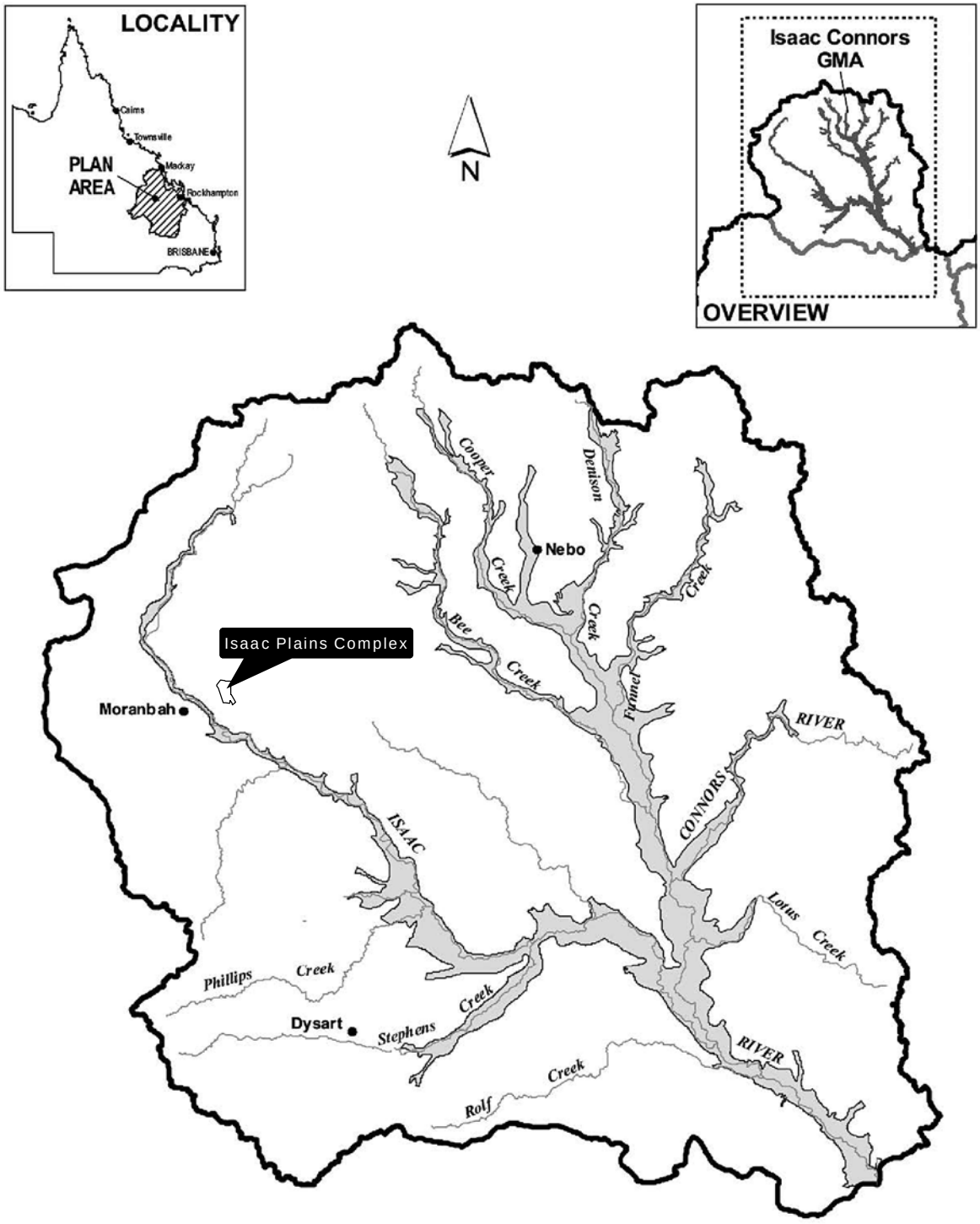
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
PROJECT LAYOUT

PROJECT No. D10175A08

FIG No. FIGURE 2

30/06/2020, EMangos, Z:\D\BNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_02_ProjectLayout.mxd



LEGEND

- Issac Connors Groundwater Management Area (GMA)
- Issac Connors Groundwater Unit 1

(source: Water Plan (Fitzroy Basin) 2011)

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Klohn Crippen Berger

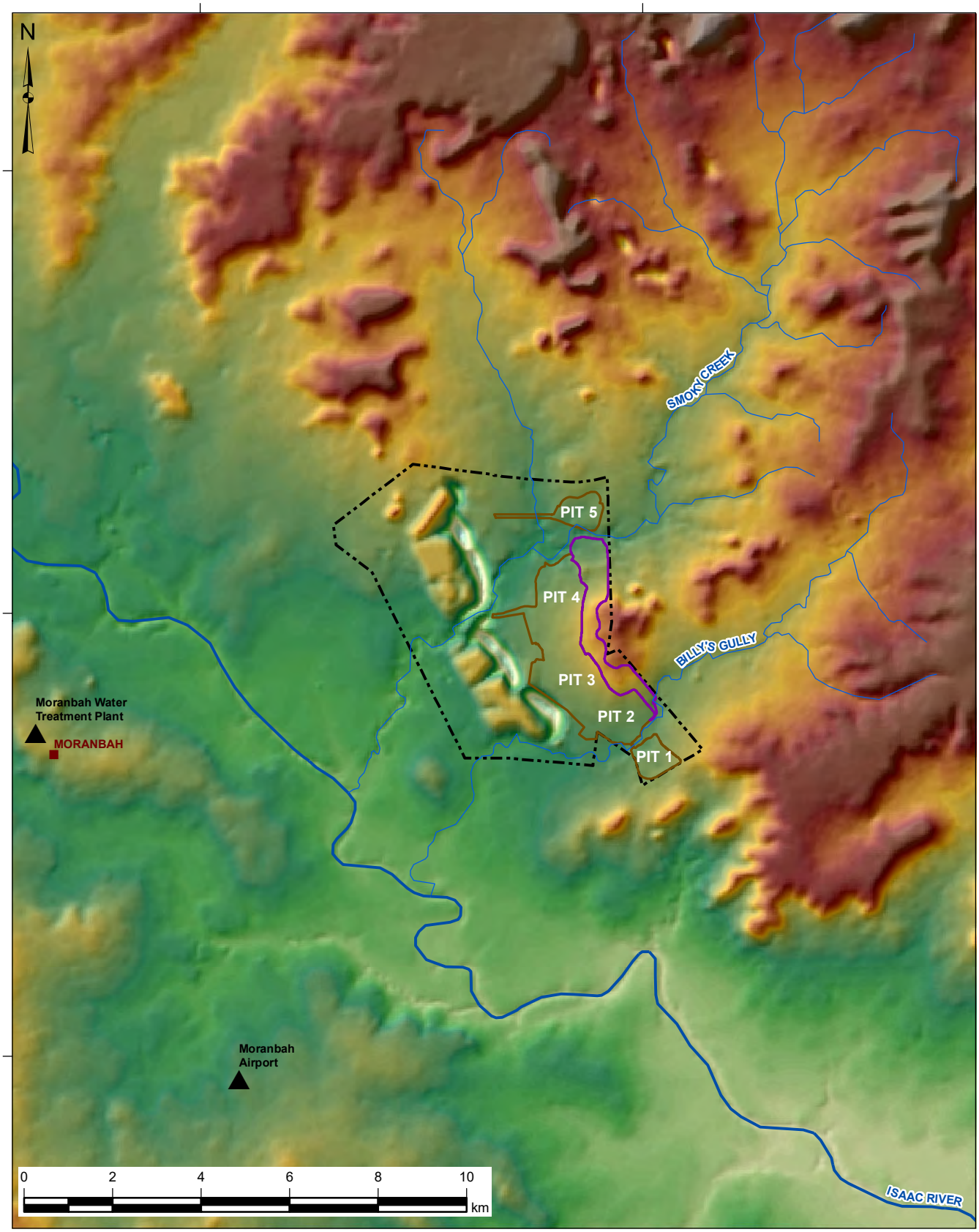
PROJECT: ISAAC PLAINS EAST EXTENSION GROUNDWATER REPORT

TITLE: PROJECT GROUNDWATER MANAGEMENT AREA

PROJECT No.: D10175A08

FIG No.: FIGURE 3

26/06/2020, EMangos, \\int.klohn.com\ProjData\D\BNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_03_ProjectGroundwaterManagementArea.mxd



Legend

- Town
- Weather Station

Surface Water Drainage
- River
- Creek

- Isaac Plains Complex Mining Lease
- Approved IPE Outline
- IPE Pit Extension

Topography Elevation
570 mAHD
150 mAHD

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:125,000

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Klohn Crippen Berger

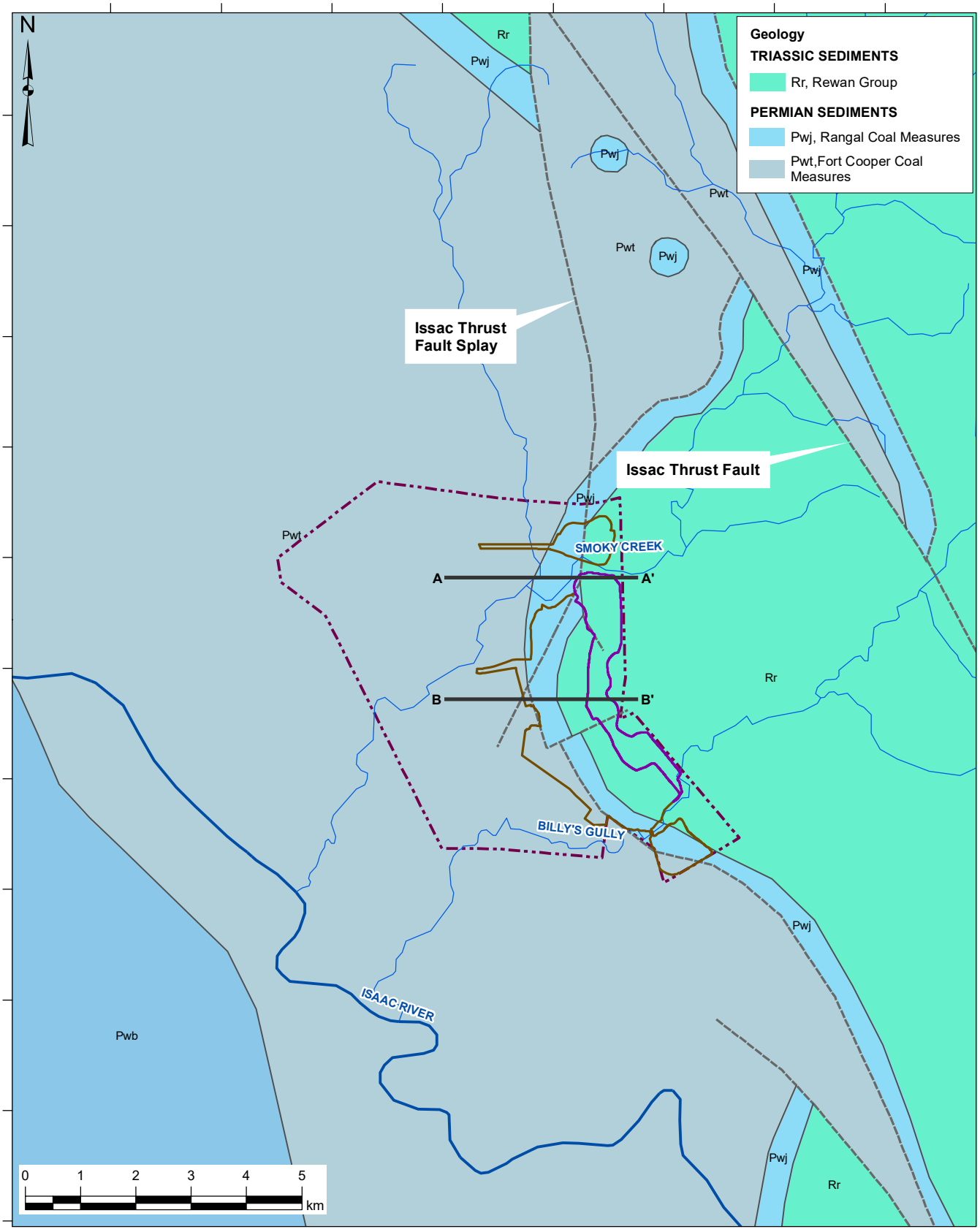
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
TOPOGRAPHY AND DRAINAGE

PROJECT No. D10175A08

FIG No. FIGURE 4

26/06/2020, EMangos, \\int.klohn.com\ProjData\D\BNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_04_TopographyandDrainage.mxd



Legend

- Town
- River
- Creek
- Isaac Plains Complex Mining Lease
- Approved IPE Outline
- IPE Pit Extension

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:100,000

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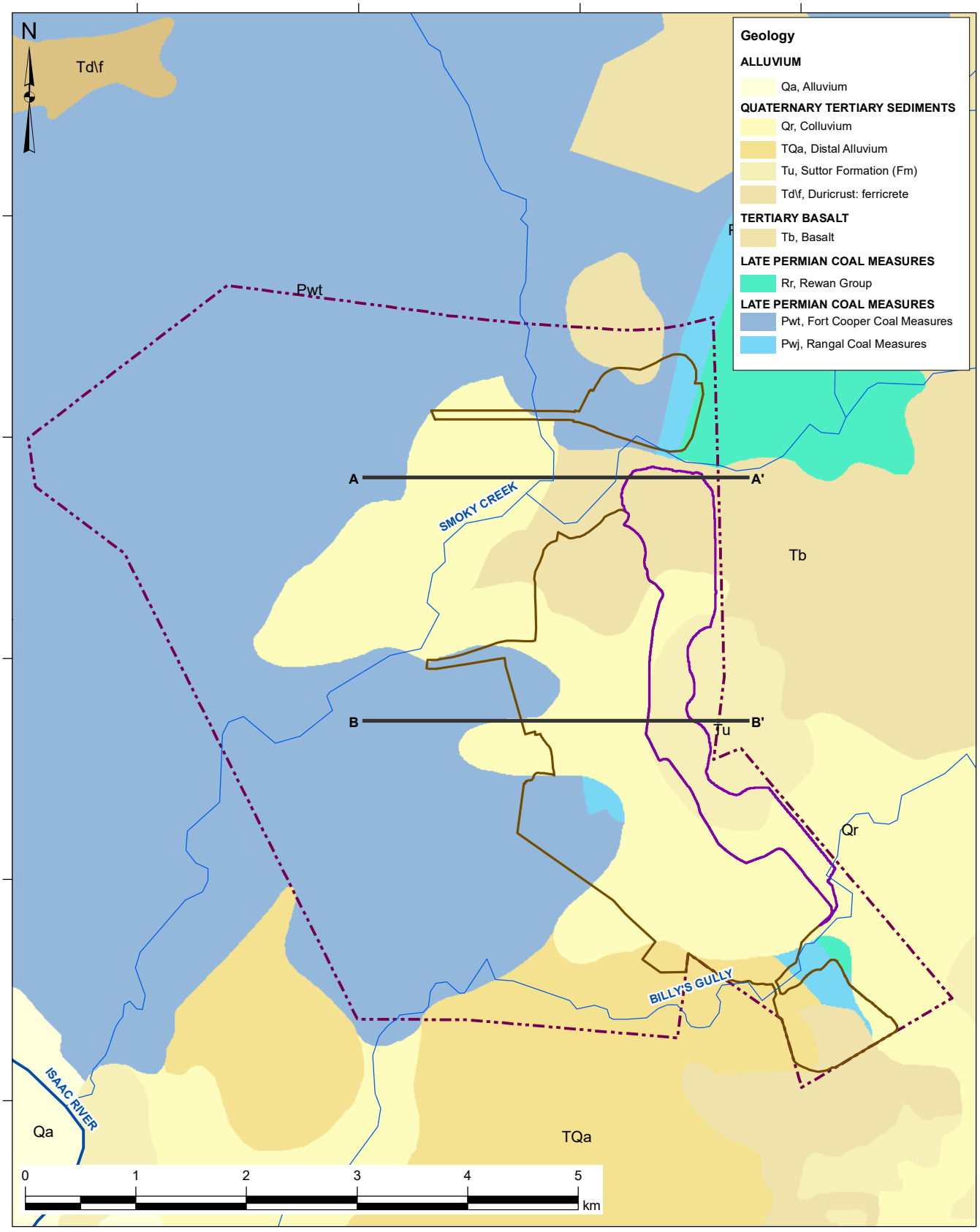
Klohn Crippen Berger

PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
SOLID GEOLOGY

PROJECT No.	FIG No.	REV
D10175A08	FIGURE 5	A

30/06/2020, EMangos, \\int.klohn.com\ProjData\D\BNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_05_SolidGeology.mxd



Legend

- River
- Creek
- Cross Section
- Isaac Plains Complex Mining Lease
- Approved IPE Outline
- IPE Pit Extension

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:50,000

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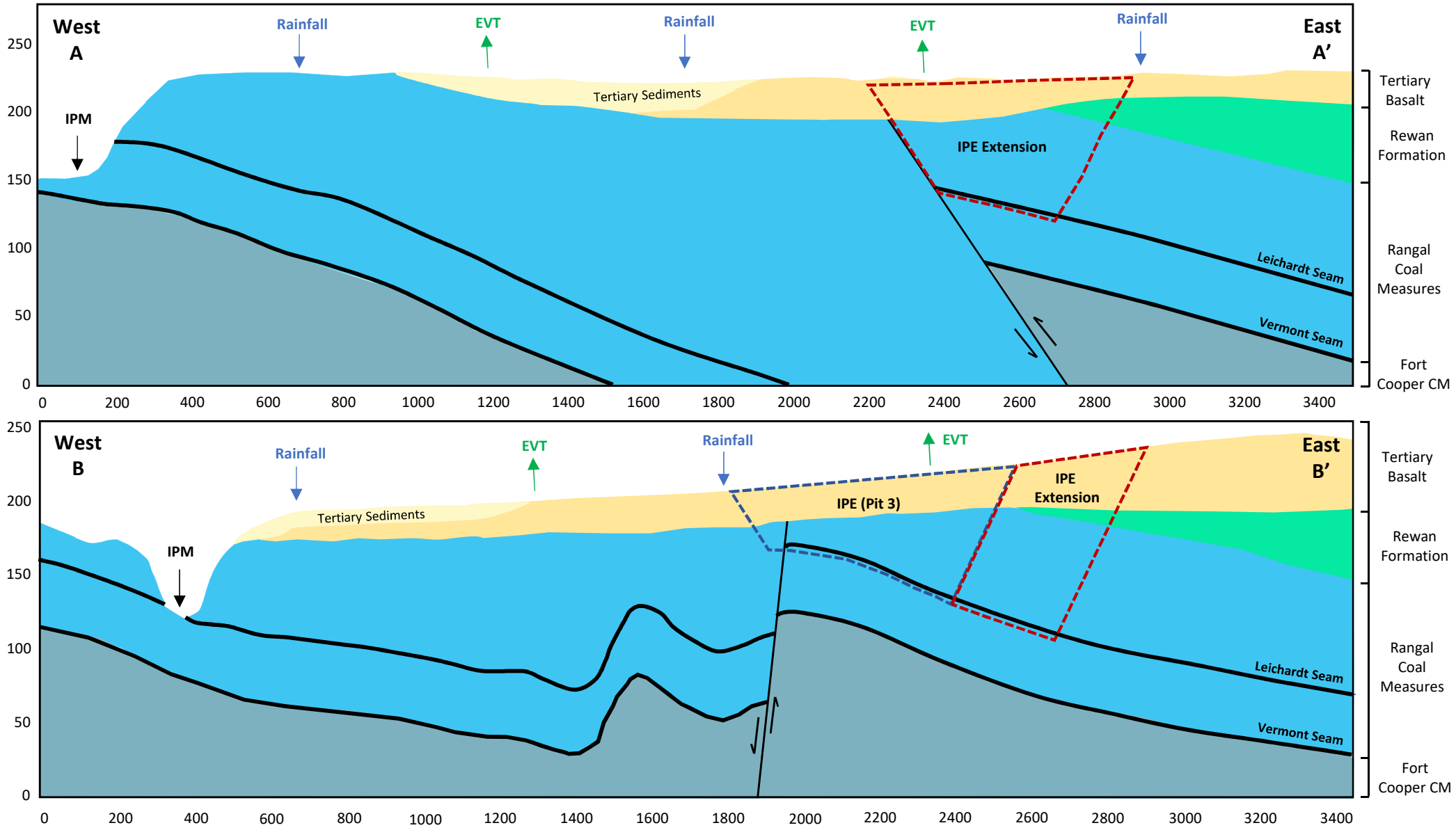
Klohn Crippen Berger

PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
SURFACE GEOLOGY

PROJECT No.	FIG No.	REV
D10175A08	FIGURE 6	A

29/06/2020, EMangos, \\int.klohn.com\Proj\Data\D\BNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_06_SurfaceGeology.mxd



Legend

- - - Fault Inferred
— Fault Location
⇄ Fault Slip Sense

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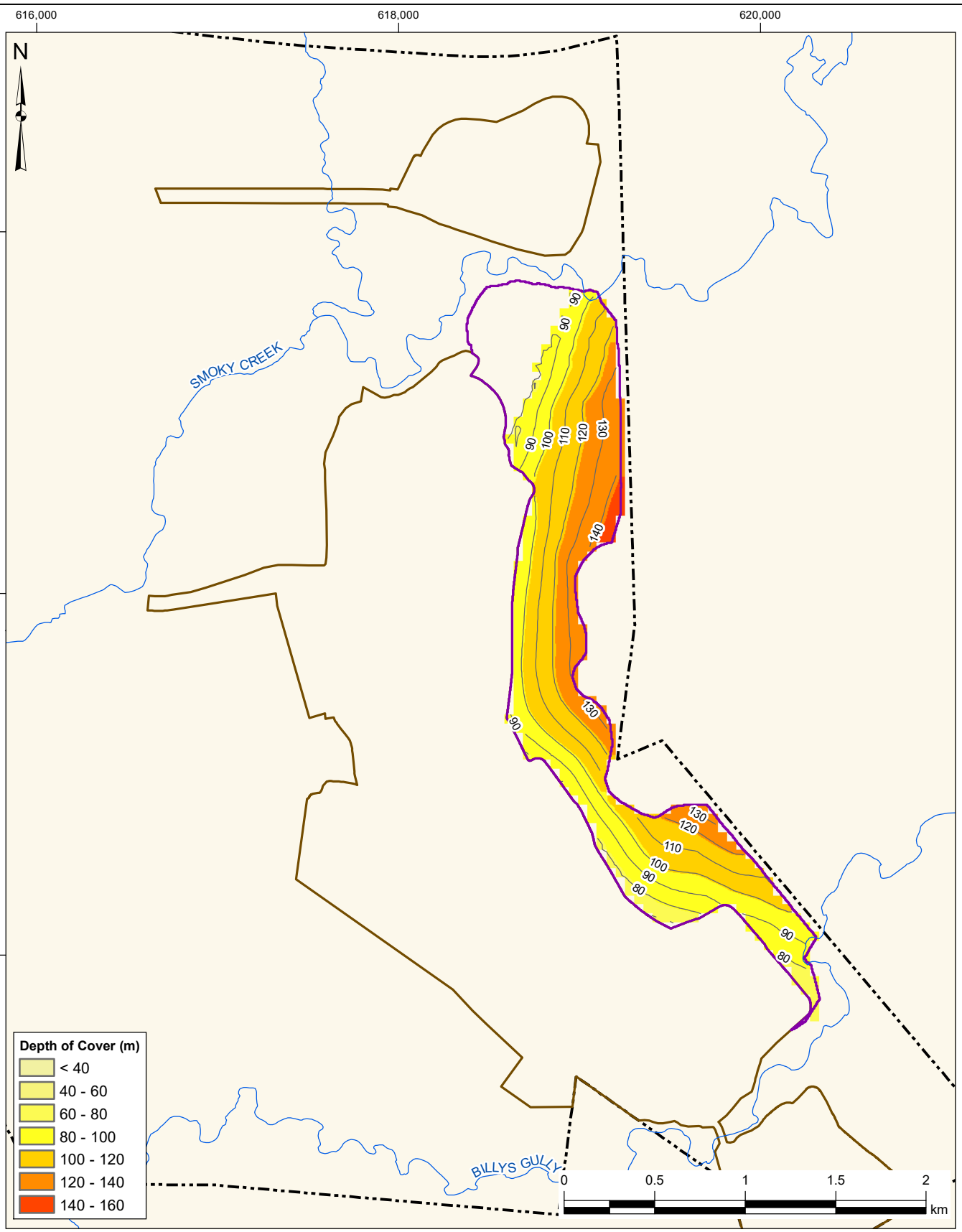
PROJECT
ISAAC PLAINS EAST EXTENSION GROUNDWATER REPORT

TITLE
CONCEPTUAL GEOLOGY CROSS-SECTION SECTION A – A' / B – B'

PROJECT No.	FIG No.	REV
D10175A08	FIGURE 7	A



Legend

- Depth of Cover Contour (m)
- River
- Creek
- Isaac Plains Complex Mining Lease
- Approved IPE Outline
- IPE Pit Extension

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:30,000

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Klohn Crippen Berger

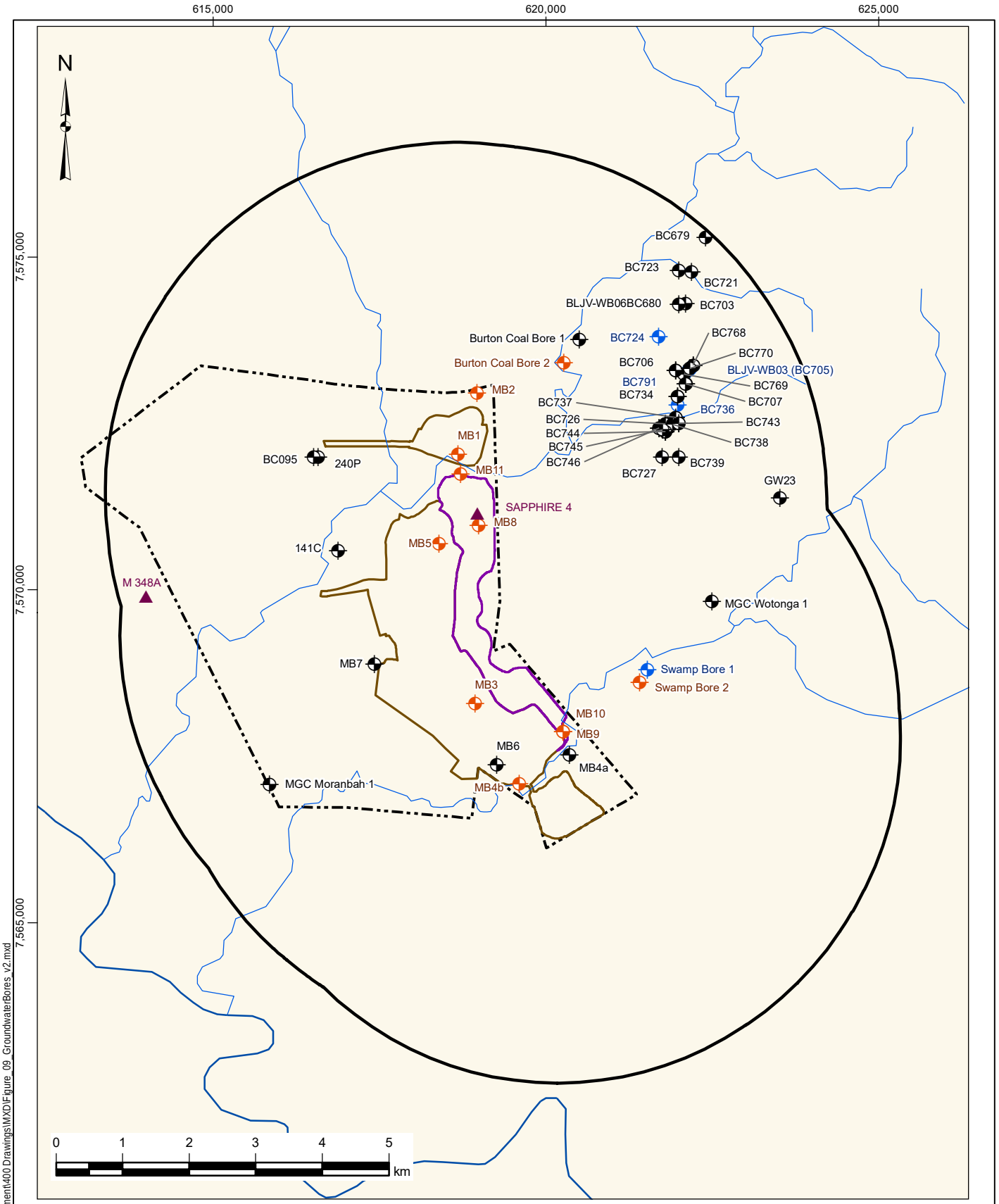
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
DEPTH OF COVER TO THE LEICHARDT SEAM

PROJECT No. D10175A08

FIG No. FIGURE 8

26/06/2020, EMangos, \\int.klohn.com\Proj\Data\DIBNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_08_DepthofCoverLeichardtSeam v1.mxd



Legend

- EA Monitoring Bore
- Monitoring Bore
- Water Supply Bore
- CSG Well
- River
- Creek
- Approved IPE Pit Outline
- IPE Pit Extension
- Isaac Plains Complex Mining Lease
- IPEE 5km Buffer

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:80,000

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Klohn Crippen Berger

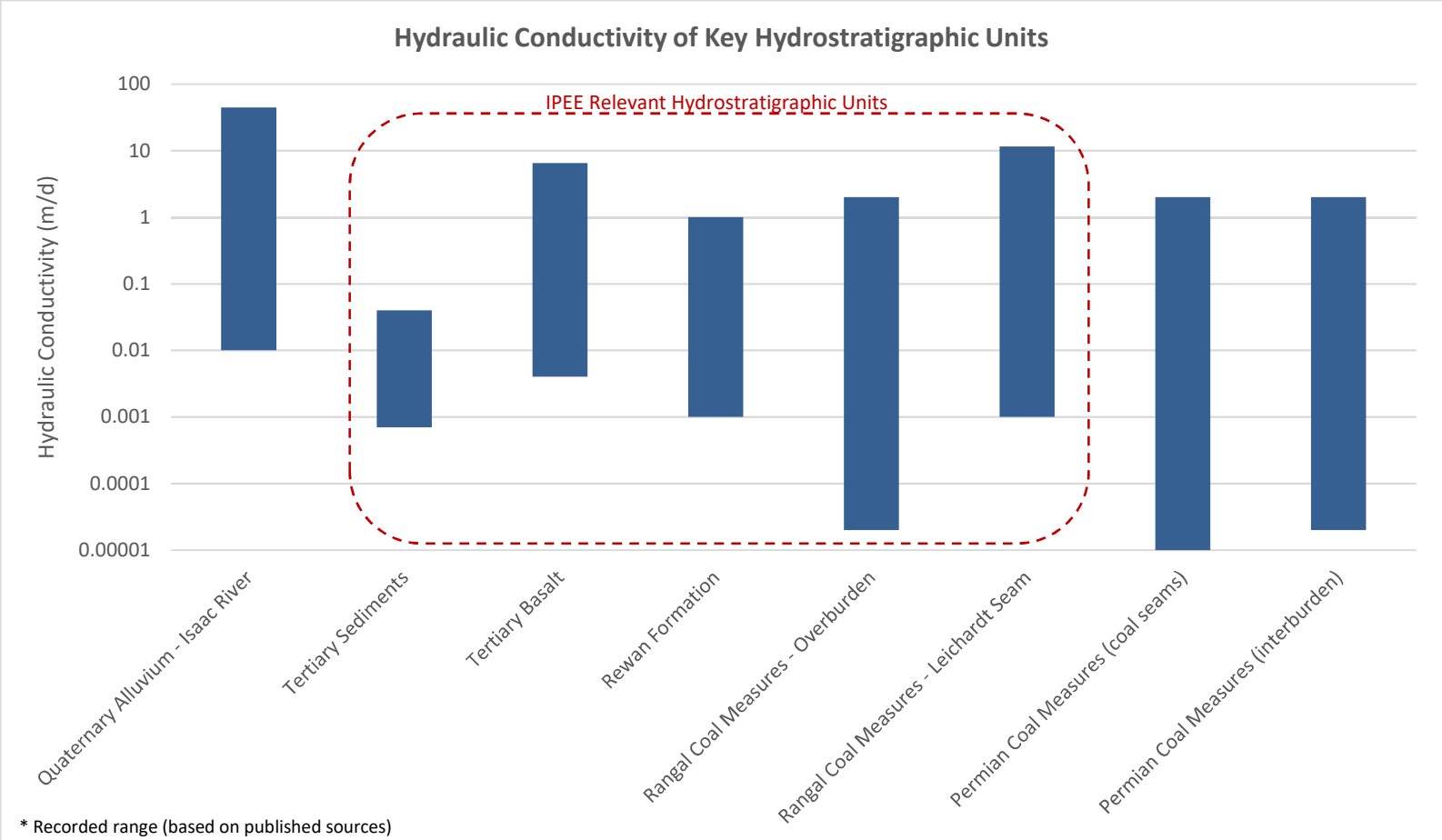
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
GROUNDWATER BORES

PROJECT No. D10175A08

FIG No. FIGURE 9

1/07/2020, EMangos, Z:\DIBNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_09_GroundwaterBores_v2.mxd



* Recorded range (based on published sources)

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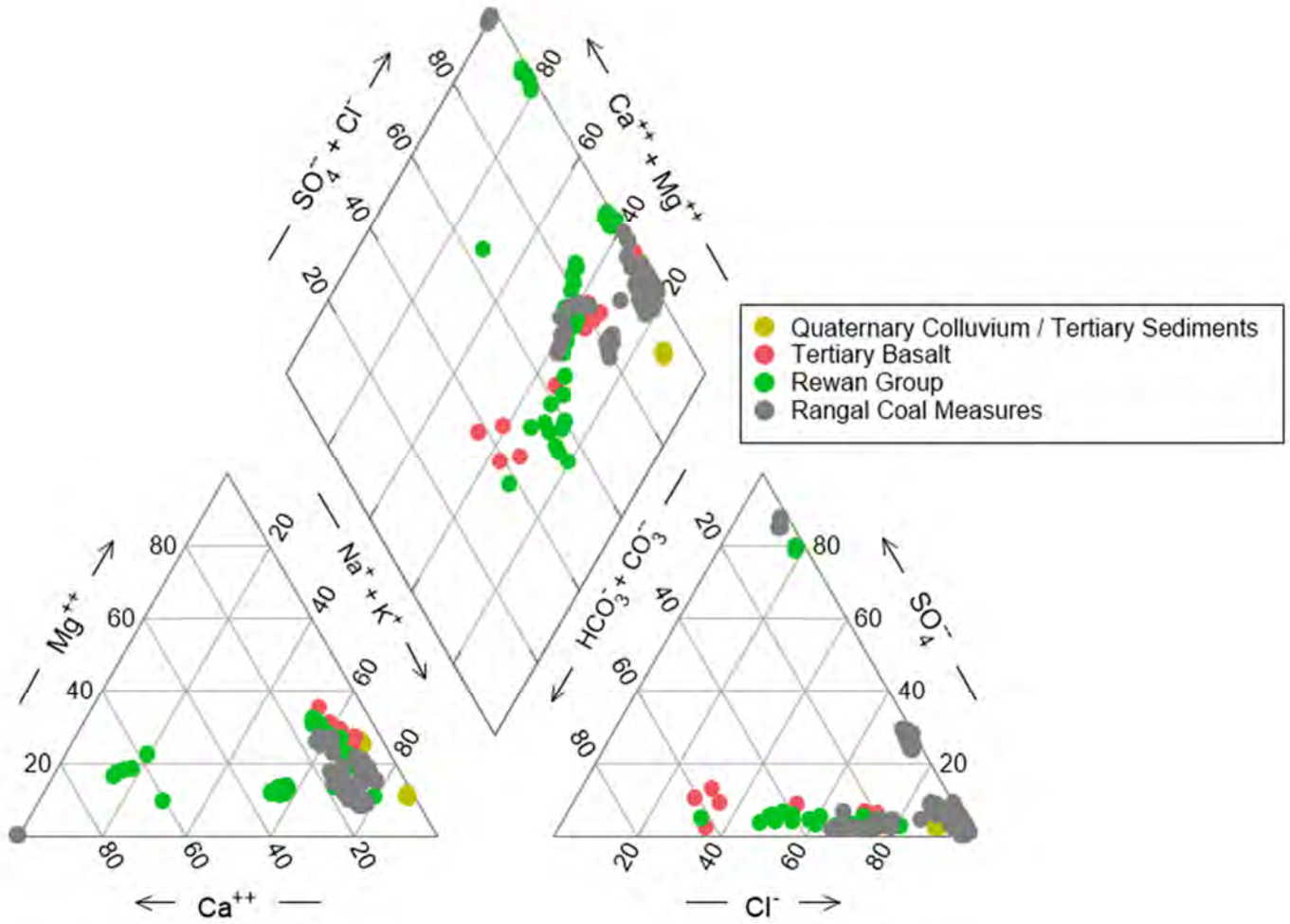
CLIENT: **Stanmore IP Coal Pty Ltd**	PROJECT NAME: **Isaac Plains East Extension Groundwater Report**		
Klohn Crippen Berger	TITLE: **Hydraulic Conductivity of Key Hydrostratigraphic Units**		
	PROJECT NO: **D10175A08**	FIG NO.: **FIGURE 10**	REV: **A**



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CLIENT:

Stanmore IP Coal Pty Ltd

Klohn Crippen Berger

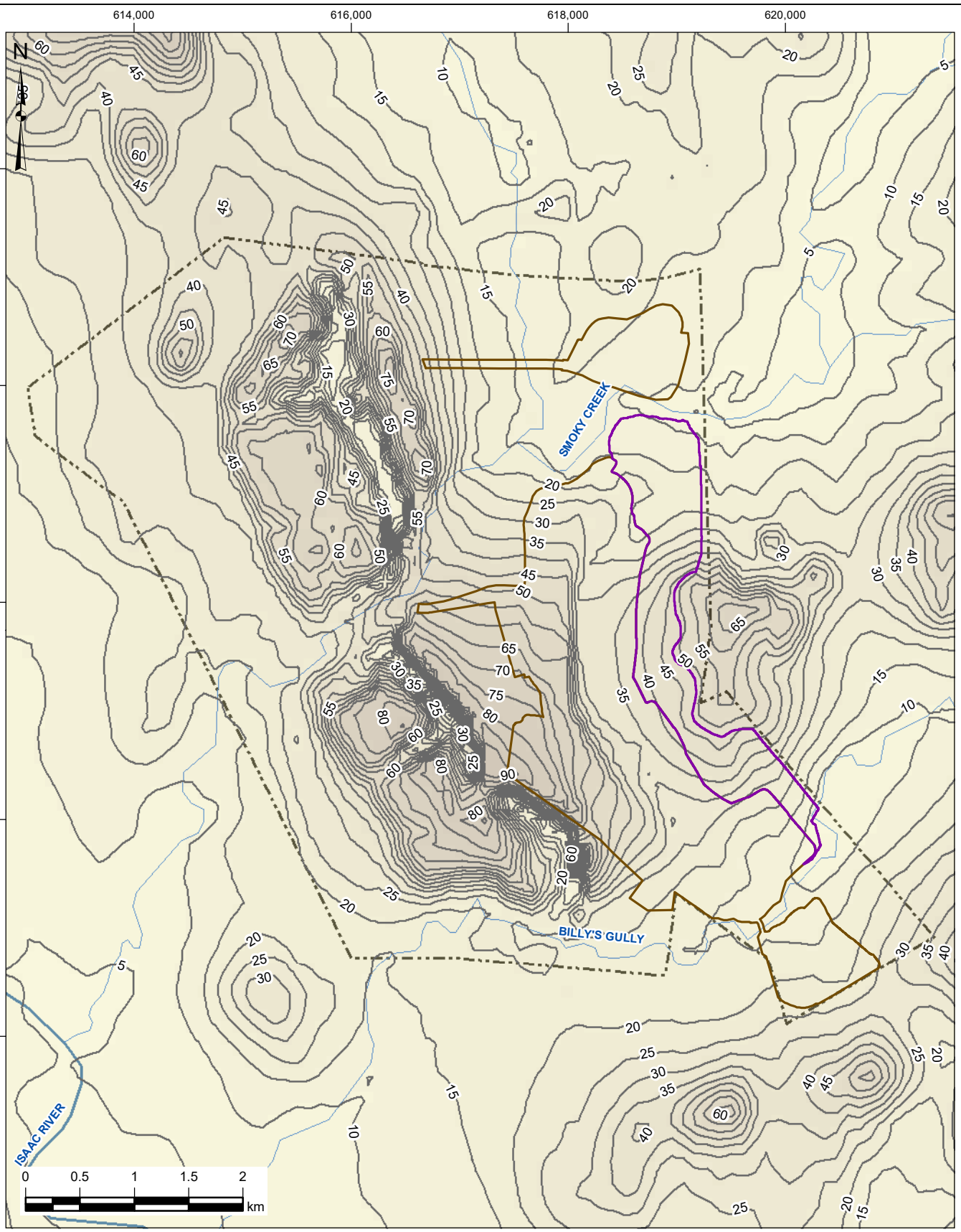
PROJECT NAME:

Isaac Plains East Extension Groundwater Assessment

TITLE:

Piper Diagram
January 2010 - April 2020 Data Set

PROJECT NO:	FIG NO.:	REV:
D10175A08	**FIGURE 11**	**A**



Legend

- River
- Creek
- Depth to Groundwater (m)
- Isaac Plains Complex Mining Lease
- IPE Pit Extension
- Approved IPE Outline

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:50,000

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Klohn Crippen Berger

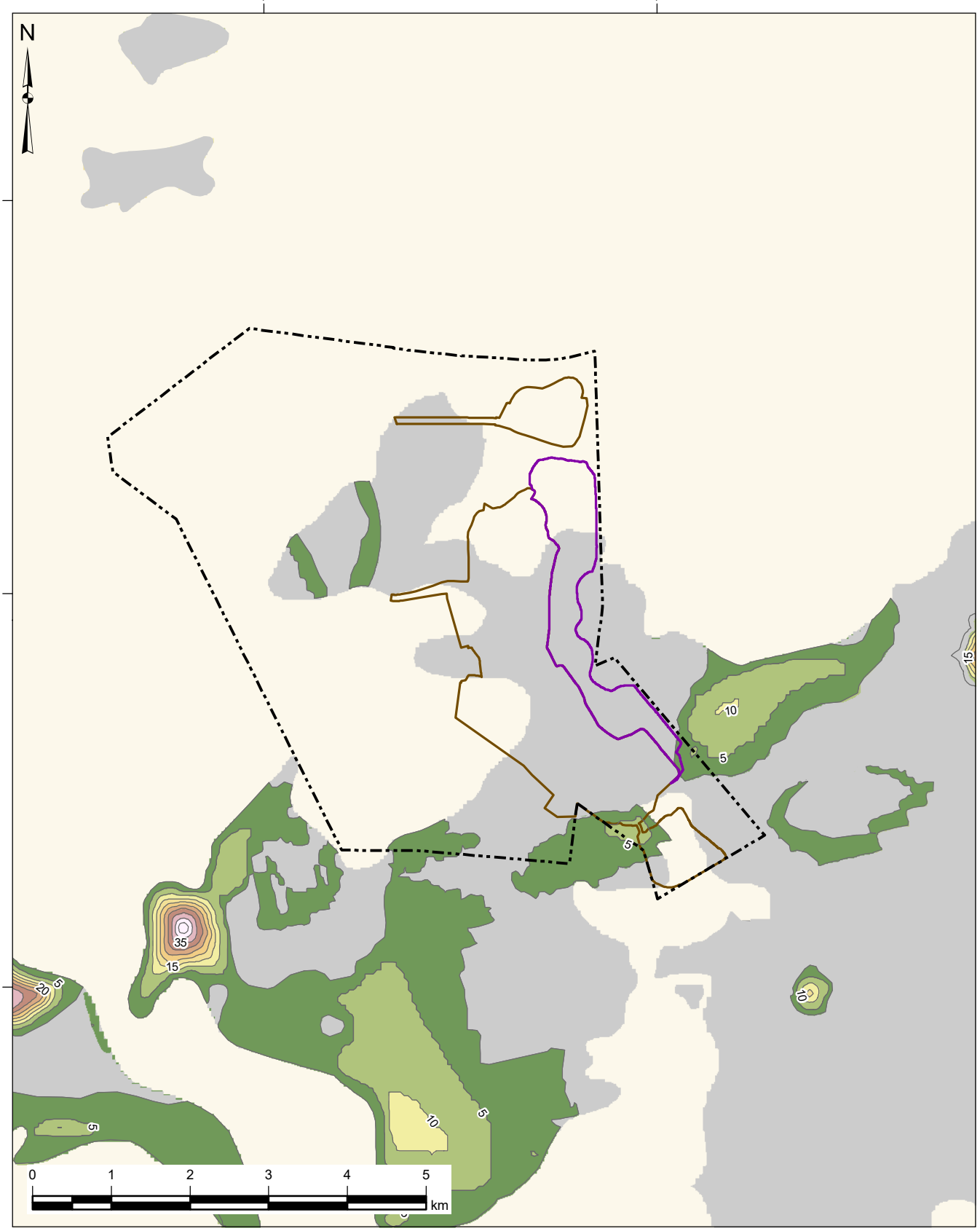
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
DEPTH TO GROUNDWATER
NOVEMBER 2018

PROJECT No. D10175A08

FIG No. FIGURE 12

26/06/2020, EMangos, \\int.klohn.com\Proj\Data\D\BNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_12_Depth_to_Groundwater_November2018.mxd



Legend

- Saturated Thickness Contour (m)
- Approved IPE Outline
- IPE Pit Extension
- Tertiary Sediments Extent
- Isaac Plains Complex Mining Lease

Tertiary Sediments Saturated Thickness (m)

0 - 5	15 - 20	30 - 35
5 - 10	20 - 25	35 - 40
10 - 15	25 - 30	40 -45

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:70,000

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Klohn Crippen Berger

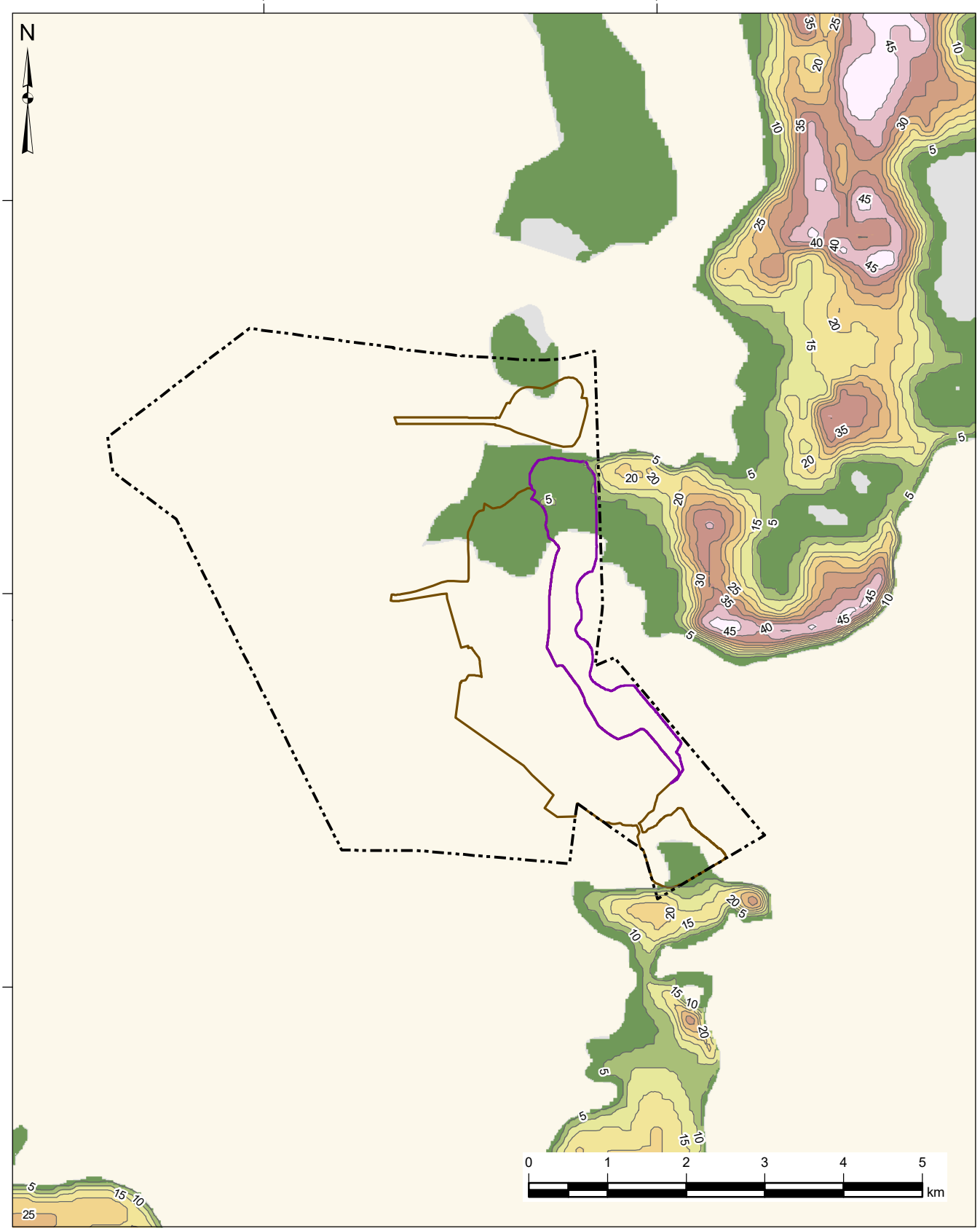
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
TERTIARY SEDIMENTS SATURATED THICKNESS

PROJECT No. D10175A08

FIG No. FIGURE 13

26/06/2020, EMangos, \\int.klohn.com\Proj\Data\DIBNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_13_SaturatedTertiarySediments.mxd



Legend

- Saturated Thickness Contour (m)
- Isaac Plains Complex Mining Lease
- IPE Pit Extension
- Approved IPE Outline
- Tertiary Basalt Extent

Saturated Tertiary Basalt Saturated Thickness (m)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:70,000

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Klohn Crippen Berger

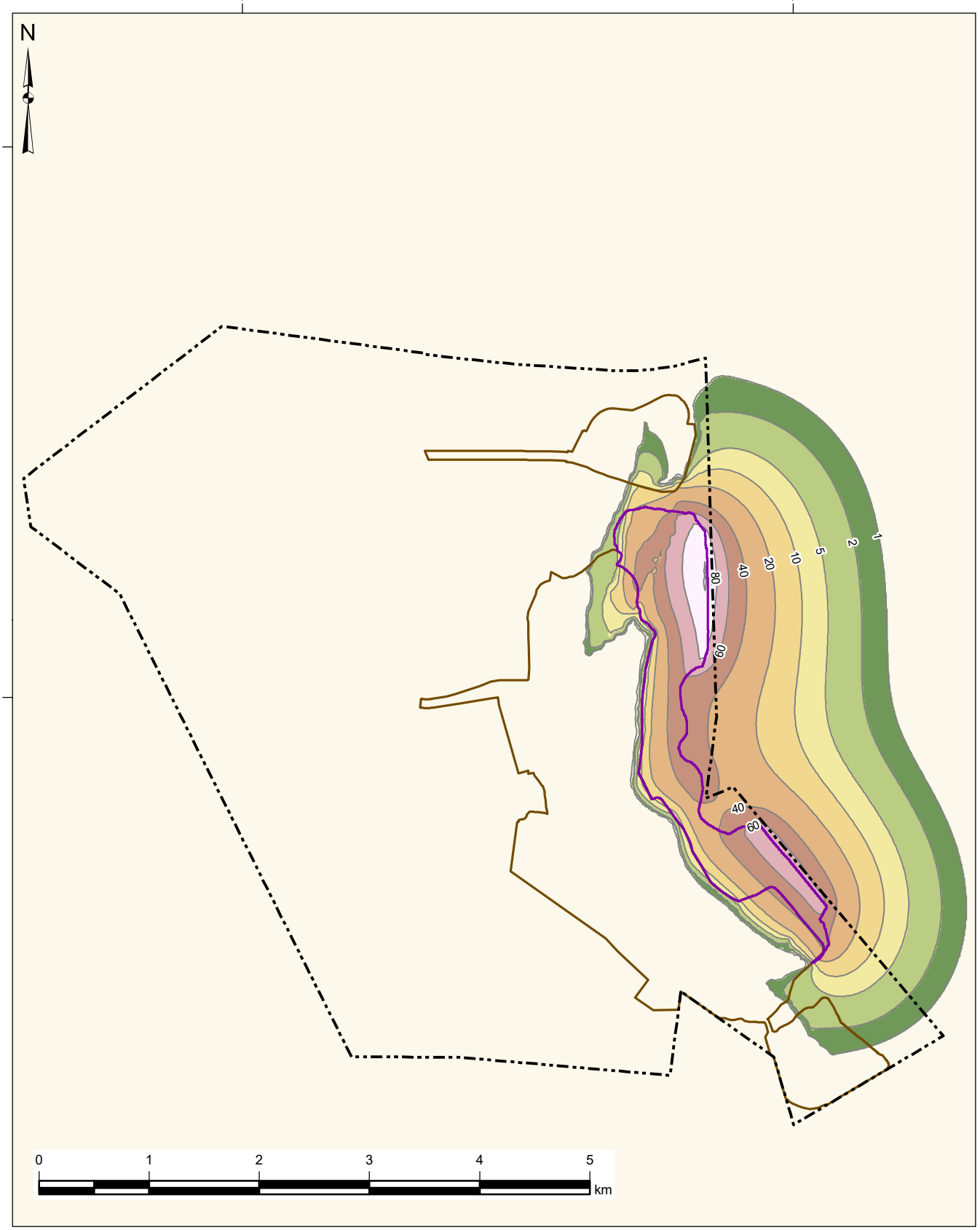
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
TERTIARY BASALT SATURATED THICKNESS

PROJECT No. D10175A08

FIG No. FIGURE 14

26/06/2020, EMangos, \\int.klohn.com\Proj\Data\DIBNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_14_SaturatedTertiaryBasalt.mxd



Legend

- Depressurisation Contour (m)
- Approved IPE Outline
- IPE Pit Extension
- Isaac Plains Complex Mining Lease

Leichardt Seam Depressurisation (m)

- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 100

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:50,000

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Klohn Crippen Berger

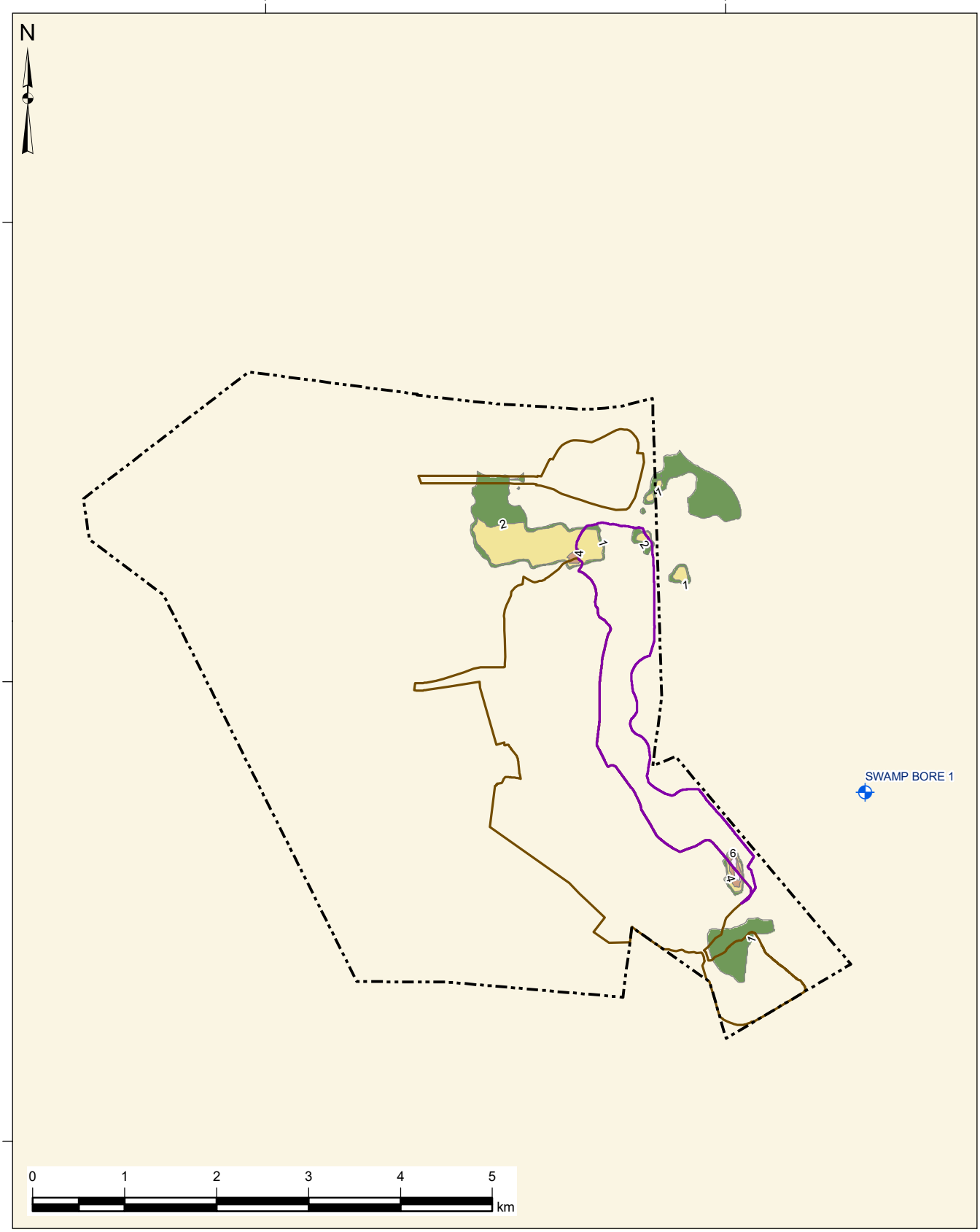
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
PREDICTED DEPRESSURISATION IN THE
LEICHARDT SEAM

PROJECT No. D10175A08

FIG No. FIGURE 15

26/06/2020, EMangos, \\int.klohn.com\ProjData\D\BNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_15_PredictedDepressurisationLeichardtSeam.mxd



Legend

- Water Supply Bore
- Depressurisation Contour (m)
- Approved IPE Outline
- IPE Pit Extension
- Isaac Plains Complex Mining Lease

Weathered Sediments Depressurisation (m)

- 1 - 2
- 2 - 4
- 4 - 6
- 6 - 8

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:60,000

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Klohn Crippen Berger

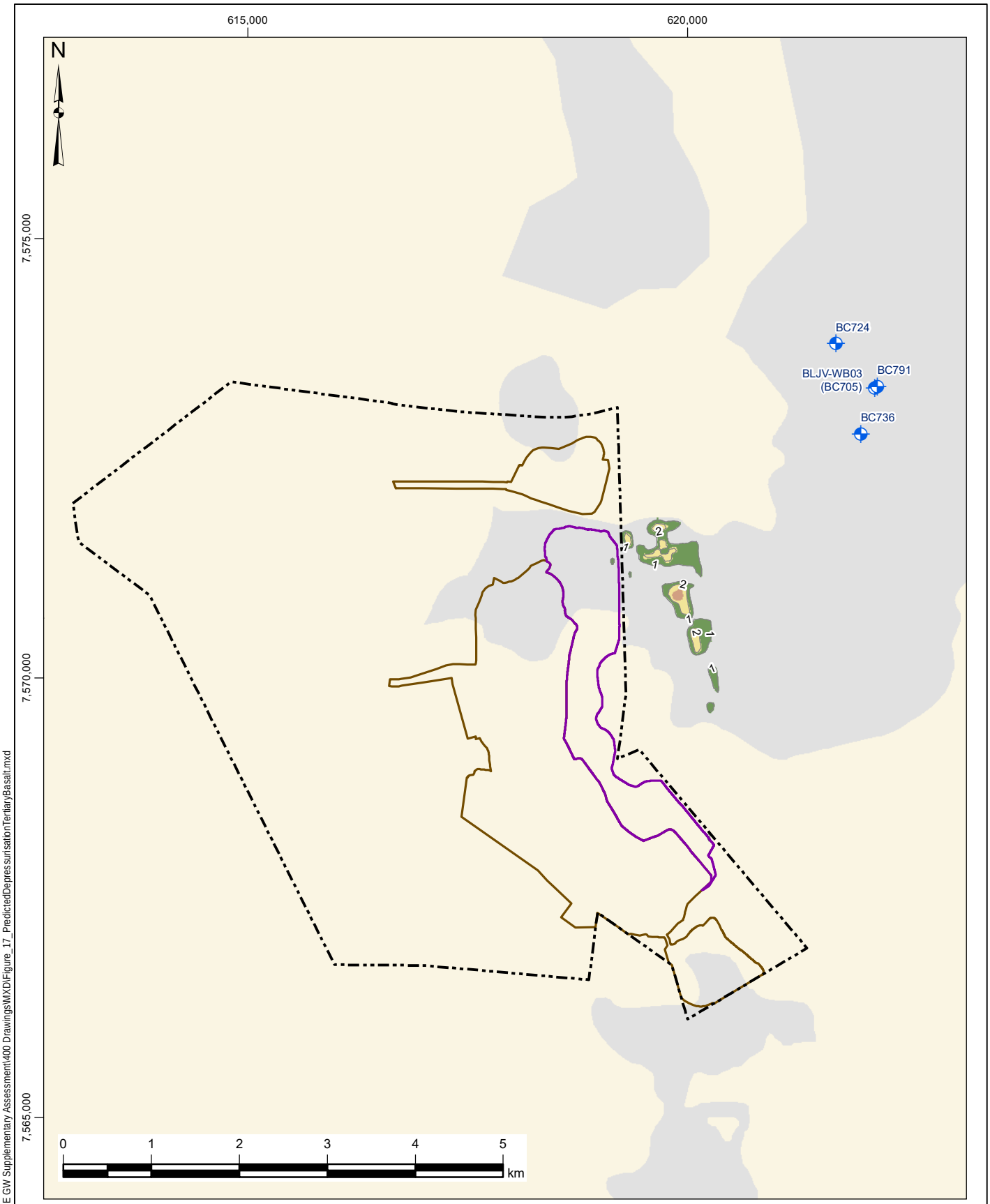
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
PREDICTED DEPRESSURISATION IN THE
WEATHERED SEDIMENTS

PROJECT No. D10175A08

FIG No. FIGURE 16

26/06/2020, EMangos, \\int.klohn.com\ProjData\D\BNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_16_PredictedDepressurisationWeatheredSediments.mxd



Legend

- Water Supply Bore
- Depressurisation Contour (m)
- Approved IPE Outline
- IPE Pit Extension
- Isaac Plains Complex Mining Lease

Basalt Depressurisation (m)

- 1 - 2
- 3 - 4
- 2 - 3

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:60,000

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Klohn Crippen Berger

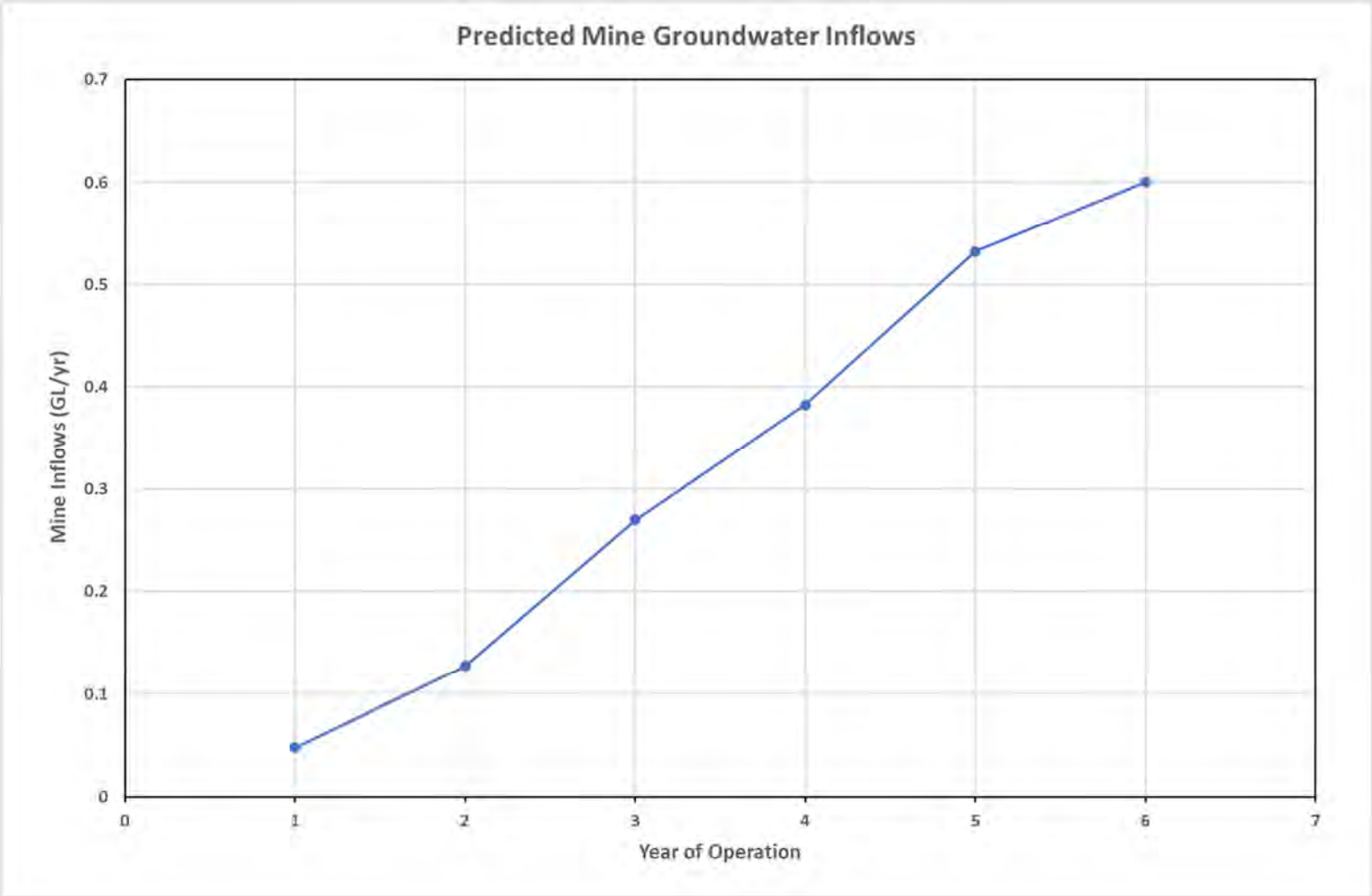
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
PREDICTED DEPRESSURISATION IN THE
TERTIARY BASALT

PROJECT No. D10175A08

FIG No. FIGURE 17

26/06/2020, EMangos, \\int.klohn.com\ProjData\D\BNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_17_PredictedDepressurisationTertiaryBasalt.mxd



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CLIENT:

Stanmore IP Coal Pty Ltd

Klohn Crippen Berger

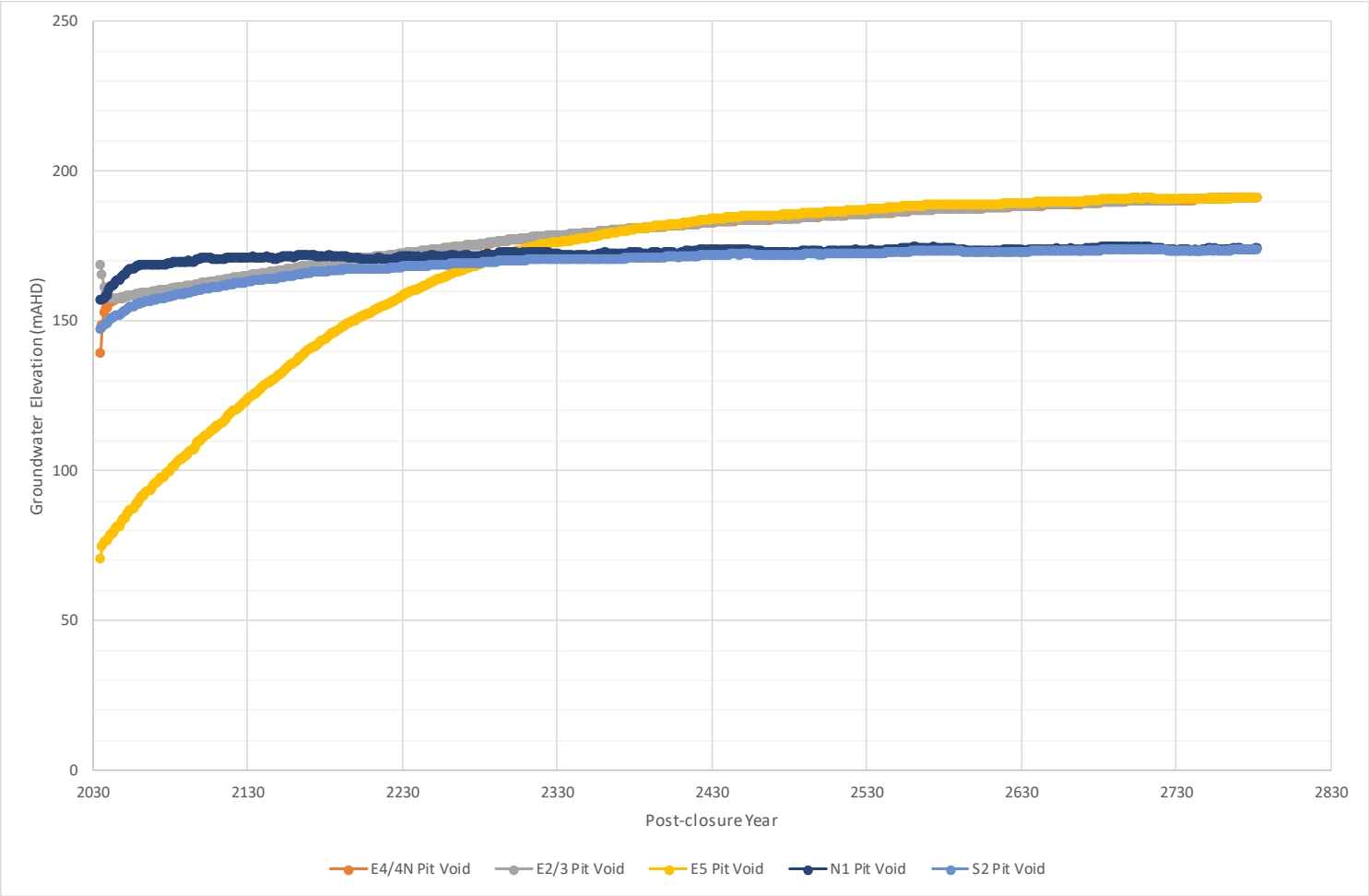
PROJECT NAME:

Isaac Plains East Extension Groundwater Report

TITLE:

Predicted Groundwater Take

PROJECT NO:	FIG NO.:	REV:
D10175A08	**FIGURE 18**	**A**



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CLIENT:

Stanmore IP Coal Pty Ltd

Klohn Crippen Berger

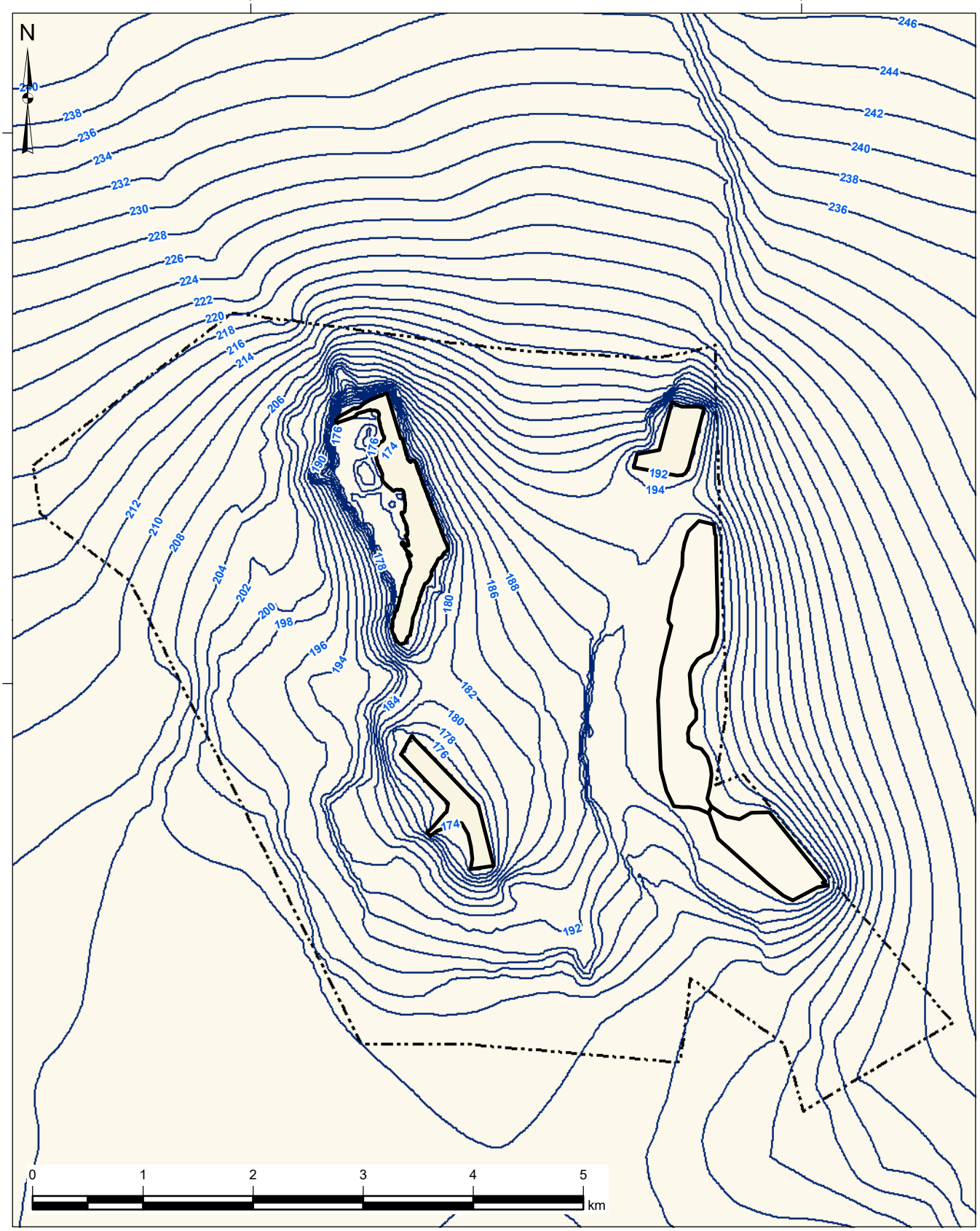
PROJECT NAME:

Isaac Plains East Extension Groundwater Report

TITLE:

Post-closure Pit Void Water Level Elevations

PROJECT NO:	FIG NO.:	REV:
D10175A08	**FIGURE 19**	**A**



Legend

- Groundwater Level Elevation (2m Interval)
- Isaac Plains Complex Mining Lease
- Pit Voids

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:50,000

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Klohn Crippen Berger

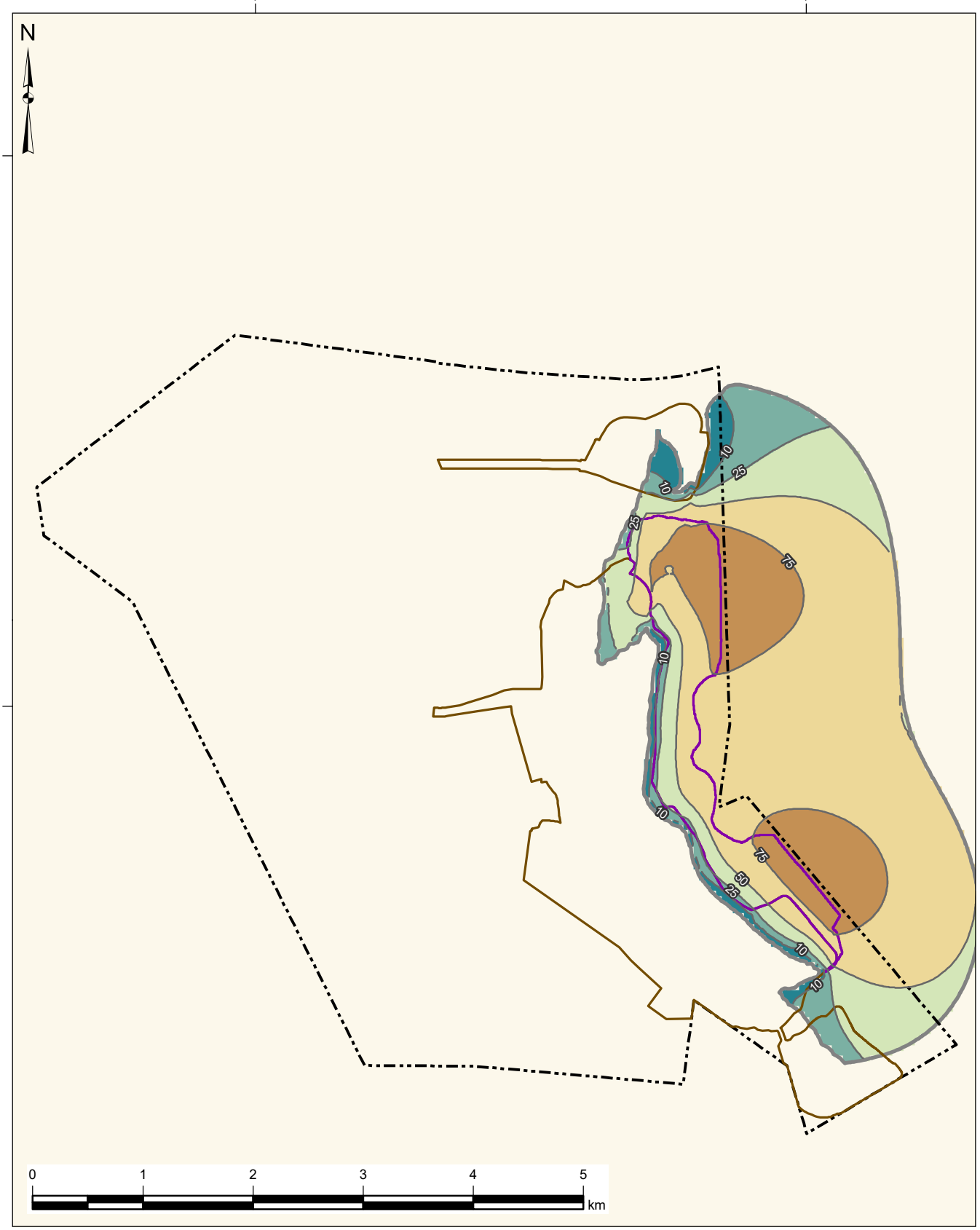
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
GROUNDWATER ELEVATION
854 YEARS POST- CLOSURE

PROJECT No. D10175A08

FIG No. FIGURE 20

26/06/2020, EMangos, \\int.klohn.com\ProjData\DBNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\FIG_20_Groundwater_Elevation_854Years_PostClosure.mxd



Legend

- Project Contribution (%)
- Drawdown Extent
- Approved IPE Outline
- IPE Pit Extension
- Isaac Plains Complex Mining Lease

Contribution of Project Depressurisation to Cumulative Depressurisation (%)

- 0 - 10
- 10 - 25
- 25 - 50
- 50 - 75
- 75 - 90

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:50,000

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Klohn Crippen Berger

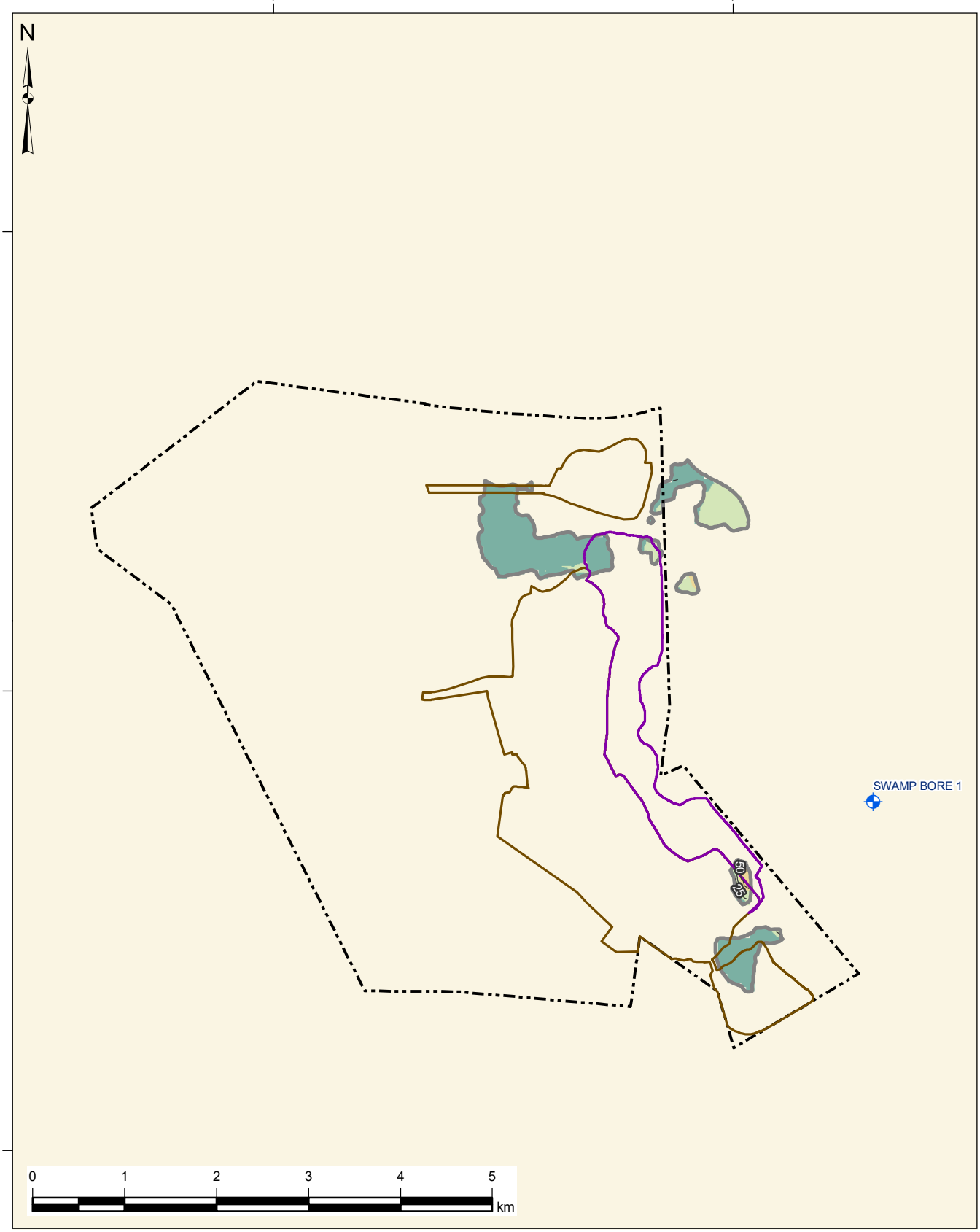
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
PROJECT CONTRIBUTION TO CUMULATIVE DEPRESSURISATION IN THE LEICHARDT SEAM

PROJECT No. D10175A08

FIG No. FIGURE 21

26/06/2020, EMangos, \\int.klohn.com\Proj\Data\D\BNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_21_ProjectContributionCumulativeDepressurisationLeichardt Seam.mxd



Legend

- Water Supply Bore
- Cumulative Contour (1m)
- Drawdown Extent
- Approved IPE Outline
- IPE Pit Extension
- Isaac Plains Complex Mining Lease
- Project Mining Area Boundary

Contribution of Project Depressurisation to Cumulative Depressurisation (%)

- 0 - 10
- 10 - 25
- 25 - 50
- 50 - 75

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:60,000

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Klohn Crippen Berger

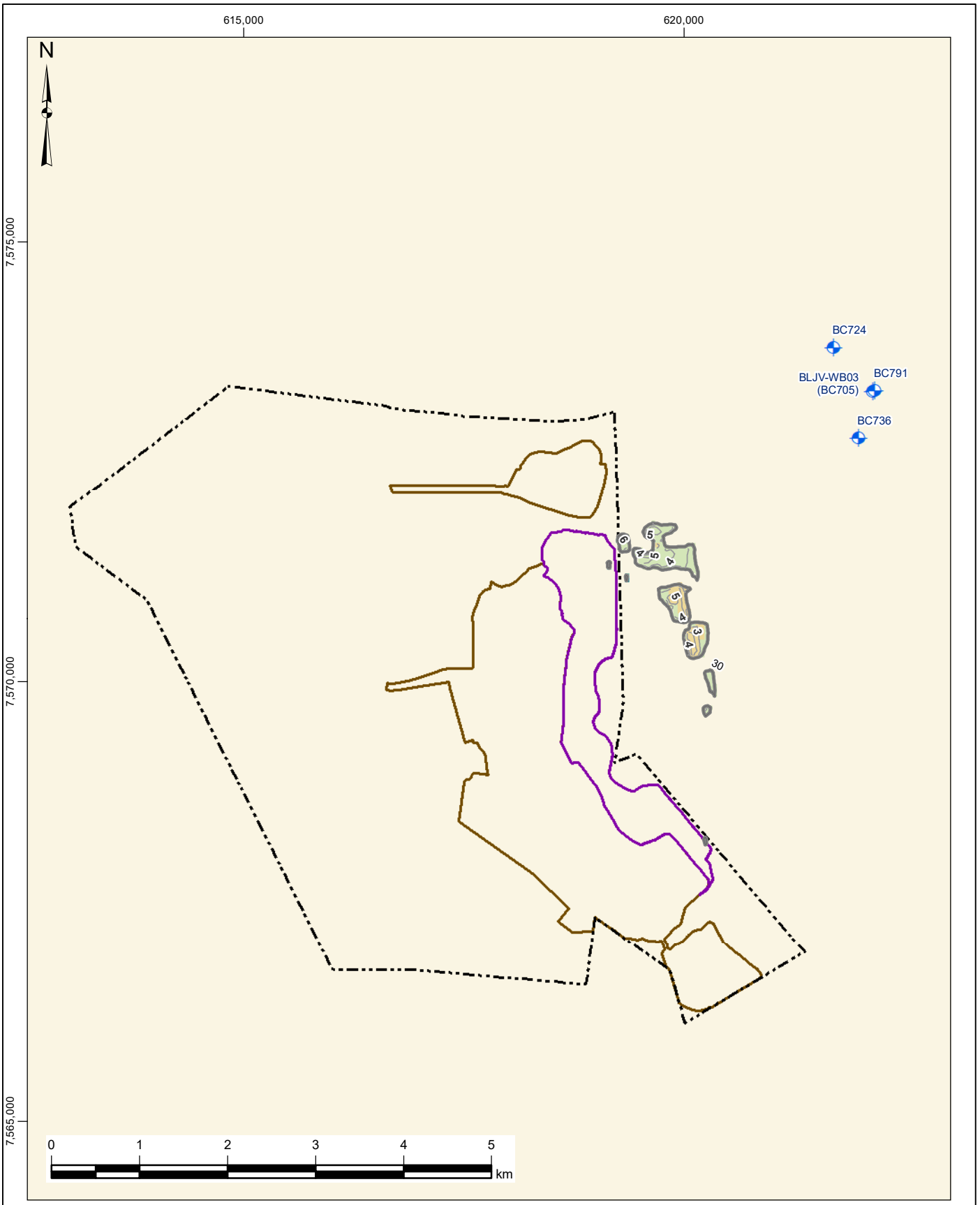
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
PROJECT CONTRIBUTION TO CUMULATIVE DEPRESSURISATION IN THE WEATHERED SEDIMENTS

PROJECT No. D10175A08

FIG No. FIGURE 22

26/06/2020, EMangos, \\int.klohn.com\Proj\Data\DIBNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_22_ProjectContributionCumulativeDepressurisationWeatheredSediments.mxd



Legend

- Water Supply Bore
- Cumulative Drawdown (1m)
- Approved IPE Outline
- IPE Pit Extension
- Isaac Plains Complex Mining Lease

Contribution of Project Depressurisation to Cumulative Depressurisation (%)

- 0 - 10
- 10 - 25
- 25 - 50
- 50 - 75

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:60,000

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Klohn Crippen Berger

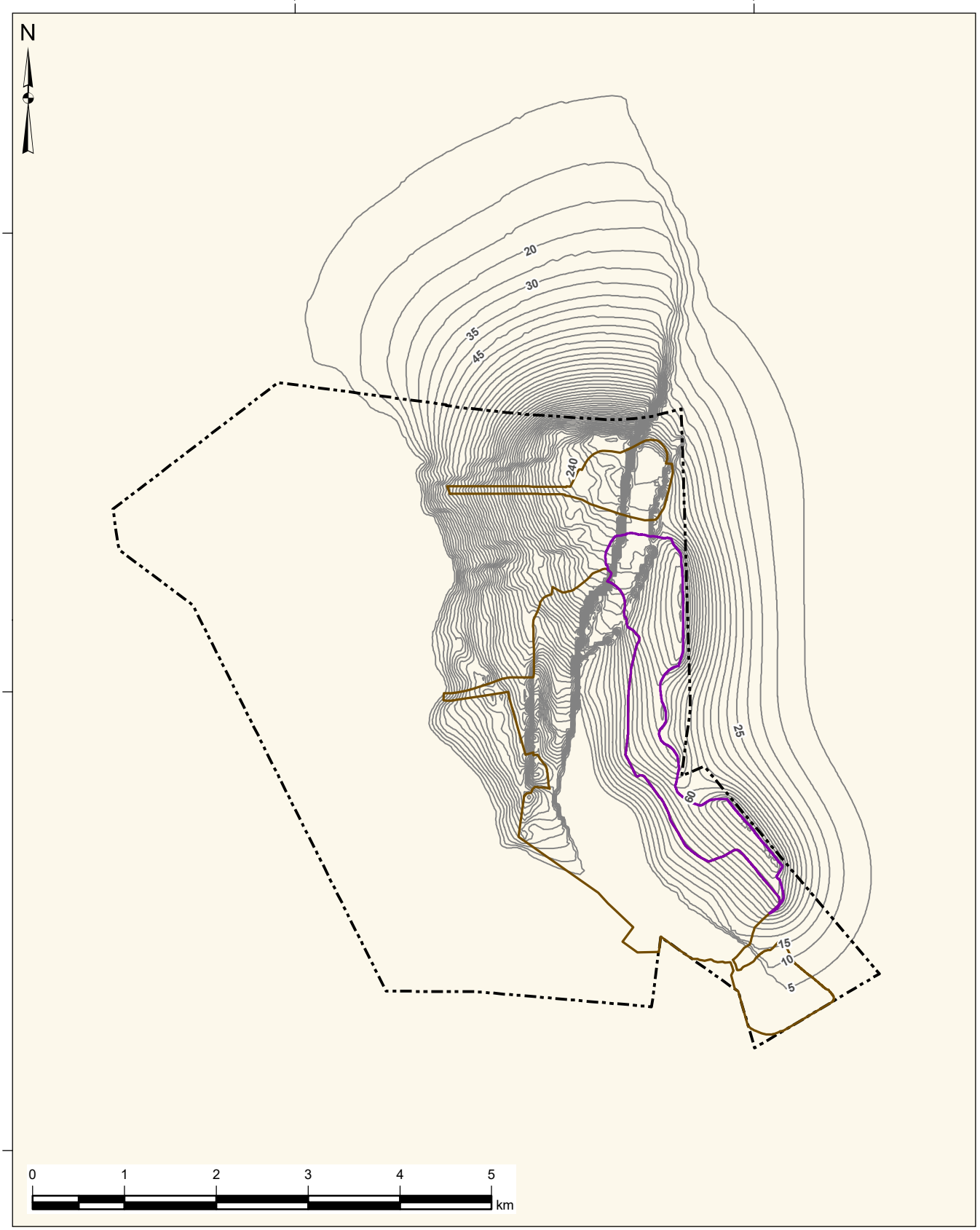
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
PROJECT CONTRIBUTION TO CUMULATIVE DEPRESSURISATION IN THE TERTIARY BASALT

PROJECT No. D10175A08

FIG No. FIGURE 23

26/06/2020, EMangos, \\int.klohn.com\Proj\Data\D\BNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_23_ProjectContributionCumulativeDepressurisationTertiaryBasalt.mxd



Legend

- Cumulative Drawdown
- Approved IPE Outline
- IPE Pit Extension
- Isaac Plains Complex Mining Lease

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:60,000

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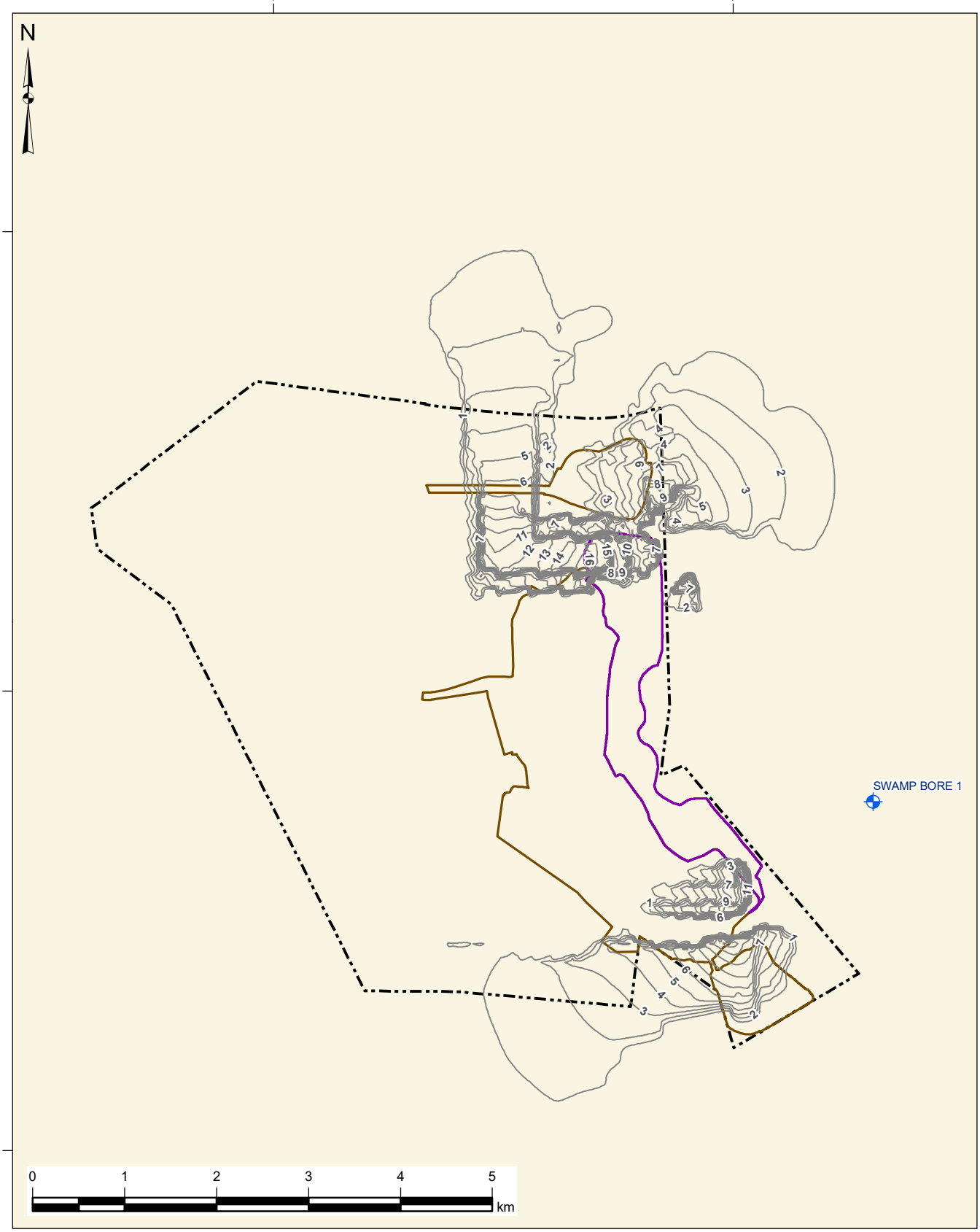
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
CUMULATIVE DEPRESSURISATION
IN THE LEICHARDT SEAM

PROJECT No. D10175A08

FIG No. FIGURE 24

26/06/2020, EMangos, \\int.klohn.com\Proj\Data\D\BNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_24_CumulativeDepressurisation_in_the_LeichardtSeam.mxd



Legend

- Water Supply Bore
- Cumulative Contour (1m)
- Approved IPE Outline
- IPE Pit Extension
- Isaac Plains Complex Mining Lease
- Project Mining Area

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:60,000

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Klohn Crippen Berger

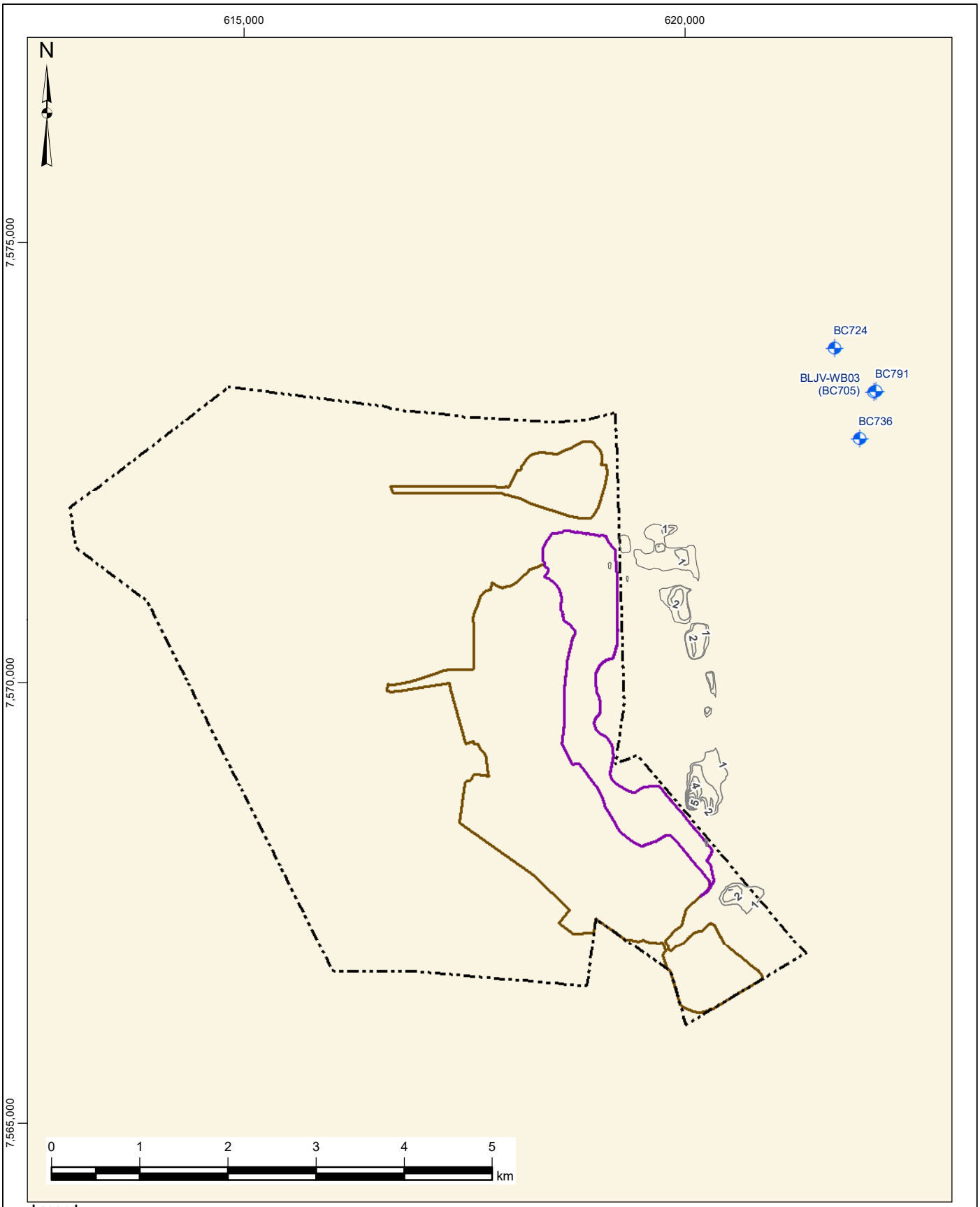
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
CUMULATIVE DEPRESSURISATION
IN THE WEATHERED SEDIMENTS

PROJECT No. D10175A08

FIG No. FIGURE 25

26/06/2020, EMangos, \\int.klohn.com\Proj\Data\DIBNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_25_CumulativeDepressurisation__in_the_WeatheredSediments.mxd



Legend

- Cumulative Drawdown (1m)
- Water Supply Bore
- Approved IPE Outline
- IPE Pit Extension
- Isaac Plains Complex Mining Lease

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:60,000

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Klohn Crippen Berger

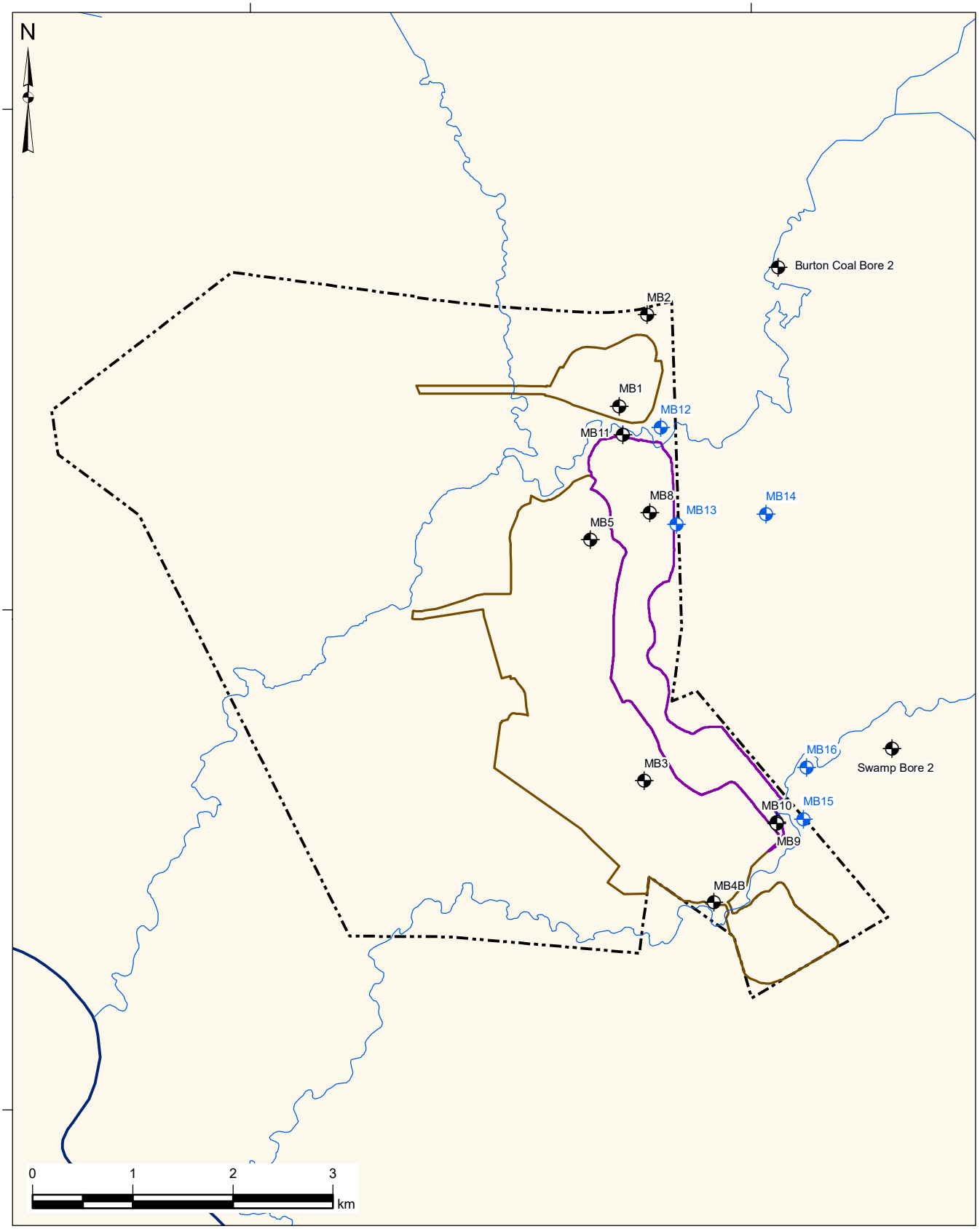
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
CUMULATIVE DEPRESSURISATION
IN THE TERTIARY BASALT

PROJECT No. D10175A08

FIG No. FIGURE 26

26/06/2020, EMangos, \\int.klohn.com\Proj\Data\D\BNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_26_CumulativeDepressurisation_in_the_TertiaryBasalt.mxd



Legend

- Monitoring Bore
- Replacement Bore
- Approved IPE Pit Outline
- IPE Pit Extension
- Isaac Plains Complex Mining Lease

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:55,000

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Klohn Crippen Berger

PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT

TITLE
GROUNDWATER MONITORING PROGRAM

PROJECT No. D10175A08

FIG No. FIGURE 27

1/07/2020, EMangos, Z:\DIBNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Figure_27_GroundwaterMonitoringProgramv2.mxd

APPENDIX I

Summary of DNRME-Registered Bores

RN	Original Name	Facility Status	Date Drilled	Easting (AGD84)	Northing (AGD84)	Screened Lithology	Elevation	SWL (mbGL)	EC (µS/cm)	Screen Interval (mbGL)	Gravel Pack Interval (mbGL)
182081	MB11	EX	1/06/2018	618831.91	7571923.5	QUATERNARY - UNDEFINED	–	–	–	3 – 4	2.4 – 5
182080	MB4	EX	30/05/2018	619626	7567072	QUATERNARY - UNDEFINED	–	–	–	8.50 – 11.50	7 – 11.50
182079	MB10	EX	30/05/2018	620368.24	7568045.8	SUTTOR FORMATION	–	–	–	21.30 – 27.30	20.30 – 27.30
182078	MB9	EX	30/05/2018	620368.48	7568048.9	BASALT	–	–	1,460 & 10,300	77.50 – 80.50	76.50 – 80.50
182077	MB8	EX	1/06/2018	619105.16	7571148.6	RANGAL COAL MEASURES	–	-24	–	117.30 – 120.30	88 – 100.50; 114.50 – 126.50
162812	SWAMP BORE 2	AU	1/01/2001	621521	7568794	–	247	-12.82	–	–	–
162811	SWAMP BORE 1	EX	1/01/2001	621517.97	7568789.7	REWAN FORMATION	249	-9.5	372	–	–
162810	BURTON COAL BORE 2	EX	17/12/1994	620384	7573599	–	246	-13.37	2,087	–	–
162565	-	EX	21/04/2016	617423	7568883	FORT COOPER CM	–	-47	–	126 – 132	6 – 122 & 124 – 137
162552	MB1	EX	22/02/2016	618792.84	7572213.9	RANGAL COAL MEASURES	236.54	-15.54	6,000	22.50 – 28.50	19.80 – 29.15
162551	MB2	EX	21/02/2016	619073.87	7573137.2	RANGAL COAL MEASURES	242.88	-15.98	–	48.70 – 51.70	46.15 – 51.93
162550	MB4	EX	19/02/2016	620241	7567301	QUATERNARY - UNDEFINED	237.56	–	–	7.80 – 10.80	2.30 – 11.00
162549	MB6	EX	19/02/2016	619374.37	7567545.1	BASALT	235.72	-11.75	–	6.50 – 12.50	3.70 – 13.00
162548	MB3	EX	19/02/2016	618933	7568292	RANGAL COAL MEASURES	253	-27.95	–	49.64 – 52.64	48.35 – 52.66
162547	MB5	EX	18/02/2016	618394	7570698	RANGAL COAL MEASURES	241.83	-22.59	–	36.30 – 39.30	34.00 – 39.40
162041	BC770	EX	4/07/2005	622162	7573331	REWAN GROUP	267.26	-35.72	4,360	94.70 – 100.70	91 – 101
162028	BC791	EX	4/07/2005	622165	7573319	BASALT	-	-27	1,210	61.00 – 67.00	7 – 82; 82 – 84.50
162020	BC769	EX	3/07/2005	622073	7573245	BASALT	267	-24.77	957	54.5 – 60.5	7 – 60.5
162017	BC746	EX	4/07/2005	621699	7572436	BASALT	259	-14.92	3,980	24 – 30	7 – 32.96
162016	BC745	EX	4/07/2005	621754	7572407	BASALT	261	-16.73	–	6 – 11	6 – 24.90
162015	BC744	EX	4/07/2005	621796	7572381	BASALT	–	–	–	–	7 – 16.97
162014	BC743	EX	4/07/2005	621993	7572501	BASALT	265	-16.22	–	14 – 20	7 – 24.72
162013	BC739	EX	3/07/2005	621998	7572002	BASALT	262.75	-17.2	3,210	34 – 40	7 – 40
162012	BC738	EX	4/07/2005	621900	7572494	BASALT	265	-15.51	–	15 – 21	7 – 21; 22 – 26.30
162011	BC737	EX	4/07/2005	621951	7572589	BASALT	264	-12.27	2,620	22 – 28	7 – 30
141981	BC768	EX	29/06/2005	622210	7573376	BASALT	272	-27	1,240	48.50 – 54.50	7 – 58
141865	BC736	EX	4/07/2005	621974	7572779	BASALT	258	-16.68	1,050	20.50 – 26.50	7 – 32
141864	BC734	AU	4/07/2005	621978	7572901	BASALT	262.7	-20.66	1,314	31.50 – 37.50	7 – 41.90
141809	BC727	EX	3/07/2005	621748	7571997	–	–	–	–	5 – 11	5 – 22
105435	141C	EX	17/12/1994	620090	7573318	REWAN GROUP	250	-17.2	2690 – 5670	-	-
141808	BC726	EX	3/07/2005	621794	7572499	BASALT	261	-14.15	4,300	22 – 28	7 – 28.50; 28.50 – 30
141807	BC724	EX	3/07/2005	621693	7573807	BASALT	261.79	-20.15		46.80 – 53	7 – 53
141696	BC723	EX	3/07/2005	621998	7574807	BASALT	260	-11.69	1,550	39 – 45	7 – 45
141605	BC721	EX	3/07/2005	622186	7574781	BASALT	259	-10.96	2,620	37 – 44	7 – 45
141561	GW23	EX	7/12/2008	623516	7571386	–	–	–	–	19 – 25	18 – 25

RN	Original Name	Facility Status	Date Drilled	Easting (AGD84)	Northing (AGD84)	Screened Lithology	Elevation	SWL (mbGL)	EC (µS/cm)	Screen Interval (mbGL)	Gravel Pack Interval (mbGL)
141458	BC707	EX	3/07/2005	622102	7573101	BASALT	266	-29.92	1,206	59 – 65	7 – 65.68
141457	BC706	EX	3/07/2005	621946	7573298	BASALT	263	-20.14	1,167	49.28 – 55.28	7 – 55.28
141456	BC703	EX	3/07/2005	622097	7574303	BASALT	267	-32.94	1,152	51 – 58.15	7 – 58.15
141441	BC679	AU	2/07/2005	622399	7575299	BASALT	260	-27.42	1,171	56.3 – 62.30	7 – 62.30; 63 – 65
131002	BLJV-WB06BC680	EX	18/11/2005	621997	7574302	BASALT	–	-27	1,022	57.5 – 62.5	7 – 63
105677	BLJV-WB03(BC705)	EX	13/06/2005	622136	7573306	TERTIARY - UNDEFINED	–	-25.14	1,055	62.10 – 67.10	7 – 67.7
100224	MGC MORANBAH 1	EX	5/11/1993	615843	7567074	–	–	–	–	–	–
100083	MGC WOTONGA 1	EX	25/09/1992	622493	7569830	REWAN FORMATION, RANGAL CM, FORT COOPER CM, & MORANBAH CM.	–	–	–	Open Hole	Open Hole
81909	SMOKY CREEK	EX	17/12/1994	620090	7573318	REWAN GROUP	250	-17.2	2,690 – 5,670	–	–
–	240P	–	–	616573	7571997	–	–	–	–	–	–
–	BC095	–	–	616507	7571995	–	–	–	–	–	–
–	Burton Coal Bore 1	AD	–	620267	7573421	–	–	–	–	–	–

APPENDIX II

Summary of Groundwater Quality Data

Appendix II

Table II.1 Summary Groundwater Chemistry Data

Bore ID			Burton Coal 1	Burton Coal 2	Swamp Bore 2	MB1	MB2	MB3	MB4a	MB4b	MB5	MB6	MB7	MB8	MB9	MB10
Geological Unit			Rewan Group	Rewan Group	Rewan Group	Rangal Coal Measures	Rangal Coal Measures	Rangal Coal Measures	Tertiary Sediments	Tertiary Sediments	Rangal Coal Measures	Tertiary Basalt	Rangal Coal Measures	Rangal Coal Measures	Rangal Coal Measures	Tertiary Basalt
Number of samples			2	45	40	17	17	10	12	7	10	11	29	9	9	13
Monitoring Duration			07/2015 – 10/2018	06/2008 – 07/2020	11/2008 – 07/2020	02/2016 – 07/2020	02/2016 – 07/2020	02/2016 – 10/2018	02/2016 – 07/2020	07/2018 – 07/2020	02/2016 – 10/2018	02/2016 – 01/2019	02/2016 – 07/2020	07/2018 – 07/2020	07/2018 – 07/2020	07/2018 – 07/2020
pH	pH units	Min	7	5	5	7	7	7	7	8	7	7	5	7	7	7
		Mean	7	7	7	8	8	8	7	8	8	8	7	8	8	8
		Max	7	8	8	8	8	8	8	8	8	8	8	8	8	9
Electrical Conductivity	µS/cm	Min	5420	1110	4670	3140	7320	18400	49300	30200	23100	6760	18000	11500	10400	1780
		Mean	6210	5074	8795	3836	8238	20790	51750	31100	24070	7292	20259	11956	10744	5240
		Max	7000	9000	9410	5030	11000	22500	54800	31700	25600	8700	24100	12600	11000	11000
Total Dissolved Solids @180°C	mg/L	Min	3110	563	2450	1740	4100	10800	34500	17600	15100	3840	11300	7160	6040	992
		Mean	3590	3077	6203	2154	4778	13210	38158	19500	16210	4076	13683	7710	6943	3121
		Max	4070	6800	8110	2720	6880	14600	42400	20500	16900	4390	17700	8200	7740	7170
Suspended Solids (SS)	mg/L	Min	3	3	2	3	3	3	180	28	5	3	3	6	5	3
		Mean	4	12	13	9	47	17	1714	8577	29	270	28	59	27	20
		Max	6	162	84	30	312	35	7530	35400	66	946	88	154	76	63
Carbonate Alkalinity as $CaCO_3$	mg/L	Min	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Mean	1	44	3	1	1	1	1	3	1	1	1	1	1	4
		Max	1	900	75	4	10	1	1	18	1	1	1	1	1	43
Bicarbonate Alkalinity as $CaCO_3$	mg/L	Min	648	1	1	394	612	571	361	1090	503	630	2	97	99	102
		Mean	679	548	78	492	759	624	398	1157	543	739	260	177	109	381
		Max	709	900	818	581	859	671	437	1270	577	790	490	272	132	623
Total Alkalinity as $CaCO_3$	mg/L	Min	648	1	1	394	612	571	361	1110	503	630	2	97	99	102
		Mean	679	627	89	492	760	624	398	1160	543	739	260	177	109	385
		Max	709	900	818	581	859	671	437	1270	577	790	490	272	132	623
Sulfate as SO_4	mg/L	Min	79	26	71	35	146	590	842	375	936	73	74	2	1	1
		Mean	89	93	124	51	178	824	921	389	1018	96	250	117	4	74
		Max	98	380	170	99	273	979	983	406	1050	142	559	361	10	139
Chloride	mg/L	Min	1480	125	982	756	1910	6530	6320	10400	1920	1730	6270	4010	3560	202
		Mean	1750	1354	3033	1076	2468	8379	16362	10657	7543	2467	7175	4173	3799	1574
		Max	2020	3600	3600	2310	3710	20300	19900	10800	8700	6600	8650	4290	3890	3860
Calcium	mg/L	Min	141	33	94	69	103	287	380	81	122	104	415	280	262	37
		Mean	174	144	527	105	159	359	591	94	351	169	619	322	306	132
		Max	206	550	608	138	546	630	726	124	422	640	793	402	360	360
Magnesium	mg/L	Min	180	16	109	94	153	368	1600	446	543	222	194	114	136	72
		Mean	225	146	133	117	190	429	1858	474	607	249	351	129	146	112
		Max	270	315	160	136	292	486	2070	521	655	284	566	139	160	160
Sodium	mg/L	Min	800	150	720	405	1220	3210	8460	6400	4060	931	2840	1840	1620	228
		Mean	860	729	1105	530	1376	3754	9537	7033	4141	1058	3462	2072	1719	833

Bore ID			Burton Coal 1	Burton Coal 2	Swamp Bore 2	MB1	MB2	MB3	MB4a	MB4b	MB5	MB6	MB7	MB8	MB9	MB10
Geological Unit			Rewan Group	Rewan Group	Rewan Group	Rangal Coal Measures	Rangal Coal Measures	Rangal Coal Measures	Tertiary Sediments	Tertiary Sediments	Rangal Coal Measures	Tertiary Basalt	Rangal Coal Measures	Rangal Coal Measures	Rangal Coal Measures	Tertiary Basalt
Number of samples			2	45	40	17	17	10	12	7	10	11	29	9	9	13
Monitoring Duration			07/2015 – 10/2018	06/2008 – 07/2020	11/2008 – 07/2020	02/2016 – 07/2020	02/2016 – 07/2020	02/2016 – 10/2018	02/2016 – 07/2020	07/2018 – 07/2020	02/2016 – 10/2018	02/2016 – 01/2019	02/2016 – 07/2020	07/2018 – 07/2020	07/2018 – 07/2020	07/2018 – 07/2020
		Max	919	1300	1300	696	1810	4110	10400	7610	4330	1320	4260	2310	1890	1890
Potassium	mg/L	Min	4	4	4	3	7	39	2	3	29	5	15	13	19	4
		Mean	5	7	22	4	8	41	4	3	32	6	18	14	20	11
		Max	5	26	29	5	9	44	6	4	35	9	22	16	20	20
Aluminium (Dissolved)	mg/L	Min	0.005	0.005	0.005	0.005	0.005	0.005	0.025	0.025	0.005	0.005	0.005	0.005	0.005	0.005
		Mean	0.005	0.0064	0.007	0.007	0.0079	0.011	0.0458	0.0392	0.014	0.0068	0.0082	0.013	0.0083	0.01
		Max	0.005	0.02	0.04	0.01	0.02	0.03	0.05	0.05	0.04	0.01	0.03	0.05	0.01	0.02
Antimony (Dissolved)	mg/L	Min	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0025	0.0025	0.0005	0.0005	0.0005	5E-04	0.0005	0.0005
		Mean	0.0005	0.0006	0.0006	0.0007	0.0007	0.0006	0.0045	0.0039	0.0007	0.0006	0.0009	0.001	0.0008	0.0008
		Max	0.0005	0.001	0.001	0.001	0.001	0.001	0.005	0.005	0.001	0.001	0.006	0.003	0.001	0.001
Arsenic (Dissolved)	mg/L	Min	0.0005	0.0005	0.0005	0.0005	0.003	0.001	0.0025	0.0025	0.0005	0.002	0.0005	0.003	0.0005	0.001
		Mean	0.0005	0.002	0.001	0.004	0.0234	0.021	0.0045	0.0045	0.0076	0.0032	0.0010	0.004	0.0026	0.0026
		Max	0.0005	0.01	0.005	0.008	0.036	0.03	0.005	0.007	0.015	0.005	0.003	0.008	0.007	0.007
Cadmium (Dissolved)	mg/L	Min				0.00005	0.00005	0.0005			0.00005	5E-05				
		Mean				0.00005	0.00005	0.0005			0.00005	5E-05				
		Max				0.00005	0.00005	0.0005			0.00005	5E-05				
Chromium (Dissolved)	mg/L	Min				0.0005	0.0005	0.0005			0.0005	0.0005				
		Mean				0.0005	0.0005	0.0005			0.0005	0.0005				
		Max				0.0005	0.0005	0.0005			0.0005	0.0005				
Cobalt (Dissolved)	mg/L	Min				0.0005	0.003	0.0005			0.0005	0.0005				
		Mean				0.0005	0.003	0.0005			0.0005	0.0005				
		Max				0.0005	0.003	0.0005			0.0005	0.0005				
Copper (Dissolved)	mg/L	Min				0.001	0.0005	0.001			0.0005	0.003				
		Mean				0.001	0.0005	0.001			0.0005	0.003				
		Max				0.001	0.0005	0.001			0.0005	0.003				
Lead (Dissolved)	mg/L	Min				0.0005	0.0005	0.0005			0.0005	0.0005				
		Mean				0.0005	0.0005	0.0005			0.0005	0.0005				
		Max				0.0005	0.0005	0.0005			0.0005	0.0005				
Manganese (Dissolved)	mg/L	Min				0.129	0.138	0.122			0.09	0.026				
		Mean				0.129	0.138	0.122			0.09	0.026				
		Max				0.129	0.138	0.122			0.09	0.026				
Molybdenum (Dissolved)	mg/L	Min	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.0025	0.0025	0.001	0.0005	0.0005	0.002	0.001	0.001
		Mean	0.0005	0.0007	0.0007	0.0022	0.0023	0.0041	0.0061	0.0067	0.0021	0.0024	0.0148	0.007	0.0025	0.011
		Max	0.0005	0.003	0.002	0.012	0.004	0.009	0.02	0.011	0.004	0.007	0.129	0.015	0.005	0.02
Nickel (Dissolved)	mg/L	Min				0.001	0.006	0.0005			0.0005	0.008				
		Mean				0.001	0.006	0.0005			0.0005	0.008				
		Max				0.001	0.006	0.0005			0.0005	0.008				
Selenium (Dissolved)	mg/L	Min	0.005	0.0005	0.0005	0.005	0.005	0.005	0.025	0.025	0.005	0.005	0.005	0.005	0.005	0.005

Bore ID			Burton Coal 1	Burton Coal 2	Swamp Bore 2	MB1	MB2	MB3	MB4a	MB4b	MB5	MB6	MB7	MB8	MB9	MB10
Geological Unit			Rewan Group	Rewan Group	Rewan Group	Rangal Coal Measures	Rangal Coal Measures	Rangal Coal Measures	Tertiary Sediments	Tertiary Sediments	Rangal Coal Measures	Tertiary Basalt	Rangal Coal Measures	Rangal Coal Measures	Rangal Coal Measures	Tertiary Basalt
Number of samples			2	45	40	17	17	10	12	7	10	11	29	9	9	13
Monitoring Duration			07/2015 – 10/2018	06/2008 – 07/2020	11/2008 – 07/2020	02/2016 – 07/2020	02/2016 – 07/2020	02/2016 – 10/2018	02/2016 – 07/2020	07/2018 – 07/2020	02/2016 – 10/2018	02/2016 – 01/2019	02/2016 – 07/2020	07/2018 – 07/2020	07/2018 – 07/2020	07/2018 – 07/2020
		Mean	0.005	0.0048	0.0056	0.0073	0.0073	0.006	0.0458	0.0392	0.007	0.0064	0.0072	0.008	0.0083	0.0080
		Max	0.005	0.01	0.01	0.01	0.01	0.01	0.05	0.05	0.01	0.01	0.01	0.01	0.01	0.01
Silver (Dissolved)	mg/L	Min	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0025	0.0025	0.0005	0.0005	0.0005	5E-04	0.0005	0.0005
		Mean	0.0005	0.0006	0.0006	0.0007	0.0007	0.0006	0.0047	0.0039	0.0007	0.0006	0.0007	8E-04	0.0008	0.0008
		Max	0.0005	0.001	0.001	0.001	0.001	0.001	0.007	0.005	0.001	0.001	0.001	0.001	0.001	0.001
Zinc (Dissolved)	mg/L	Min				0.01	0.0025	0.0025			0.0025	0.0025				
		Mean				0.01	0.0025	0.0025			0.0025	0.0025				
		Max				0.01	0.0025	0.0025			0.0025	0.0025				
Boron (dissolved)	mg/L	Min				0.34	0.97	0.93			1.57	0.86				
		Mean				0.34	0.97	0.93			1.57	0.86				
		Max				0.34	0.97	0.93			1.57	0.86				
Iron (Dissolved)	mg/L	Min	0.025	0.005	0.005	0.025	0.025	0.025	0.025	0.025	0.05	0.025	0.025	0.025	0.06	0.025
		Mean	0.025	0.234	0.352	0.135	0.780	2.724	0.198	0.042	1.453	0.056	0.993	0.08	0.43	0.148
		Max	0.025	1.64	1.16	0.55	1.69	5.44	1.17	0.07	3.34	0.26	3.41	0.17	0.7	0.62
Mercury (Dissolved)	mg/L	Min	5E-05	3E-05	3E-05	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	5E-05	0.00005	5E-05	5E-05	0.00005
		Mean	5E-05	6E-05	6E-05	7.353E-05	7.353E-05	0.00006	0.0001	7.857E-05	0.00007	6E-05	7.2E-05	8E-05	8E-05	8.08E-05
		Max	5E-05	0.0003	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	1E-04	0.0001	0.0001
Fluoride	mg/L	Min	0.2	3E-05	0.05	0.4	0.4	0.2	0.2	0.5	0.2	0.4	0.05	0.1	0.1	0.1
		Mean	0.2	0.1714	0.0733	0.48	0.48	0.225	0.283	0.6	0.275	0.455	0.093	0.2	0.1778	0.2230
		Max	0.2	0.2	0.1	0.6	0.6	0.3	0.3	0.8	0.3	0.5	0.1	0.3	0.2	0.4
C6 - C9 Fraction	µg/L	Min	10	5	5	10	10	10	10	10	10	10	10	10	10	10
		Mean	10	10.9	11.6	14.7	14.7	12	18.3	15.7	10	12.7	14.4	16.7	16.7	16.1
		Max	10	20	20	20	20	20	20	20	10	20	20	20	20	20
C10 - C36 Fraction (sum)	µg/L	Min	25	50	25	25	25	25	25	25	25	25	25	25	25	25
		Mean	25	51.67	33.8	77.5	78.24	79	97.5	65	74	38.64	49.14	41.7	41.7	62.5
		Max	25	100	50	270	270	270	230	230	270	50	50	50	50	200

Table II.2 Summary Hydrostratigraphic Unit Chemistry Data and Comparison Against Applicable Objectives/Guidelines

Unit	Parameter	Unit	Count	5%ile	10%tile	90%ile	95%ile	Min	Max	Range	Average	Median	STDEV	Lower Isaac Zone 34 WQ Objectives (<30m)			Lower Isaac Zone 34 WQ Objectives (>30m)			ANZG – Aquatic Ecosystem (2018)
														20%ile	50%ile	80%ile	20%ile	50%ile	80%ile	
Tertiary Sediments	pH Value		15	6.8	6.9	7.8	8.0	6.7	8.3	1.6	7.4	7.6	0.5	7.1	7.75	8.1				
	Electrical Conductivity	µS/cm	15			52,880	53,030	30,200	53,100	22,900	42,053	49,300	10,665	498	2150	8910				
	Total Hardness as CaCO3	mg/L	0											163	674	2228				
	Total Alkalinity as CaCO3	mg/L	15			1,168	1,207	361	1,270	909	749	437	399	154	435	752				
	Calcium	mg/L	15			694	709	81	726	645	392	578	291	18	84	215				
	Magnesium	mg/L	15			1,958	1,973	446	1,980	1,534	1,233	1,760	737	27	108	389				
	Sodium	mg/L	15			10,156	10,330	6,400	10,400	4,000	8,455	8,900	1,450	135	747	1500				
	Chloride	mg/L	15			19,860	19,900	10,400	19,900	9,500	15,447	19,000	4,644	171	1309	3185				
	Sulfate	mg/L	15			963	970	375	983	608	673	842	277	12	140	318				
	HCO3	mg/L	0											187	536	878				
	Nitrate	mg/L	0											0	0.95	5.3				
	SiO2	mg/L	0											21	36	52				
	Fluoride	mg/L	15			0.60	0.66	0.30	0.80	0.50	0.44	0.30	0.17	0.1	0.28	0.5				
	Iron (Dissolved)	mg/L	15			0.06	0.06	0.05	0.07	0.02	0.05	0.05	0.01	0	0.03	0.14				0.7
	Manganese (Dissolved)	mg/L	0											0	0.01	0.16				1.9
	Zinc (Dissolved)	mg/L	0											0	0.015	0.06				
	Copper (Dissolved)	mg/L	0											0	0.01	0.03				
	Lead (Dissolved)	mg/L	0																	0.0034
	Cadmium (Dissolved)	mg/L	0																	0.0002
	Nickel (Dissolved)	mg/L	0																	0.011
	Total Dissolved Solids @180°C	mg/L	15			41,300	41,770	17,600	42,400	24,800	30,093	36,000	10,404							
	Suspended Solids (SS)	mg/L	15			9,312	17,970	28	35,400	35,372	5,130	1,690	8,918							
	Potassium	mg/L	15			5	5	2	6	4	4	3	1							
	Aluminium (Dissolved)	mg/L	15			0.05	0.05	0.05	0.05	0	0.05	0.05	7.18E-18							0.0055
	Antimony (Dissolved)	mg/L	15			0.01	0.01	0.01	0.01	0	0.01	0.01	0							0.009
	Arsenic (Dissolved)	mg/L	15			0.01	0.01	0.01	0.01	0.002	0.01	0.01	0.0005							0.013
	Molybdenum (Dissolved)	mg/L	13			0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.0047							0.034
	Selenium (Dissolved)	mg/L	15			0.05	0.05	0.05	0.05	-	0.05	0.05	7.18E-18							0.005
	Silver (Dissolved)	mg/L	15			0.01	0.01	0.01	0.01	0.002	0.01	0.01	0.0005							0.00005
	Mercury (Dissolved)	mg/L	15			0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.00003							0.0006
	C6 - C9 Fraction	µg/l	15			20	20	20	20	0	20	20	0							
	C10 - C36 Fraction (sum)	µg/l	15			164	223	50	230	180	75	50	61							
	Chromium (Dissolved)	mg/L	0																	0.001
	Cobalt (Dissolved)	mg/L	0																	0.0014
	Boron (Dissolved)	mg/L	0																	0.94
	Ammonia as N	mg/L	0																	0.9
	Carbonate Alkalinity as CaCO3	mg/L	15			1	6	1	18	17	2	1	4							

Unit	Parameter	Unit	Count	5%ile	10%tile	90%ile	95%ile	Min	Max	Range	Average	Median	STDEV	Lower Isaac Zone 34 WQ Objectives (<30m)			Lower Isaac Zone 34 WQ Objectives (>30m)			ANZG – Aquatic Ecosystem (2018)
														20%ile	50%ile	80%ile	20%ile	50%ile	80%ile	
Rangal Coal Measures	pH Value		101	7.0	7.2	8.1	8.2	5.1	8.3	3.2	7.6	7.5	0.5				7.4	7.8	8.03	
	Electrical Conductivity	µS/cm	101			23,500	24,000	3,140	25,600	22,460	14,313	12,300	7,220				3419	6100	16000	
	Total Hardness as CaCO3	mg/L	0														359	919	3208	
	Total Alkalinity as CaCO3	mg/L	92			764	774	2	859	857	413	455	232				156	275	536	
	Calcium	mg/L	101			633	727	69	793	724	348	320	210				46	145	442	
	Magnesium	mg/L	101			553	616	94	655	561	279	194	168				35	115	491	
	Sodium	mg/L	101			4,060	4,140	405	4,330	3,925	2,434	2,270	1,300				480	1100	2565	
	Chloride	mg/L	101			8,200	8,520	756	20,300	19,544	4,943	4,180	3,039				753	1900	5905	
	Sulfate	mg/L	101			961	1,040	1	1,050	1,049	304	167	337				25	138	398	
	HCO3	mg/L	0														188	330	650	
	Nitrate	mg/L	0														0.01	2.15	14.92	
	SiO2	mg/L	0														16	25	36	
	Fluoride	mg/L	81			0.50	0.50	0.10	0.60	0.50	0.29	0.20	0.16				0.02	0.155	0.4	
	Iron (Dissolved)	mg/L	101			2.91	3.84	0.05	5.44	5.39	0.90	0.36	1.25				0	0.05	0.246	0.7
	Manganese (Dissolved)	mg/L	4			0.14	0.14	0.09	0.14	0.05	0.12	0.13	0.02				0	0.05	0.291	1.9
	Zinc (Dissolved)	mg/L	4			0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00				0.01	0.025	0.317	
	Copper (Dissolved)	mg/L	4			0.001	0.001	0.001	0.001	0	0.001	0.001	0				0.017	0.03	0.03	
	Lead (Dissolved)	mg/L	4			0	0	0.001	0.001	0	0.001	0.001	0							0.0034
	Cadmium (Dissolved)	mg/L	4			0.0001	0.0001	0.0001	0.00	0	0.0001	0.0001	0							0.0002
	Nickel (Dissolved)	mg/L	4			0.005	0.005	0.001	0.01	0.01	0.002	0.001	0.003							0.011
	Total Dissolved Solids @180°C	mg/L	101			16,200	16,700	1,740	17,700	15,960	9,314	8,090	5,104							
	Suspended Solids (SS)	mg/L	101			66	88	5	312	307	30	18	40							
	Potassium	mg/L	101			35	41	3	44	41	17	17	11							
	Aluminium (Dissolved)	mg/L	101			0.01	0.03	0.01	0.05	0.04	0.01	0.01	0.01							0.0055
	Antimony (Dissolved)	mg/L	101			0.001	0.001	0.001	0.01	0.01	0.001	0.001	0.001							0.009
	Arsenic (Dissolved)	mg/L	101			0.03	0.03	0.001	0.04	0.04	0.01	0.003	0.01							0.013
	Molybdenum (Dissolved)	mg/L	96			0.01	0.02	0.001	0.13	0.13	0.01	0.002	0.02							0.034
	Selenium (Dissolved)	mg/L	101			0.01	0.01	0.01	0.01	0	0.01	0.01	7.0E-18							0.005
	Silver (Dissolved)	mg/L	101			0.001	0.001	0.001	0.001	0	0.001	0.001	6.5E-19							0.00005
	Mercury (Dissolved)	mg/L	101			0.0001	0.0001	0.0001	0.0001	0	0.0001	0.0001	5.4E-20							0.0006
	C6 - C9 Fraction	µg/l	101			20	20	20	20	0	20	20	0							
	C10 - C36 Fraction (sum)	µg/l	101			50	270	50	270	120	180	50	45							
	Chromium (Dissolved)	mg/L	4			0.001	0.001	0.001	0.001	0	0.001	0.001	0							0.001
	Cobalt (Dissolved)	mg/L	4			0.002	0.003	0.001	0.003	0.002	0.002	0.001	0.001							0.0014
	Boron (Dissolved)	mg/L	4			1.39	1.48	0.34	1.57	1.23	0.95	0.95	0.50							0.94
	Ammonia as N	mg/L	0																	0.9
	Carbonate Alkalinity as CaCO3	mg/L	92			1	1	1	10	9	1	1	1							

Unit	Parameter	Unit	Count	5%ile	10%tile	90%ile	95%ile	Min	Max	Range	Average	Median	STDEV	Lower Isaac Zone 34 WQ Objectives (<30m)			Lower Isaac Zone 34 WQ Objectives (>30m)			ANZG – Aquatic Ecosystem (2018)
														20%ile	50%ile	80%ile	20%ile	50%ile	80%ile	
Rewan Group	pH Value		43	7.1	7.3	7.9	8.2	4.7	8.3	3.6	7.4	7.4	0.7				7.4	7.8	8.03	
	Electrical Conductivity	µS/cm	42			8,439	8,962	1,110	9,460	8,350	5,763	5,390	1,845				3419	6100	16000	
	Total Hardness as CaCO3	mg/L	3			2,050	2,060	1,880	2,070	190	1,973	1,970	95				359	919	3208	
	Total Alkalinity as CaCO3	mg/L	40			798	818	1	840	839	619	709	242				156	275	536	
	Calcium	mg/L	40			229	520	35	581	546	158	126	124				46	145	442	
	Magnesium	mg/L	40			282	288	16	315	299	168	162	71				35	115	491	
	Sodium	mg/L	40			1,011	1,091	150	1,180	1,030	767	758	196				480	1100	2565	
	Chloride	mg/L	40			2,292	2,862	125	3,100	2,975	1,449	1,340	686				753	1900	5905	
	Sulfate	mg/L	40			129	135	26	145	119	91	88	25				25	138	398	
	HCO3	mg/L	0														188	330	650	
	Nitrate	mg/L	2			0.31	0.32	0.01	0.34	0.33	0.18	0.18	0.23				0.01	2.15	14.92	
	SiO2	mg/L	0														16	25	36	
	Fluoride	mg/L	16			0.20	0.20	0.10	0.20	0.10	0.18	0.20	0.04				0.02	0.155	0.4	
	Iron (Dissolved)	mg/L	36			0.82	1.00	0.05	1.64	1.59	0.24	0.05	0.39				0	0.05	0.246	0.7
	Manganese (Dissolved)	mg/L	0														0	0.05	0.291	1.9
	Zinc (Dissolved)	mg/L	0														0.01	0.025	0.317	
	Copper (Dissolved)	mg/L	0														0.017	0.03	0.03	
	Lead (Dissolved)	mg/L	0																	0.0034
	Cadmium (Dissolved)	mg/L	0																	0.0002
	Nickel (Dissolved)	mg/L	0																	0.011
	Total Dissolved Solids @180°C	mg/L	43			4,914	7,780	563	8,750	8,187	3,511	3,100	1,774							
	Suspended Solids (SS)	mg/L	39			17	20	3	162	159	13	5	25							
	Potassium	mg/L	40			6	24	4	27	23	7	5	6							
	Aluminium (Dissolved)	mg/L	36			0.01	0.01	0.01	0.01	0	0.01	0.01	0.00							0.0055
	Antimony (Dissolved)	mg/L	36			0.001	0.001	0.001	0.00	0	0.00	0.00	0.00							0.009
	Arsenic (Dissolved)	mg/L	36			0.002	0.007	0.001	0.01	0.01	0.00	0.00	0.00							0.013
	Molybdenum (Dissolved)	mg/L	35			0.001	0.001	0.001	0.00	0.00	0.00	0.00	0.00							0.034
	Selenium (Dissolved)	mg/L	36			0.010	0.010	0.001	0.01	0.01	0.01	0.01	0.00							0.005
	Silver (Dissolved)	mg/L	36			0.001	0.001	0.001	0.001	-	0.001	0.001	0.0003							0.00005
	Mercury (Dissolved)	mg/L	37			0.0001	0.0001	0.0001	0.0001	0.00004	0.0001	0.0001	0.00003							0.0006
	C6 - C9 Fraction	µg/l	36			20	20	10	20	10	20	20	6							
	C10 - C36 Fraction (sum)	µg/l	36			50	50	50	100	50	51	50	17							
	Chromium (Dissolved)	mg/L	0																	0.001
	Cobalt (Dissolved)	mg/L	0																	0.0014
	Boron (Dissolved)	mg/L	1			0.93	0.93	0.93	0.93	0	0.93	0.93								0.94
	Ammonia as N	mg/L	1			0.87	0.87	0.87	0.87	0	0.87	0.87								0.9
	Carbonate Alkalinity as CaCO3	mg/L	40			1	2	1	840	839	22	1	133							

Unit	Parameter	Unit	Count	5%ile	10%tile	90%ile	95%ile	Min	Max	Range	Average	Median	STDEV	Lower Isaac Zone 34 WQ Objectives (<30m)			Lower Isaac Zone 34 WQ Objectives (>30m)			ANZG – Aquatic Ecosystem (2018)
														20%ile	50%ile	80%ile	20%ile	50%ile	80%ile	
Tertiary Basalt	pH Value		20	7.2	7.4	8.2	8.2	7.2	8.5	1.3	7.8	7.9	0.4	7.1	7.75	8.1				
	Electrical Conductivity	µS/cm	20			7,260	8,700	1,780	8,700	6,920	5,287	6,840	2,414	498	2150	8910				
	Total Hardness as CaCO3	mg/L	0											163	674	2228				
	Total Alkalinity as CaCO3	mg/L	18			770	777	339	790	451	621	627	148	154	435	752				
	Calcium	mg/L	20			143	172	37	640	603	117	104	129	18	84	215				
	Magnesium	mg/L	20			264	284	72	284	212	179	222	82	27	108	389				
	Sodium	mg/L	20			1,095	1,320	228	1,320	1,092	774	935	349	135	747	1500				
	Chloride	mg/L	20			2,710	2,905	202	6,600	6,398	1,631	1,730	1,420	171	1309	3185				
	Sulfate	mg/L	20			139	142	23	142	119	100	96	28	12	140	318				
	HCO3	mg/L	0											187	536	878				
	Nitrate	mg/L	0											0	0.95	5.3				
	SiO2	mg/L	0											21	36	52				
	Fluoride	mg/L	18			0.50	0.50	0.20	0.50	0.30	0.36	0.40	0.12	0.1	0.28	0.5				
	Iron (Dissolved)	mg/L	20			0.05	0.10	0.05	0.26	0.21	0.06	0.05	0.05	0	0.03	0.14				0.7
	Manganese (Dissolved)	mg/L	1			0.03	0.03	0.03	0.03	0	0.03	0.03		0	0.01	0.16				1.9
	Zinc (Dissolved)	mg/L	1			0.01	0.01	0.01	0.01	0	0.01	0.01		0	0.015	0.06				
	Copper (Dissolved)	mg/L	1			0.003	0.003	0.003	0.003	0	0.003	0.003		0	0.01	0.03				
	Lead (Dissolved)	mg/L	1			-	0.0001	0.0001	0.0001	0	0.0001	0.0001								0.0034
	Cadmium (Dissolved)	mg/L	1			0.0001	0.0001	0.0001	0.0001	0	0.0001	0.0001								0.0002
	Nickel (Dissolved)	mg/L	1			0.01	0.01	0.01	0.01	0	0.01	0.01								0.011
	Total Dissolved Solids @180°C	mg/L	20			4,270	4,276	992	4,390	3,398	2,976	3,850	1,312							
	Suspended Solids (SS)	mg/L	20			518	539	5	946	941	159	28	255							
	Potassium	mg/L	20			9.00	9.00	4.00	9.00	5.00	6.45	6.00	1.54							
	Aluminium (Dissolved)	mg/L	20			0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.00							0.0055
	Antimony (Dissolved)	mg/L	20			0.001	0.001	0.001	0.001	0	0.001	0.001	0.000							0.009
	Arsenic (Dissolved)	mg/L	20			0.005	0.005	0.001	0.005	0.00	0.003	0.002	0.001							0.013
	Molybdenum (Dissolved)	mg/L	19			0.02	0.02	0.00	0.02	0.02	0.01	0.00	0.01							0.034
	Selenium (Dissolved)	mg/L	20			0.01	0.01	0.01	0.01	0	0.01	0.01	1.8E-18							0.005
	Silver (Dissolved)	mg/L	20			0.001	0.001	0.001	0.001	0	0.001	0.001	4.4E-19							0.00005
	Mercury (Dissolved)	mg/L	20			0.0001	0.0001	0.0001	0.0001	0	0.0001	0.0001	1.4E-20							0.0006
	C6 - C9 Fraction	µg/l	20			20	20	20	20	0	20	20	0							
	C10 - C36 Fraction (sum)	µg/l	20			50	57.5	25	200	175	51.5	50	41.3							
	Chromium (Dissolved)	mg/L	1			0.001	0.001	0.001	0.001	0	0.001	0.001								0.001
	Cobalt (Dissolved)	mg/L	1			0.001	0.001	0.001	0.001	0	0.001	0.001								0.0014
	Boron (Dissolved)	mg/L	1			0.86	0.86	0.86	0.86	0	0.86	0.86								0.94
	Ammonia as N	mg/L	0																	0.9
	Carbonate Alkalinity as CaCO3	mg/L	18			1	7	1	43	42	3	1	10							

APPENDIX III

Summary of Groundwater Level Hydrographs

Appendix III

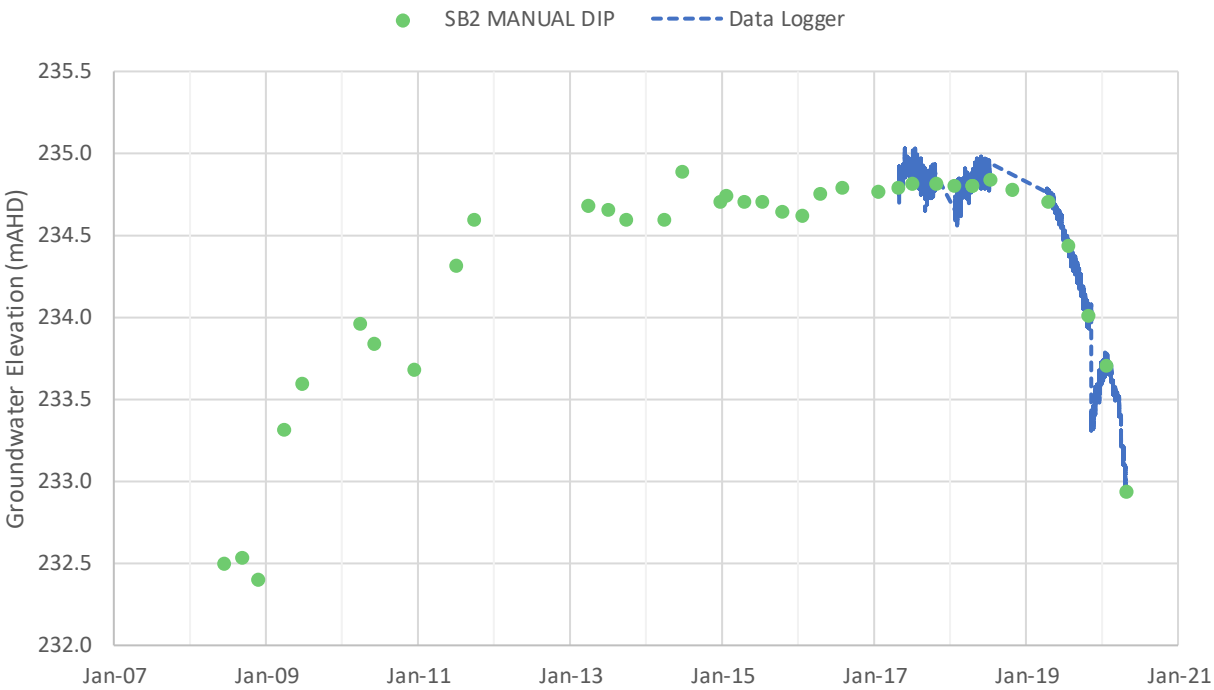

Figure III.1 Swamp Bore 2 Groundwater Elevation Hydrograph (Rewan Group)

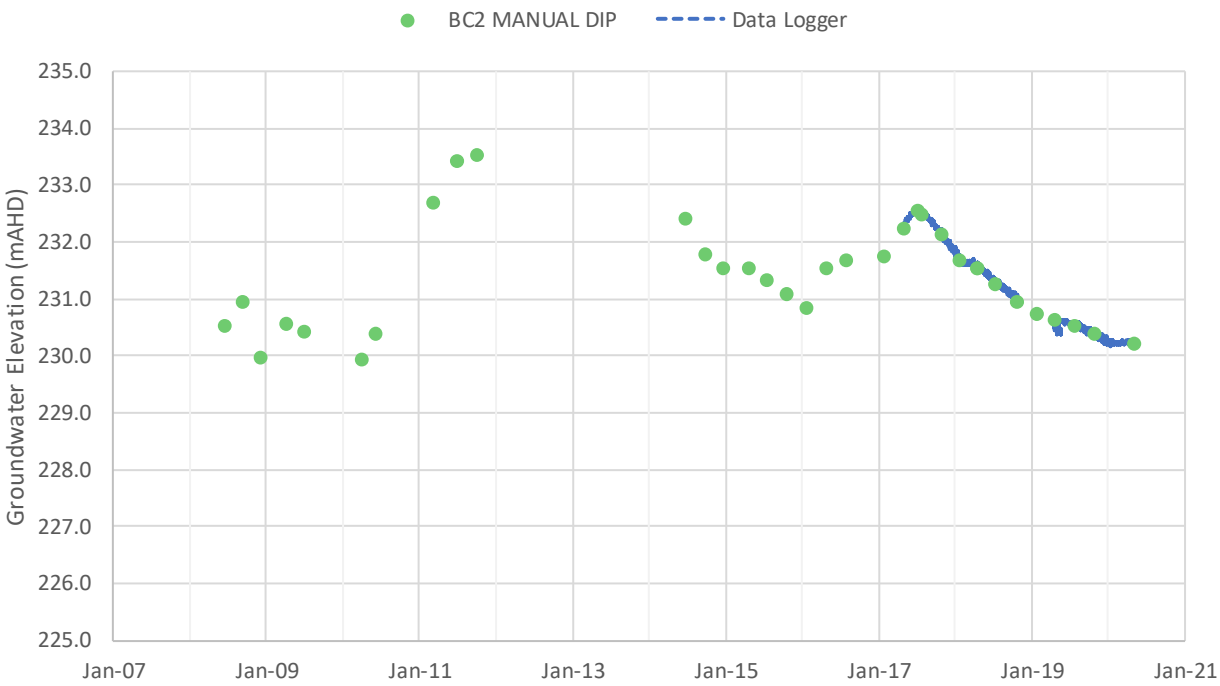

Figure III.2 Burton Coal Bore 2 Groundwater Elevation Hydrograph (Rewan Group)

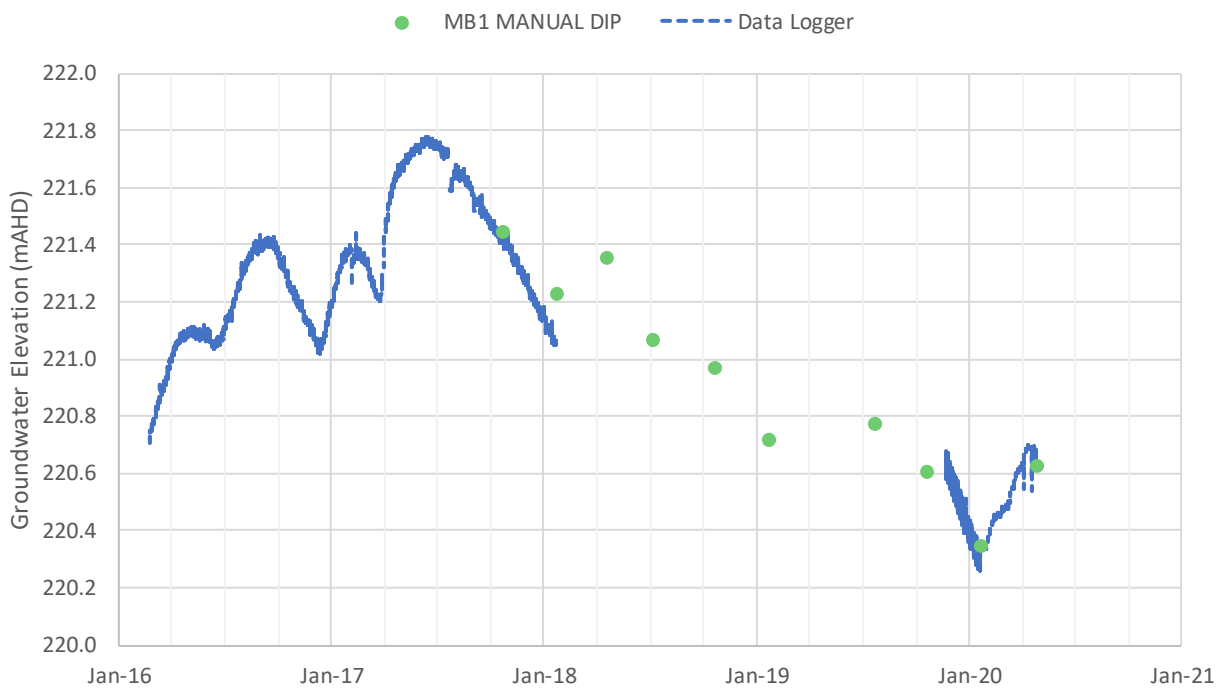

Figure III.3 MB1 Groundwater Elevation Hydrograph (Rangal Coal Measures)

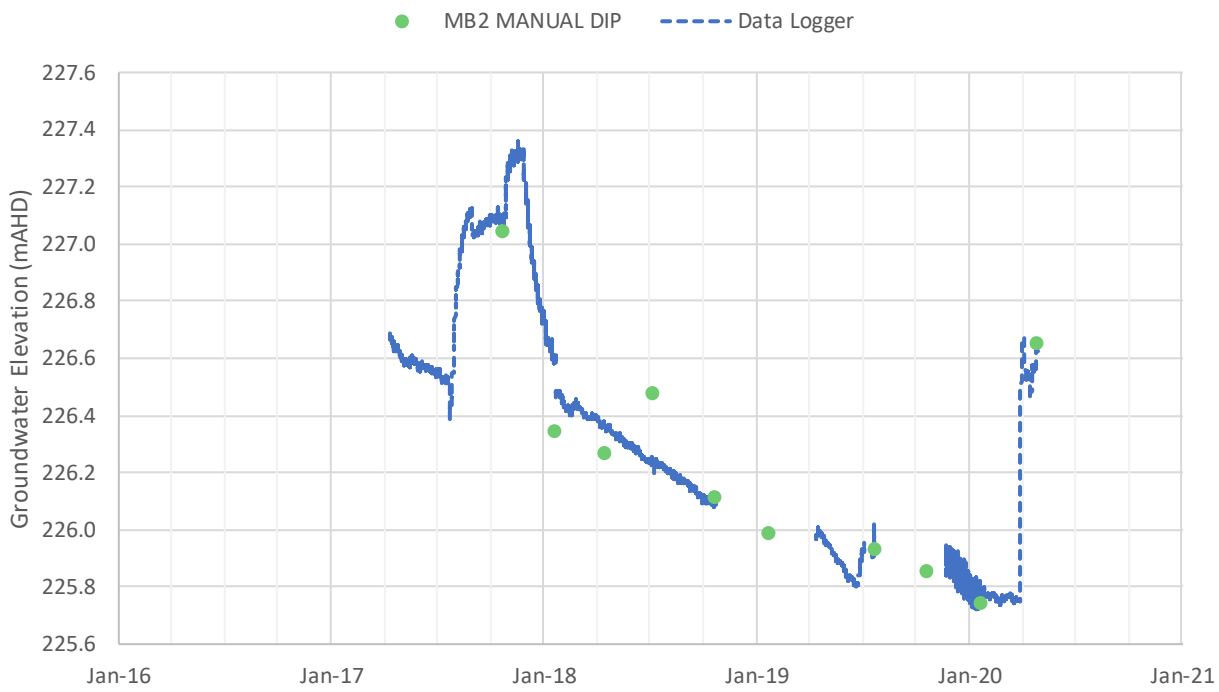

Figure III.4 MB2 Groundwater Elevation Hydrograph (Rangal Coal Measures)

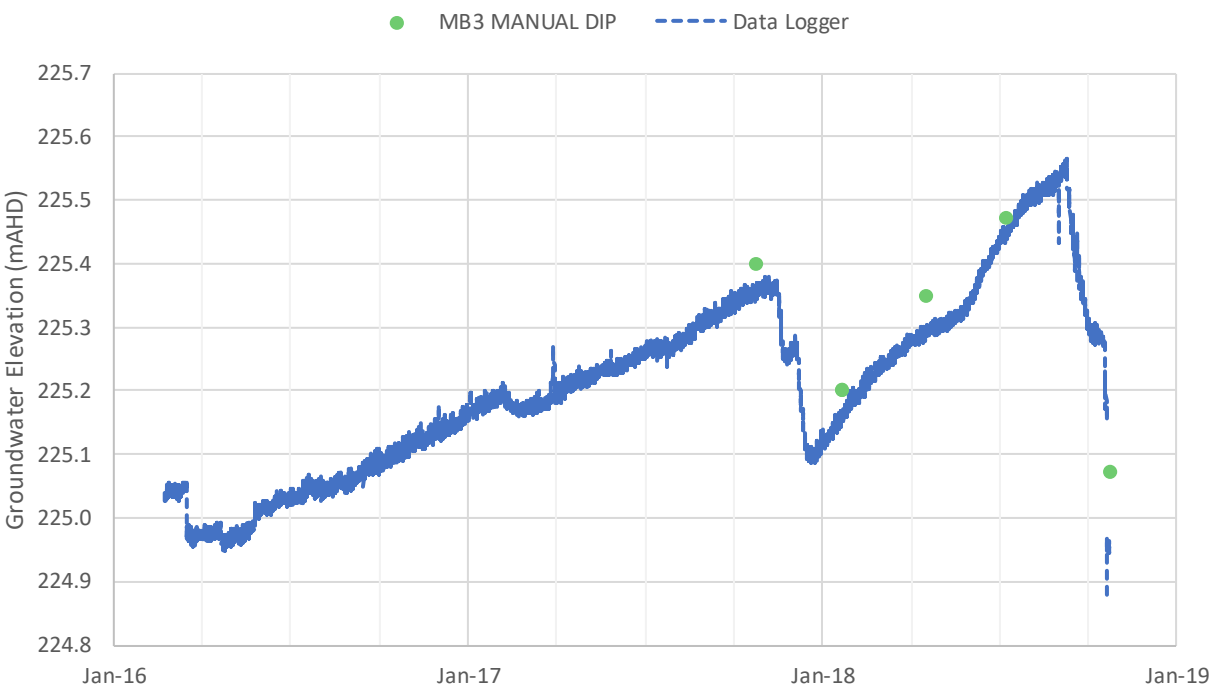

Figure III.5 MB3 Groundwater Elevation Hydrograph (Rangal Coal Measures)

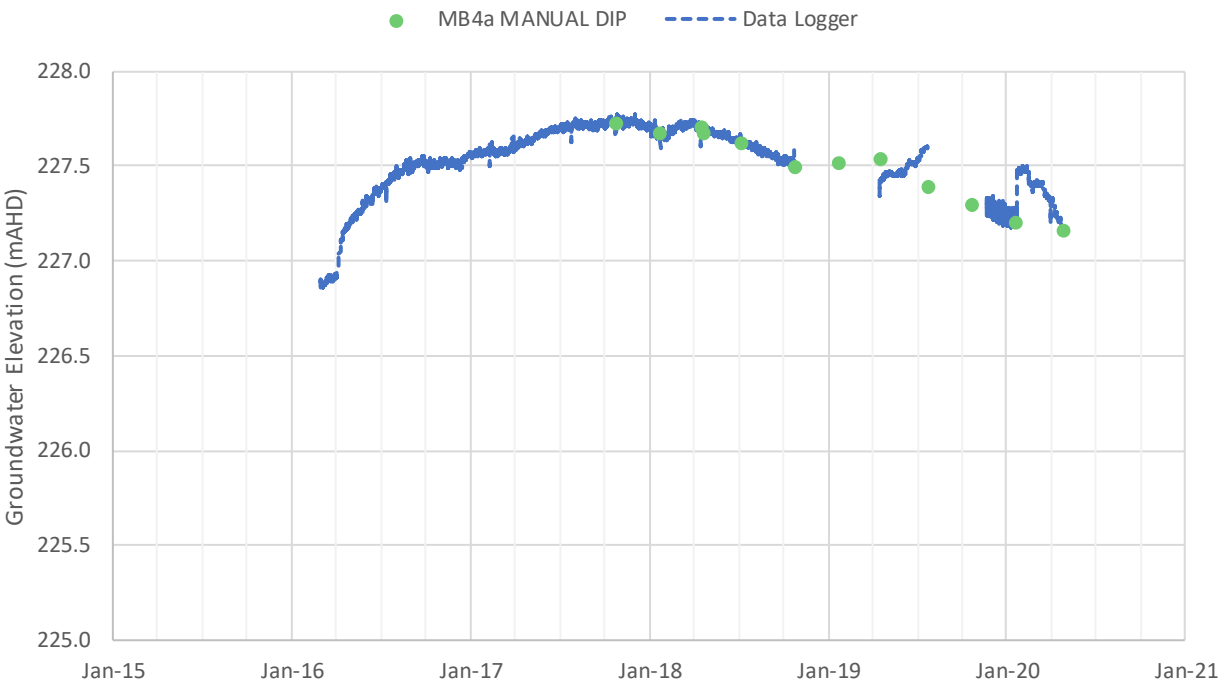

Figure III.6 MB4a Groundwater Elevation Hydrograph (Tertiary Sediments)

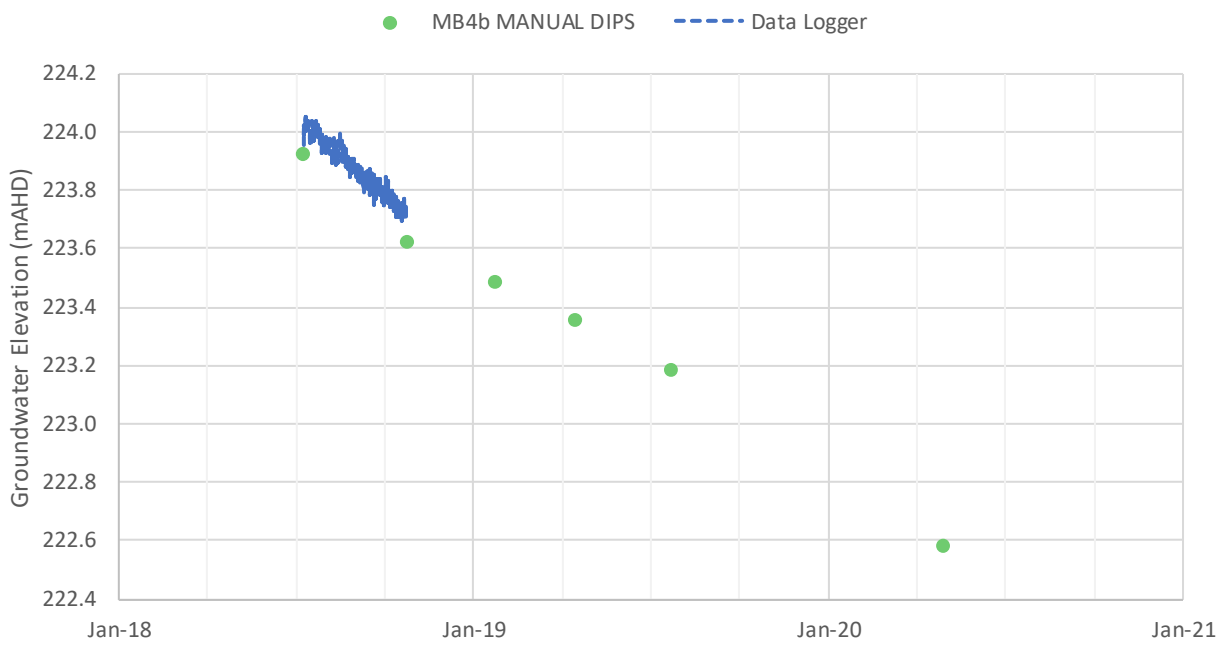

Figure III.7 MB4b Groundwater Elevation Hydrograph (Tertiary Sediments)

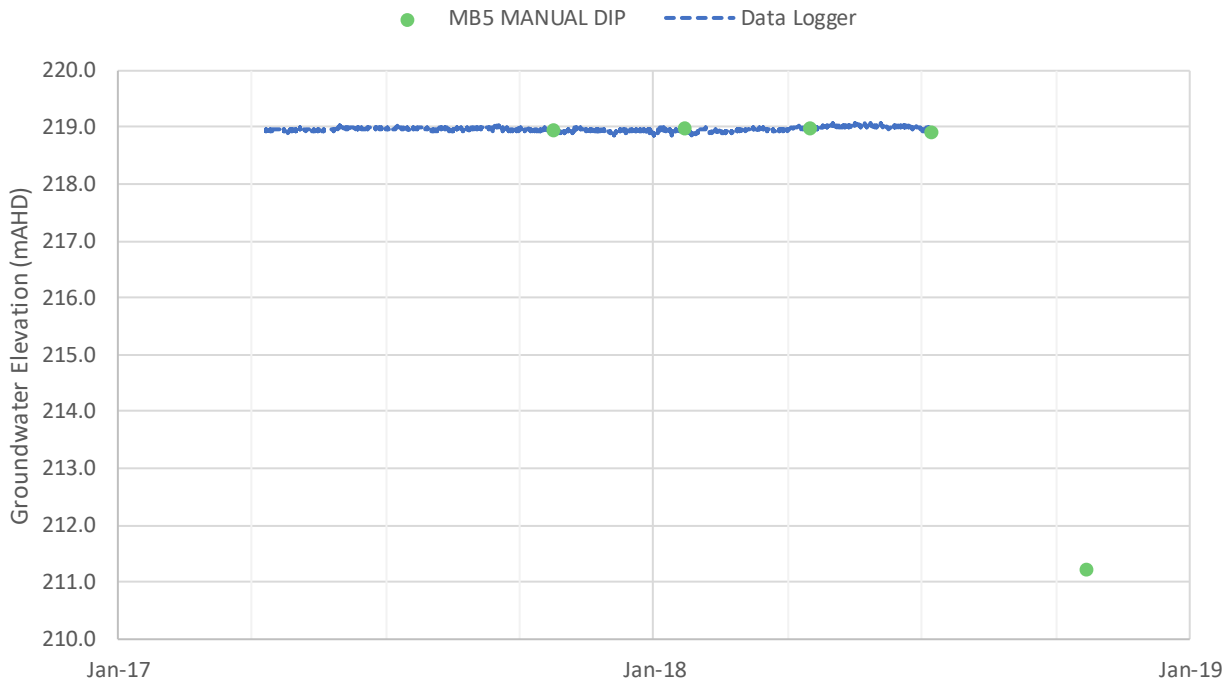

Figure III.8 MB5 Groundwater Elevation Hydrograph (Rangal Coal Measures)

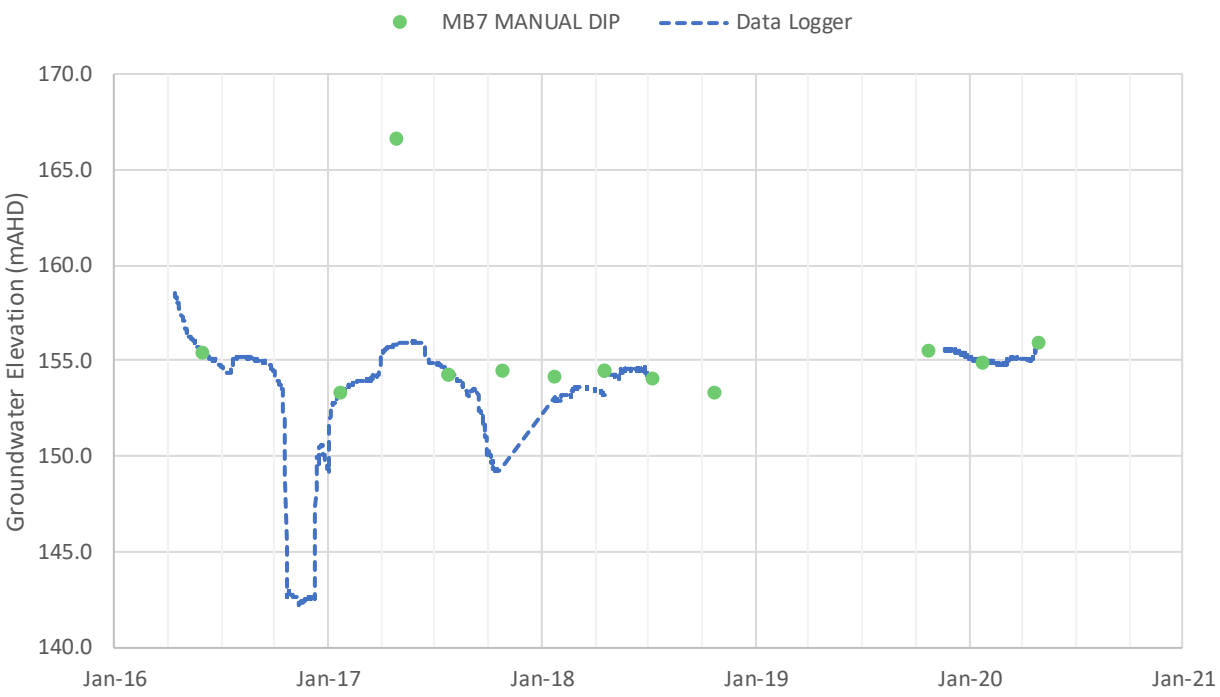

Figure III.9 MB7 Groundwater Elevation Hydrograph (Rangal Coal Measures)

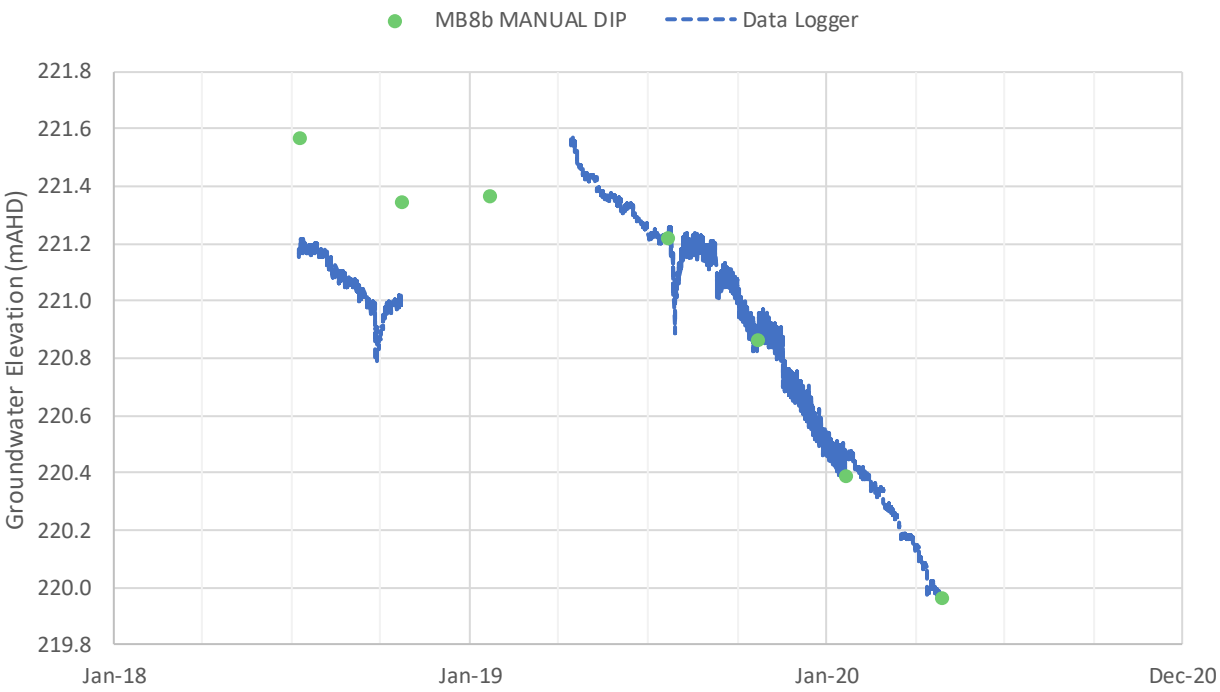

Figure III.10 MB8 Groundwater Elevation Hydrograph (Rangal Coal Measures)

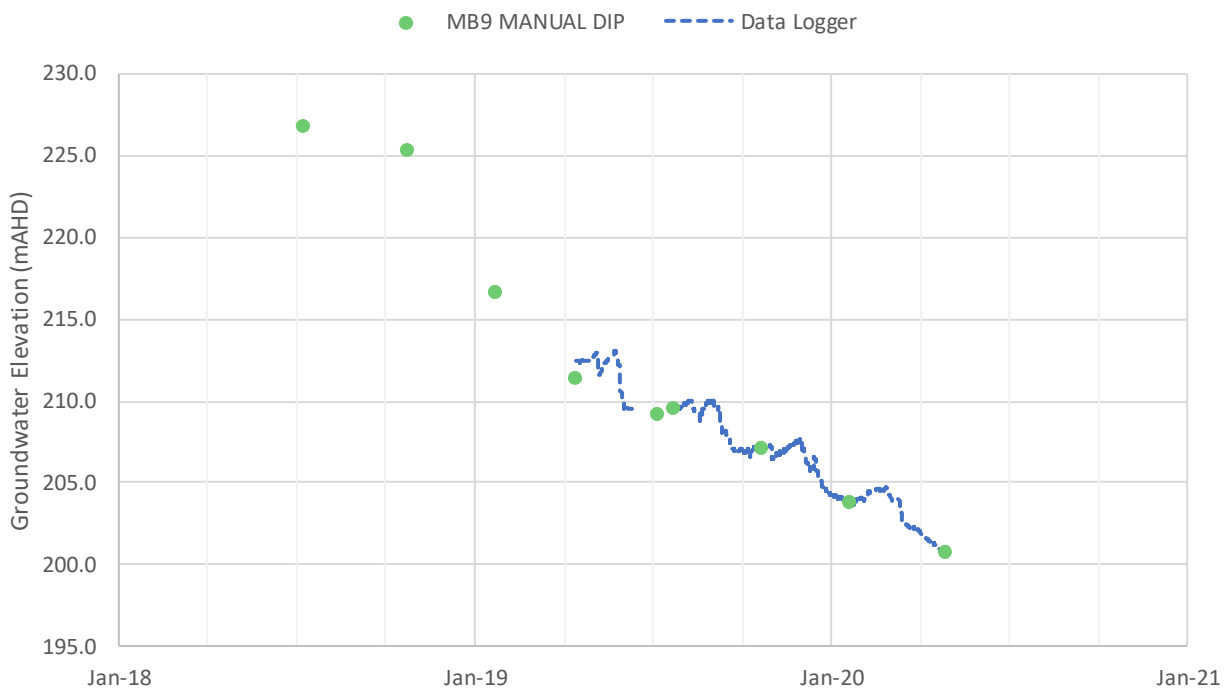

Figure III.11 MB9 Groundwater Elevation Hydrograph (Rangal Coal Measures)

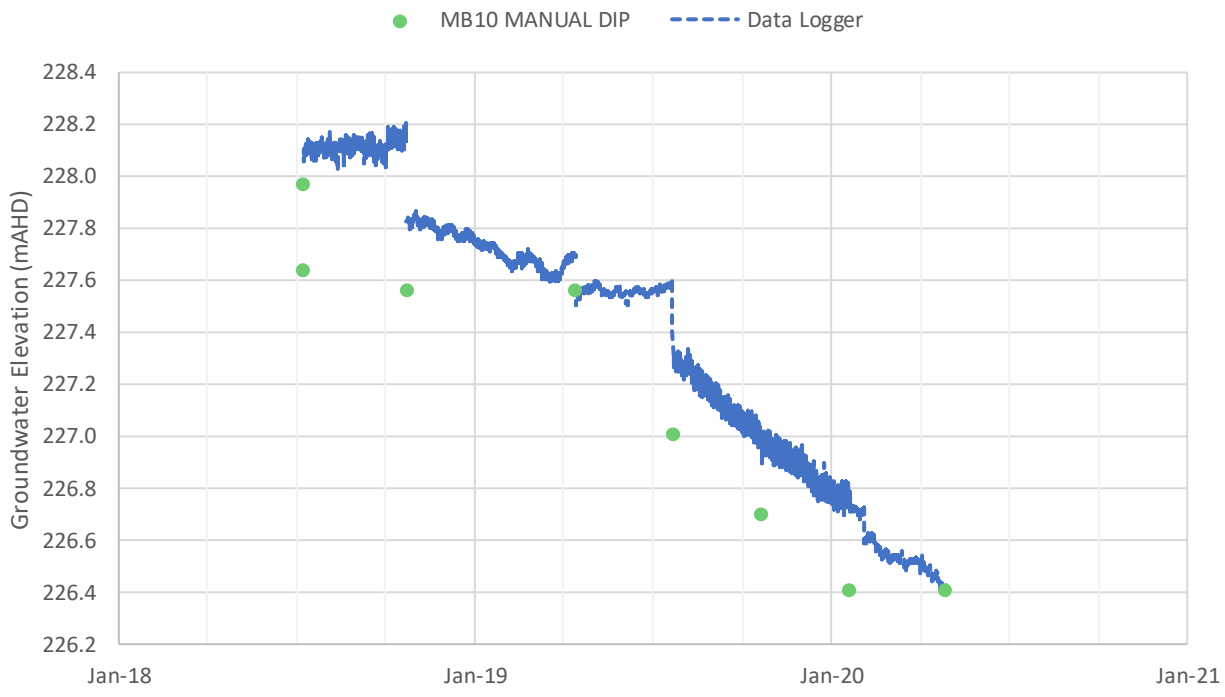

Figure III.12 MB10 Groundwater Elevation Hydrograph (Tertiary Basalt)

APPENDIX IV

Groundwater Modelling Report

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1 INTRODUCTION

Klohn Crippen Berger Ltd (KCB) has developed a 3D numerical groundwater flow model for the Isaac Plains East Extension Project (the project) to simulate the existing conditions of the groundwater regime and provide predictions of the potential impacts of the proposed mining activities. The Extension Project is within the Isaac Plains Complex (IPC) comprising Isaac Plains Mine (IPM) and Isaac Plains East (IPE).

The model represents the hydrogeology of the project mining area and its surrounds based on the conceptual groundwater model described in the Groundwater Report; and, the proposed mine plan and mining schedule of the project. The modelling results presented in this appendix have been used to support the assessment of groundwater impacts presented in the Groundwater Report.

1.1 Model Objectives

A calibrated groundwater flow model was developed for the project and its surrounds to assess the impact of project depressurisation on the local and regional groundwater systems. The groundwater flow model also incorporates cumulative stresses from neighboring mining activities.

The objectives of the model were to quantify:

- Changes to local and regional groundwater flow patterns due to the project;
- Project depressurisation on groundwater resources, users and the environment;
- Groundwater inflow into the project open pit mining area;
- Groundwater recovery following cessation of the project operations; and
- Cumulative depressurisation on groundwater resources as a result of the project and surrounding mines / approved projects; and, the project contribution to the cumulative depressurisation.

The sensitivity of the model to key parameter changes was tested.

1.2 Model Domain and Hydrogeological Study Area

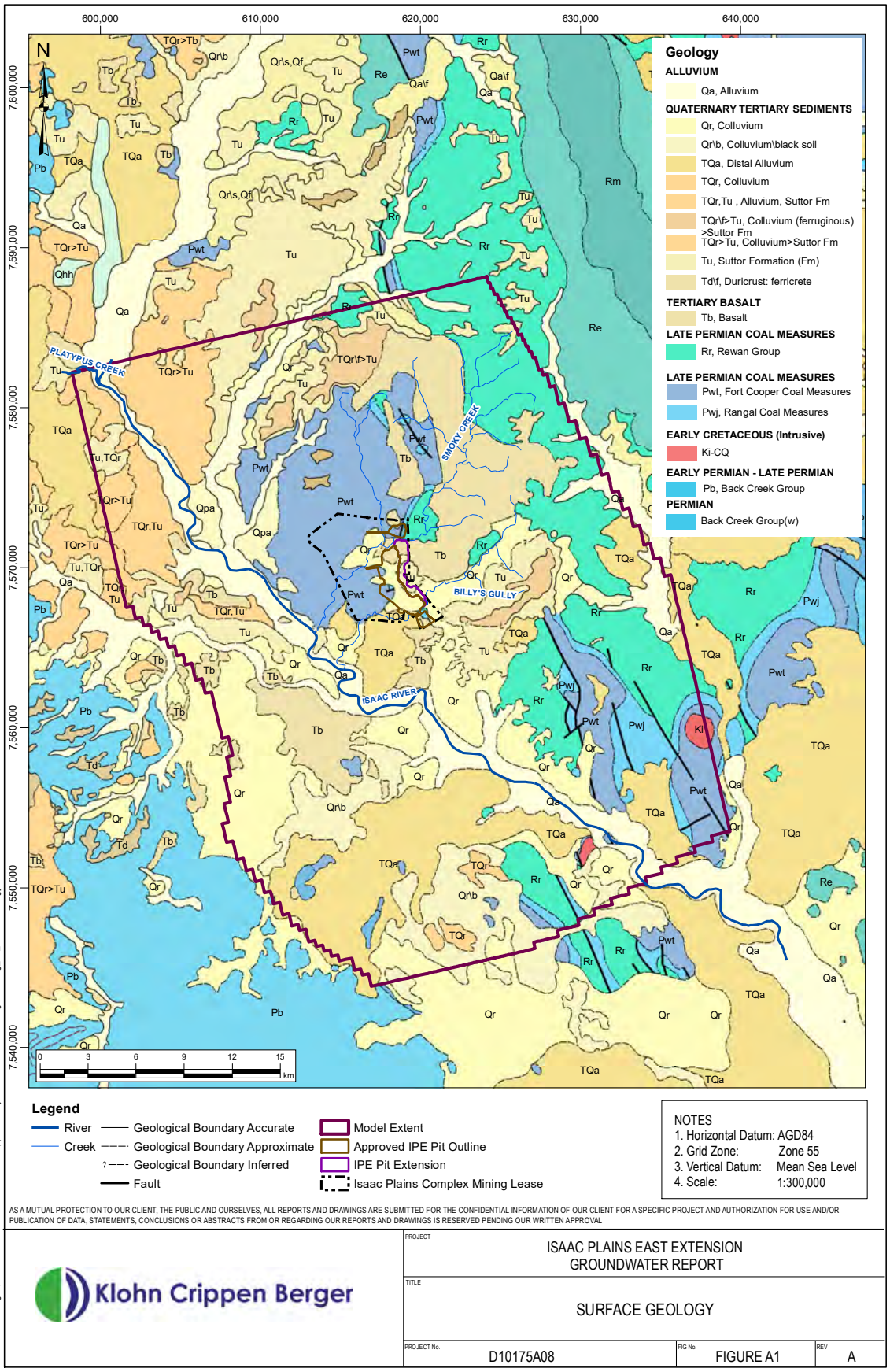
600,000
610,000
620,000
630,000
640,000
7,600,000
7,590,000
7,580,000
7,570,000
7,560,000
7,550,000
7,540,000
N
PLATYPUS CREEK
SMOKY CREEK
BILLY'S GULLY
ISAAC RIVER
Geology
ALLUVIUM
Qa, Alluvium
QUATERNARY TERTIARY SEDIMENTS
Qr, Colluvium
Qr\b, Colluvium\black soil
TQa, Distal Alluvium
TQr, Colluvium
TQr,Tu , Alluvium, Suttor Fm
TQr\f>Tu, Colluvium (ferruginous) >Suttor Fm
TQr>Tu, Colluvium>Suttor Fm
Tu, Suttor Formation (Fm)
Td\f, Duricrust: ferricrete
TERTIARY BASALT
Tb, Basalt
LATE PERMIAN COAL MEASURES
Rr, Rewan Group
LATE PERMIAN COAL MEASURES
Pwt, Fort Cooper Coal Measures
Pwj, Rangal Coal Measures
EARLY CRETACEOUS (Intrusive)
Ki-CQ
EARLY PERMIAN - LATE PERMIAN
Pb, Back Creek Group
PERMIAN
Back Creek Group(w)
0 3 6 9 12 15 km
Legend
River
Creek
Geological Boundary Accurate
Geological Boundary Approximate
Geological Boundary Inferred
Fault
Model Extent
Approved IPE Pit Outline
IPE Pit Extension
Isaac Plains Complex Mining Lease
NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:300,000
AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL
Klohn Crippen Berger
PROJECT
ISAAC PLAINS EAST EXTENSION
GROUNDWATER REPORT
TITLE
SURFACE GEOLOGY
PROJECT No.
D10175A08
FIG No.
FIGURE A1
REV
A
1/07/2020, EMangos, Z:\D\BNE\D10175A08 - IPEE GW Supplementary Assessment\400 Drawings\MXD\Fig_A1_SurfaceGeology\ModelExtent.mxd

Figure A1 and Figure A2 presents the spatial extents of the groundwater flow model domain. The model domain was selected to reflect the regional hydrostratigraphic units while also ensuring sufficient lateral extents to include relevant existing and approved future mining operations in the region. The location of existing and approved future mines near the project mining area is shown in Figure 1 of the Groundwater Report. In setting the model domain, the potential extent of project groundwater impacts were also considered.

The established model domain boundaries and orientation are as follows:

- The western limits of the model reflect the outcrop of the Back Creek Group and thus defines the extent of the overlying Permian sediments;
- The northern extent of the model is positioned to include the Moranbah North Mine;
- The eastern extent of the model is positioned to incorporate the mining activities of the Carborough Down Mine and Millennium Mine;
- The southern limit of the model was located to include the Poitrel Mine; and
- The model has been slightly rotated to align the principal axis of the model along the strike and dip of the thrust fault as this geological feature plays a significant role in the groundwater flow regime.

1.3 Application of the Conceptual Model

Development of the groundwater flow model is based on the conceptualisation of the hydrogeological system. This conceptualisation is described in Section 5 of the Groundwater Report. The hydrogeological conceptualisation is a descriptive representation of the groundwater flow system and stresses. The closer the conceptual understanding approximates the field situation, the better the performance of the numerical model in making predictions (Anderson and Woessner, 1991). The conceptual understanding defines the key processes of the groundwater system with consideration to the influence of stresses (Barnett et al., 2012).

The application of the conceptual understanding to the groundwater flow model required synthesis and description of the geology framework and consideration of the groundwater flow systems that are present within the vicinity of the project mining area.

The Isaac Thrust Fault and Isaac Thrust Fault Splay are key geological features in the vicinity of the project mining area, with IPE and the Extension Project to the east of the Isaac Thrust Fault Splay, and IPM to the west of the Isaac Thrust Fault Splay. The position of the thrust fault splay defines the location of appreciable hydrostratigraphic unit displacement and has been represented by model layer elevations and hydraulic property zones. In this setting the fault splay restricts groundwater flow in the horizontal direction as discussed in Section 5 of the Groundwater Report.

2 MODEL DESIGN

2.1 Model Code Selection

MODFLOW-SURFACT Version 4.0 was used to undertake the numerical modelling for this assessment. This modelling platform is based on the groundwater flow model MODFLOW, while MODFLOW-SURFACT has the additional ability of implementing the Newton-Raphson technique in solution of model heads. This addition accommodates the drying and re-wetting of model cells in a robust manner, which is a pervasive condition in groundwater numerical models developed for predictions of mining operations.

In this model variable saturation is implemented using a pseudo-soil function method with upstream weighting for the calculation of relative hydraulic conductivities.

The model also utilises an adaptive-time-stepping approach to assist in the solution of non-linear problems associated with the model simulations.

2.2 Model Processing and Discretisation

A combination of Groundwater Vistas Version 7.19 and PLPROC (Doherty, 2016b) were used for model construction and for model results post-processing.

The model grid was constructed from a base grid comprising 400 m x 400 m cells. Grid refinement is used over an area that encompasses the Isaac Plains Complex (IPC), which includes the Extension Project. In this area, the refinement of model grid cells progressively reduced the cell sizes to 50 m x 50 m. The grid is further refined to 25 m grid cells within the project mining area to provide greater resolution on flux transfers and head changes within this area of the model domain.

The model grid is rotated by 13 degrees to the west to better align the principal axis of the model with the strike of the Isaac Thrust Fault Splay. Figure A3 shows the rotated model domain and associated grid refinement.

2.3 Units and Datum

The time unit for the model is days and the length unit is meters. In the horizontal plane the model uses the AMG84 Zone 55 projection, while the vertical datum is the Australian Height Datum (AHD) in meters.

2.4 Model Layers

The hydrostratigraphy of the study area was represented using 17 model layers that are continuous across the model domain. Discontinuity of the units is accommodated by applying hydraulic parameters of the underlying units where appropriate. The uppermost model surface is defined by a digital elevation model derived from 1 second Arc SRTM data blended with 2018 LiDAR derived elevations over the project mining area and its surrounds. The elevation data was provided by the Stanmore.

Table 2-1 presents the model layers and the correlating primary geological units that it is representing. The top three layers are used to represent the unconfined to semi-confined Quaternary and Tertiary units.

Both the Triassic Rewan Group and the Permian Fort Cooper Coal Measures are distributed over five layers, on opposite sides of the Isaac Thrust Fault Splay, to accommodate the extra layers that arise from offsets in the elevations of the geological units across the fault.

Table 2-1: Summary of Model Layers

Model Layer	Geology West of Isaac Thrust Fault Splay	Geology East of Isaac Thrust Fault Splay
1	Alluvium, Tertiary Sediments, Basalt	Alluvium, Tertiary Sediments, Basalt
2	Tertiary Sediments, Basalt	Tertiary Sediments, Basalt
3	Weathered Profile, Basalt	Weathered Profile, Basalt
4	Pseudo layer - Rewan Group	Rewan Group
5	Pseudo layer - Rewan Group	Rangal Coal Measures - Overburden
6	Pseudo layer - Rewan Group	Rangal Coal Measures - Overburden
7	Pseudo layer - Rewan Group	Rangal Coal Measures: Leichardt Seam
8	Rewan Group	Rangal Coal Measures - Interburden
9	Rangal Coal Measures - Overburden	Rangal Coal Measures: Vermont Seam
10	Rangal Coal Measures - Overburden	Pseudo layer - Fort Cooper Coal Measures
11	Rangal Coal Measures: Leichardt Seam	Pseudo layer - Fort Cooper Coal Measures
12	Rangal Coal Measures - Interburden	Pseudo layer - Fort Cooper Coal Measures
13	Rangal Coal Measures: Vermont Seam	Pseudo layer - Fort Cooper Coal Measures
14	Fort Cooper Coal Measures	Fort Cooper Coal Measures
15	Moranbah Coal Measures - Overburden	Moranbah Coal Measures - Overburden
16	Moranbah Coal Measures: Goonyella Middle Seam	Moranbah Coal Measures : Goonyella Middle Seam
17	Moranbah Coal Measures - Underburden	Moranbah Coal Measures - Underburden

The surfaces of the above layers are derived from the following:

1. Surfaces and isopachs provided by Stanmore from the geological block models on both sides of the thrust fault and includes:
   - Depth of cover above the top of the Leichardt Seam;
   - Leichardt seam floor and roof;
   - Base of Tertiary units; and,
   - Isaac Thrust Fault Splay plane.
2. Borehole logs from Geological Survey of Queensland drilled investigation holes;
3. Publicly available CSG drilling logs accessed from the QDEX database;
4. Surfaces and data from the Bowen Basin Supermodel 2000; and,
5. Outcrop locations of Permian formations from surface geology mapping

2.5 Model Boundary Conditions

Boundary conditions are necessary for the solution of the 3D groundwater flow equation that is implemented by MODFLOW-SURFACT. They also provide a means by which auxiliary groundwater fluxes and stresses can be specified within the model. The following boundary conditions have been adopted in the model:

- Rainfall Recharge was applied in zones based on the extents of outcropping geological units, using the RCH package of MODFLOW. Recharge is regarded as the fraction of rainfall that passes through the unsaturated zone and arrives at the groundwater system. Within the model it has been calculated as a percentage of historically recorded monthly rainfall totals. Seven recharge zones are defined, each of which has a unique recharge rate that reflects the porosity of the strata through which it infiltrates. The percentage of rainfall that enters the model as recharge in each zone was adjusted during calibration. The zones are defined by the extents/outcrop of Quaternary alluvium, Tertiary sediments, Tertiary basalt, Rewan Group and Permian sediments, and are shown in Figure A4.

- Evapotranspiration is a boundary component of the water budget for the groundwater system. In this model, it has been implemented using the MODFLOW EVT package. A uniform extinction depth has been applied across the domain and set at 1.5 m below the natural surface, below which evaporative losses from the groundwater surface are zero. Where the groundwater elevation is above this level, water is removed from the system at a maximum rate of 1,200 mm/annum. This value is adopted from the average areal potential evapotranspiration map (BOM, 2008), which is based on a standard 30-year climatology from 1961-1990.

- General Head Boundary cells (GHB package) were implemented around the active perimeter of the model domain. They are applied to all layers of the model. Use of this boundary type allows for the regional groundwater flow system to be better replicated in the semi-regional model developed here. Conductance values applied to the GHB cells were calculated to be consistent with hydraulic conductivity values for each

hydrostratigraphic unit and the dimensions of the boundary cells. A reference head for these cells was obtained from steady-state model heads in a pre-development scenario. This boundary is sufficiently distant from the study area so as not to materially influence model prediction performance.

- The major water courses in the model domain are represented using the MODFLOW Drains package (DRN). The surface drainage system of the area is ephemeral in nature. When stream flows do happen, they are usually rapid and persist for short periods of time. Under these circumstances use of drains along these reaches is considered appropriate. In these cells the reference head was specified as the model top and a conductance was calculated to be consistent with the hydraulic conductivity and dimensions of the cell in which they are placed.

- Drains cells have also been used to simulate open-cut and underground mining activities across the model domain. In the project area itself, drains are placed in all layers above the elevation of mining, in accordance with the mining schedule provided by Stanmore. Reference drain elevations were specified in accordance with this schedule. Elsewhere within the model, open-cut mining operations were simulated using drains placed in all layers above and including the target coal seam layer. In underground mining operations, drains are placed in the target seam only. Reference heads were specified as the bottom of the target layer in which mining activity is targeting, while conductance values for these drain cells were set nominally high values of more than 10 m^2/day; and,

- The default, no flow boundary condition is used on the base of the model which coincides with the interface between the Moranbah Coal Measures and the Back Creek Group. This boundary is located at significant depth in the vicinity of the project mining area and has no significant bearing on the model results.

2.6 Application of Hydraulic Properties

Hydraulic properties for model layers 1 to 3, corresponding to the Quaternary and Tertiary age units and the weathered surface of the Permian age sediments, have been applied in a zonal fashion. This was also the approach adopted for the Rewan Group, Fort Cooper Coal Measures and the Permian overburden/interburden/underburden units. In the case of the Leichardt, Vermont and Goonyella Middle Coal Seams, a depth dependent relationship has been applied to horizontal/vertical hydraulic conductivities.

Conceptually, the horizontal and vertical hydraulic conductivity of the Permian coal seams reduces as a function of the depth of the units. This is the result of increasing pressure on the seams, as depth increases, due to the overlaying material which causes compression of the cleats and therefore a decrease in conductivity. As the general dipping of the Permian units is laterally west to east at the site, the distribution of hydraulic conductivity is therefore spatially variable within the model domain.

The equation that has been implemented to describe coal seam horizontal hydraulic conductivity variability is:

$$Kh_{coal} = Kh_0 \times depth^{(slope)}$$

Where: Kh_{coal} is depth specific horizontal hydraulic conductivity;

Kh_0 is horizontal hydraulic conductivity of material at depth of 0 meters;

slope is a term representing steepness of the curve;

depth is the depth to the mid-point of the cell at that location.

Figure A5 illustrates these relationships. Note the use of log scale for conductivity in this figure. During the calibration process the terms Kh_0 and $slope$ of the above equation were estimated.

Adjustment of the Kh_0 term has the effect of raising or lowering the curves presented in Figure A5. Adjustment of the $slope$ term alters the gradient of the curves. Figure A5 demonstrates the calibrated settings for the three modelled coal seams.

Vertical hydraulic conductivity in all layers is calculated as a factor of the horizontal hydraulic conductivity. Therefore, in the layers where coal seams are represented, vertical hydraulic conductivity also varies spatially across the model domain in accordance with decreasing horizontal hydraulic conductivity.

2.7 Calibration Process and Metrics

Model calibration was performed based on the adjustment of model parameter values to allow better replication of historical observations of the system. The outcome of the calibration process also provides the initial conditions for transient predictive simulations used to assess potential impacts of the project on the groundwater regime.

The transient period used for model calibration consists of monthly stress periods over the duration January 2015 to November 2018. This was preceded by a steady-state stress period to condition the model prior to the transient calibration. For predictive model runs a quarterly stress period sequence was adopted.

2.7.1 Calibration Approach

The location of the project mining area within this area of the Bowen Basin has numerous mining operations that have been in operation for some time. Calibration of this model focused parameter estimation on the more recent system condition (over the period January 2015 to November 2018). This duration also captures the vast majority of available observation data acquired at the Isaac Plains Complex.

The calibration model run was initiated as a steady state simulation with boundary conditions applied to replicate known mining development at the beginning of 2015. Following this initial model conditioning period, the model transitions to transient mode for the aforementioned calibration period, during which monthly stress periods are implemented. This stress period

length readily accommodates the inclusion of seasonal, climatic variations in rainfall records. All observations used as calibration targets pertain to the transient component of the simulation.

Automatic parameter estimation was implemented with the use of PEST (Doherty, 2016a). In all, 85 adjustable parameters were used. These include hydraulic conductivities, storage properties and recharge factors.

2.7.2 Calibration Targets

All observations that comprise the calibration dataset are water level measurements. These measurements were compiled from 15 monitoring bores for which reliable water level measurements were available over the transient calibration simulation period. In total, 5,858 individual measurements are used in the calibration process, with the majority of these arising from eleven installed water-level recording data-loggers.

2.7.3 Calibration Results

Figure A6 presents a comparison between groundwater level measurements and the calibrated model output equivalents. During calibration, all measurements of the calibration dataset were given equal weight, thereby seeking to extract maximum information from the calibration dataset during estimation of parameters.

Table 2-2 presents statistics from the calibration process. The scaled root Mean Square (SRMS) of errors from the calibration is 4.0%, which is within the guidance limits recommended by the Australian Groundwater Modelling Guidelines (Barnett et al., 2012) of 10% SRMS.

Hydrographs demonstrating the fit between modelled and measured observations, achieved through the calibration process, are shown in Figure A16 to Figure A29.

Table 2-2: Summary Model Calibration Performance

Statistical Metric	Value
Number of Observations	5,858
RMS error (m)	3.8
Scaled RMS (%)	4.0
Mean Sum of Residuals (m)	0.92
Scaled Mean Sum of Residuals (%)	4.2
Correlation coefficient	0.8

The transient calibration results are based on monitored groundwater levels for each of the key hydrostratigraphic units within the vicinity of the project area, and from monitoring bores distributed across the project area; which highlights the lateral and vertical distribution of the calibration targets. Furthermore, transient groundwater level trends identified in the groundwater level monitoring records, as a result of seasonal rainfall variability or adjacent mining activities, have been captured by the transient calibration simulation. Therefore, the model calibration is considered robust and adequate for undertaking subsequent predictive simulations.

2.8 Calibrated Hydraulic Parameters

Table 2-3 provides a summary of calibrated hydraulic property values for each hydrostratigraphic unit represented in the model. As described in Section 2.6, hydraulic conductivity values of the Permian coal seams vary in accordance with the specified depth dependent relationship. As such the values presented in Table 2-3 for the Leichardt, Vermont and Goonyella Middle Seams are average values arising in the vicinity of the proposed project. Similarly, the vertical hydraulic conductivity values presented in this table also represent average values for the aforementioned coal seams.

Table 2-3 : Summary Calibrated Hydraulic Properties

Geological Unit	Calibrated Kxy (m/d)	Calibrated Kz (m/d)	Calibrated Specific Yield (-)	Calibrated Specific Storage (m^{-1})
Isaac River Alluvium	4.20	0.87	1.55E-01	1.02E-04
All other Quaternary Deposits	0.52	0.52	4.98E-02	2.00E-05
Tertiary Basalt	0.32	0.16	5.02E-02	1.90E-04
Suttor Formation	0.02	0.002	5.00E-04	1.80E-05
All other Tertiary deposits	0.01	0.01	4.01E-04	1.61E-05
Weathering Horizon	0.69	0.36	3.98E-04	1.70E-05
Rewan Group	0.02	0.01	4.09E-04	1.59E-05
Rangal Coal Measures - Overburden/Interburden	0.002	0.0003	4.01E-04	1.65E-05
Rangal Coal Measures: Leichardt Seam	0.27*	0.03*	4.00E-04	1.40E-05
Rangal Coal Measures: Vermont Seam	1.80E-03*	1.8E-04*	4.00E-04	1.60E-05
Fort Cooper Coal Measures	1.65E-03	3.11E-04	4.00E-04	1.60E-05
Moranbah Coal Measures - Overburden/Interburden	2.08E-04	2.17E-05	4.00E-04	1.60E-05
Moranbah Coal Measures: Goonyella Middle Seam	4.50E-05*	4.50E-06*	1.07E-02	5.40E-06
Thrust Fault	1.00E-04	1.20E-04	5.00E-02	6.67E-06

Note: Hydraulic Conductivity values for coal seams are depth dependant; "*" indicates that reported values are average values across project mining area.

2.9 Calibrated Recharge Rates

Recharge to the model domain was calculated as a percentage of recorded rainfall within the model domain during each stress period of the calibration model run. During the steady-state conditioning period, long-term average annual rainfall was converted to daily rainfall, while during the monthly transient periods, recorded quarterly rainfall totals were used to calculate average daily rainfall for that period. The percentage of this average daily rainfall that results as recharge were estimated during calibration and these are provided in Table 2-4.

Table 2-4 : Summary Calibrated Recharge Rates

Modelled Recharge Zone	Percentage of Daily Rainfall
Quaternary Alluvium	0.53
Other Quaternary deposits	0.72
Tertiary Basalt	0.56
Suttor Formation	0.14
Other Tertiary deposits	0.25
Weathering Horizon	0.04

2.10 Calibrated Water Balance

The mass balance error of the transient calibration model represents the difference between model inflows and model outflows calculated by the model. An error of approximately 1% is considered acceptable (Anderson and Woessner, 1991). The model reported water budget for the steady state period of the calibrated model is presented in Table 2-5. The water balance error is less than 1%, indicating that convergence of the numerical solution of the groundwater flow problem has been achieved.

Table 2-5 : Summary Water Balance at the End of Calibration Period

Water Budget Item	Inflow (m^3/day)	Outflow (m^3/day)
Recharge (Rainfall deep drainage)	7,360	0
General Head Boundary Throughflow (Regional flow across model extents)	7,658	6,675
Evapotranspiration (from surface heating/vegetation)	0	6,848
Drains (Groundwater removed from system via mining and surface drainage)	0	873
Wells (Pumping from the Broadlea Borefield)	0	621
TOTAL	15,019	15,018
Mass Balance error	< 0.01%	

2.11 Model Classification

Barnett et al. (2012) developed a system to classify the confidence level of groundwater flow models based on the calibration process used and the predictive capability of the model. Three classes of model were developed: Class 1, Class 2 and Class 3. A Class 3 model has the greatest confidence level, and a Class 1 model has the least. Factors that are considered when determining model confidence level are:

- Data availability;
- Calibration procedures;
- Consistency between calibration and predictive analyses; and
- Stresses induced on the model.

The model outlined in this report is considered a Class 2 model because:

- A transient calibration was undertaken and mining-induced groundwater trends have been replicated;
- Independent observations and calculations were used to support the calibration process; and,
- The water balance error is less than 1%.

The model meets the criteria for a Class 2 model, and, exceeds the criteria for a Class 1 model. The exceedance of the Class 1 classification is driven by the following:

- Model is calibrated and key calibration statistics have been met;
- Calibration has been undertaken to transient conditions; and,
- Model parameters are within the range of conceptualised hydraulic parameters.

The model is therefore assessed as being a suitable tool for assessing groundwater impacts that may arise as a result of the project.

3 MODEL SIMULATIONS

3.1 Operational Depressurisation

The transient model for the predictive scenarios simulating depressurisation of the Leichardt Seam and overlying hydrostratigraphic units is an extension of the transient calibration model, and, comprises annual stress periods for a 43 year duration (starting at the commencement of mining activity within the model domain) leading into the prediction period to allow development of surrounding mining operations to occur. Following this, the simulation then proceeds in quarterly stress periods for the life of the project. Mine development for the predictive scenarios comprises the progressive assignment of MODFLOW drain cells representing open-cut mining operations, and the modification of hydraulic parameters to represent mined void space.

For the simulation of mine advancement, drain cells were assigned to all layers above and including the elevation of the mined area specified by mine plan elevation models. The reference drain elevation was assigned in accordance with the mine plan elevation models. A drain conductance value of 10 m^2/d was applied to each drain.

Once overburden/coal material is mined, these cells then take on modified hydraulic properties to simulate the void space. This was achieved by use of the Time-Varying-Material-Properties (TMP) package of MODFLOW-SURFACT.

The results of this operational simulation are presented as Section 6 of the Groundwater Report.

3.2 Post–closure Groundwater Level Recovery

An analysis of post-closure groundwater level recovery was performed to assess the response of the system to total cessation of mining operations and water level elevations within each of the pit voids once equilibrated conditions of the groundwater system have been achieved. A simulation was also undertaken to assess the groundwater source / sink trigger elevation within each pit void, which represents the elevation within each pit void where discharge downstream of the pit void would occur if water level elevations were above the trigger elevation. A summary of the simulations completed for the post-closure groundwater level recovery and the source / sink trigger elevation assessment is provided in the following sections.

3.2.1 Groundwater Level Recovery Simulation

A model simulation was run over a 864 year period to allow for the equilibration of the groundwater levels and water levels in the pit voids following the cessation of mining activities. Key model fluxes that were incorporated into the post-closure simulation as input boundary conditions included:

- Evapotranspiration (applied with the EVT package) on each of the pit voids water surfaces when water recovered within the pit void;
- Direct rainfall in the pit void (applied with the RCH package) which was applied as 100% of rainfall contributing the pit void; and,

- Pit void surface water catchments runoff that contributed to the pit void. Post-closure runoff volumes from these catchments were estimated by WRM (WRM 2020) for monthly timesteps and were applied to the module using the RCH package.

The starting water level condition for the post-closure recovery simulation was the groundwater level surface from the final time-step of the operational depressurisation simulation. Drain cells representing mining activity in the operational depressurisation simulation were deactivated to allow groundwater to recover across the model domain. Observation points were placed within each of the pit voids to allow monitoring of water level recovery within each void, while zone budgets were applied in each void to allow assessment of groundwater inflow flux into the pit void over time.

Recovering water levels within each pit void is presented in Figure 19 of the main Groundwater Report, while groundwater inflow fluxes for each pit void is present in Figure A7 to Figure A11. Discussion regarding the post-closure recovery results is provided in Section 6.2.3 of the main Groundwater Report.

3.2.2 Pit Void Source / Sink Trigger Assessment Simulation

Assessment of the pit void source / sink trigger elevations was undertaken to identify the elevation in each pit void, above which, water will discharge from the pit voids during post-closure conditions. This assessment was completed by simulating pre-mining conditions across the model domain (i.e. all mining activity, not just mining associated with IPC); which included the following model conditions / modifications prior to undertaking the simulation:

- Drain cells simulating all mining activities in the model domain were deactivated;
- Material properties for hydrostratigraphic units (i.e. model layers) intersected by the pit voids reinstated in the model domain to represent pre-mining conditions; and,
- Recharge rates for the pit voids updated to represent pre-mining pit void surface geology conditions.

The starting groundwater level condition for the source / sink trigger assessment simulation was adopted from the final time-step of the operational depressurisation simulation. A nominal simulation duration of 1,000 years was applied to provide sufficient time for groundwater levels to equilibrate to steady-state conditions. Groundwater levels within each pit void extent were extracted following recovery to steady-state conditions. The lowest elevation within each of the pit void extents was identified as the source / sink trigger elevation.

Discussion of the predicted source / sink trigger elevation is provided in Section 6.2.3 of the main Groundwater Report.

3.3 Sensitivity Analysis for Predicted Project Impacts

3.3.1 Overview

A sensitivity analysis of the numerical model predictions was undertaken as a method of uncertainty analysis. This adopted method of uncertainty analysis, also identified as “deterministic scenario analysis with subjective probably assessment” (IESC 2018), is an acceptable uncertainty quantification technique that has been identified by the Independent Expert Scientific Committee

(IESC) on Coal Seam Gas and Large Coal Mining Development. The sensitivity analysis was performed to assess the response of the model to varying hydraulic properties and recharge rates. This analysis provides for a comparison of the influence of these properties on the outcomes of predictions made by the model. Impacts to predictions of mine groundwater inflows and maximum drawdown due to changes in hydraulic properties have been examined.

Parameters that were assessed during predictive sensitivities were grouped and varied in the following manner:

- Horizontal (Kh) and vertical (Kv) hydraulic conductivity of all layers was varied by 100% above and below calibrated values;
- Specific storage (Ss) and specific yield (Sy) values for all layers was varied by 100% above and below calibrated values;
- Recharge rates (Rch) were varied by 100% above and below calibrated values; and
- Horizontal (Kh) and vertical (Kv) hydraulic conductivity of Isaac Thrust Fault Splay was varied by 100% above and below calibrated values.

The adopted sensitivity analysis range (i.e. +/- 100%) is considered appropriate to assess the uncertainty associated with the adopted model parameters as the range broadly captures the range of measured parameter values from within the vicinity of the project area.

3.3.2 Mine Inflow Estimates

The effects of the sensitivity scenarios on predicted mine inflows are shown in Figure A12. Table 3-1 presents a summary of the change in predicted mine inflows resulting from scenarios tested in the sensitivity analysis. This table shows that in this model, predictions of mine inflows are most sensitive to changes in hydraulic conductivity. Changes in storage values have a significant effect on inflow rates. The third column of Table 3-1 (i.e. SRMS metric) demonstrates that these changes in hydraulic property values significantly “de-calibrate” the model, or in the case of Sensitivity Scenario 1 (Kx and Kz: Minus 100%), the model failed to coverge. Therefore, these scenarios represent extreme cases and are not an accurate reflection of real world conditions.

Modelled recharge rates have a negligible impact on predicted mine inflows. Similarly, the hydraulic conductivity applied to the thrust fault, also has negligible effects on mine inflows.

Table 3-1 : Summary Results from Sensitivity Analysis

Sensitivity Scenario	Parameter Adjustment	Transient SRMS (%)	Maximum Mine Groundwater Inflow (L/s)	Average Mine Groundwater Inflow (L/s)
Calibrated – Baseline	NA	4.0	24.7	13.1
1	Kx and Kz: Minus 100%	Simulation Failed to Converge		
2	Kx and Kz: Plus 100%	11.2	39.7	22.3
3	Recharge: Minus 100%	11.8	24.0	13.5
4	Recharge: Plus 100%	9.9	28.7	16.6
5	Ss and Sy: Minus 100%	17.4	11.5	5.9
6	Ss and Sy: Plus 100%	11.0	33.8	18.4

Sensitivity Scenario	Parameter Adjustment	Transient SRMS (%)	Maximum Mine Groundwater Inflow (L/s)	Average Mine Groundwater Inflow (L/s)
7	Fault Kx and Kz: Minus 100%	10.9	25.9	14.5
8	Fault Kx and Kz: Plus 100%	10.7	26.7	15.0

3.3.3 Drawdown Extents

The maximum extent of project induced drawdown that results from the scenarios outlined in Section 3.3.1 are shown in Figure A13, Figure A14 and Figure A15. These figures present the project drawdown effects in the Tertiary basalt, weathered horizon and the Leichardt Seam (which comprises Layers 7 east of the thrust fault splay and Layer 11 on the west side of the thrust fault splay). As can be seen from these figures, the extent of drawdown impact (defined by the 1 m drawdown contour) have limited changes under the sensitivity scenarios.

3.3.4 Sensitivity Classification

The Murray Darling Basin Modelling Guidelines (MDBC, 2000) provide a framework for classification of a predictive model parameters in terms of their impacts on the model. These can be summarised as follows:

- Type I: Insignificant changes to calibration and predictions;
- Type II: Significant changes to calibration with insignificant changes to predictions;
- Type III: Significant changes to calibration with significant changes to predictions; and
- Type IV: Insignificant changes to calibration and significant changes to prediction.

Types I to III present no concern where management decisions are to be based on the model, provided the model is calibrated and encapsulates sufficient complexity to replicate the system. However, Type IV classification may be of concern as calibration may have done little to reduce potential for predictive error.

With consideration to the results of the sensitivity analysis, parameters employed in this model can be considered Type I to II classification and are suitable for the purpose of supporting a groundwater assessment for the project.

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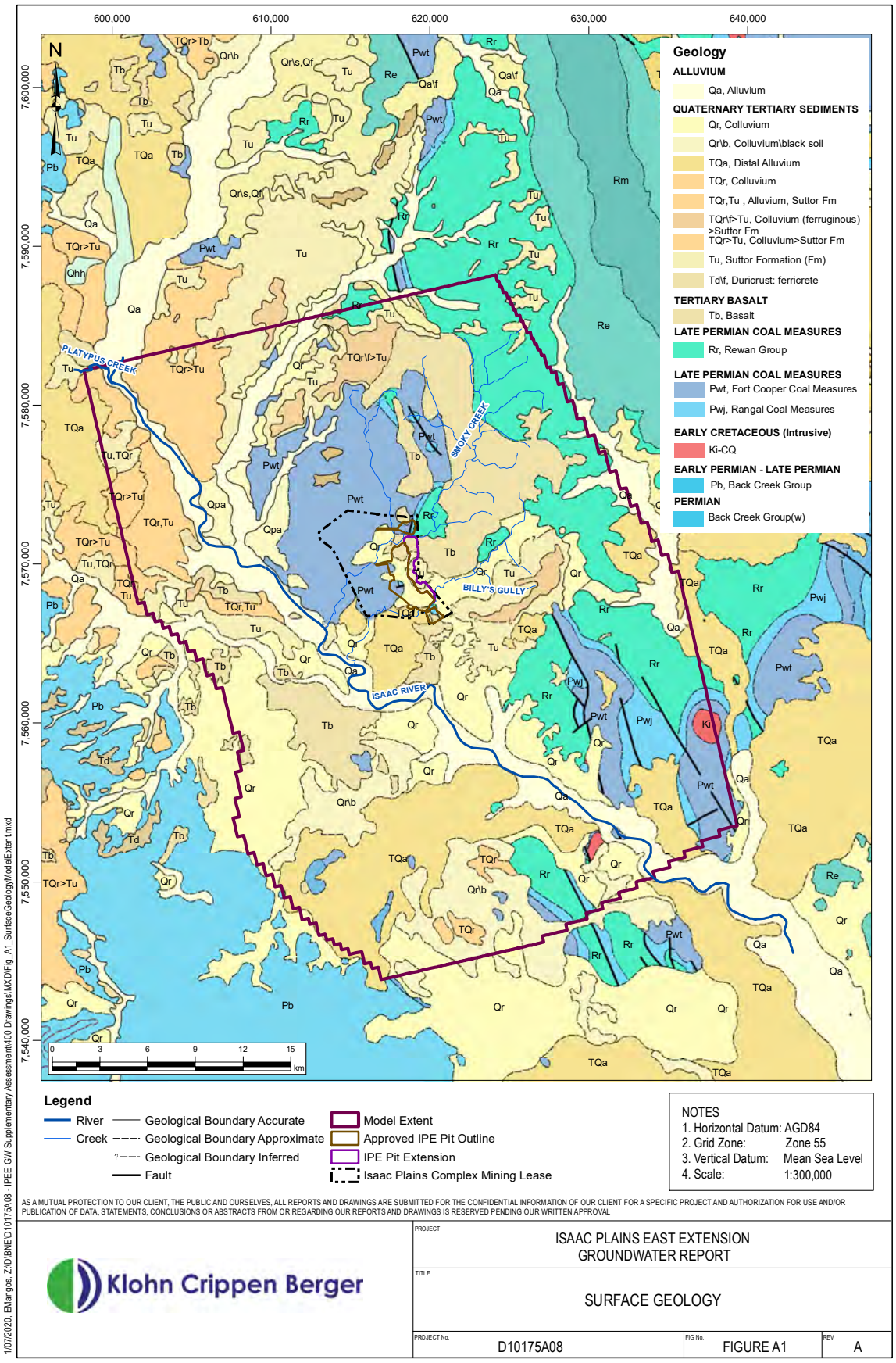

Figure A1: Model extent over surface geological mapping

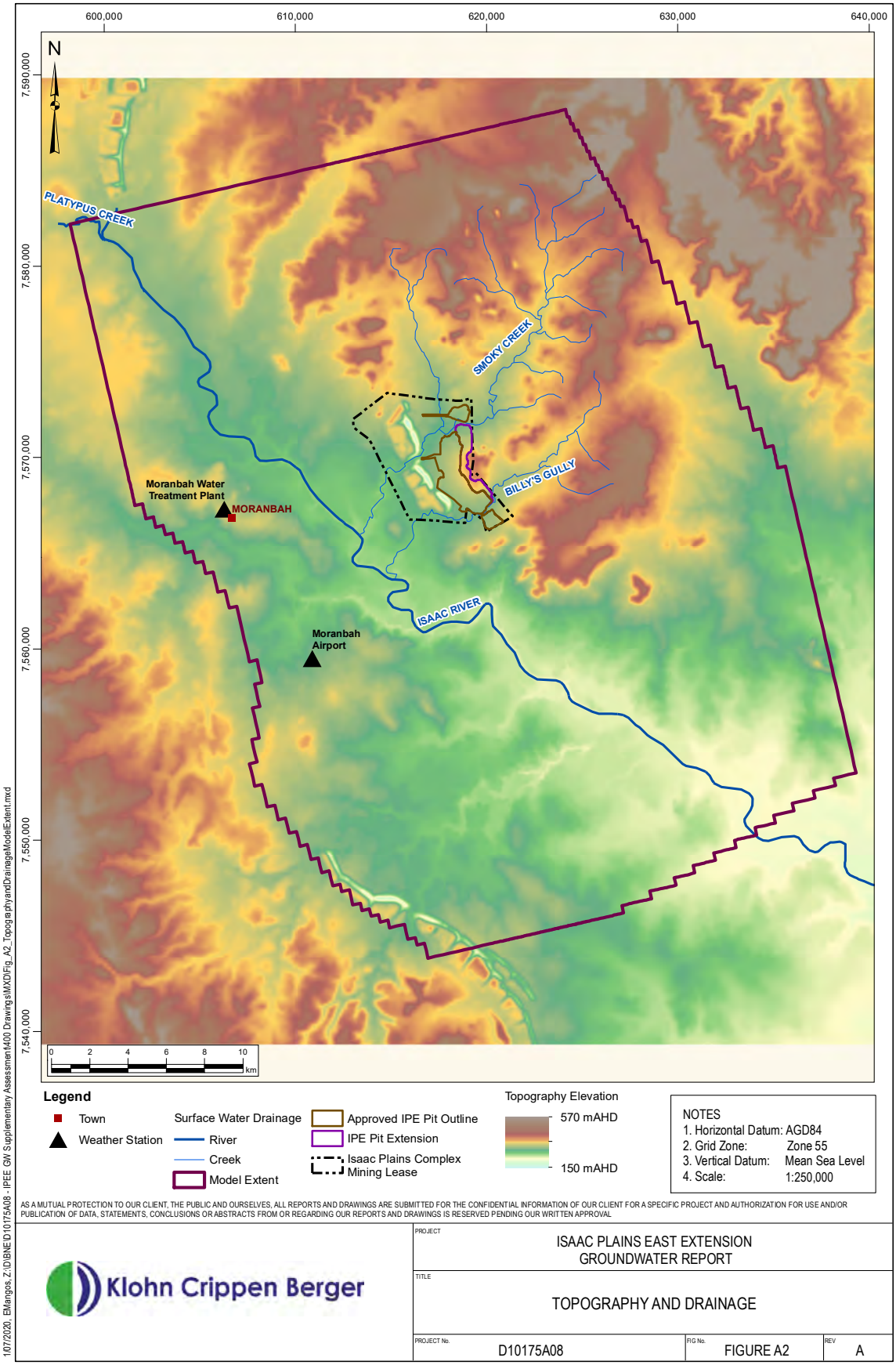

Figure A2: Model extent over topography

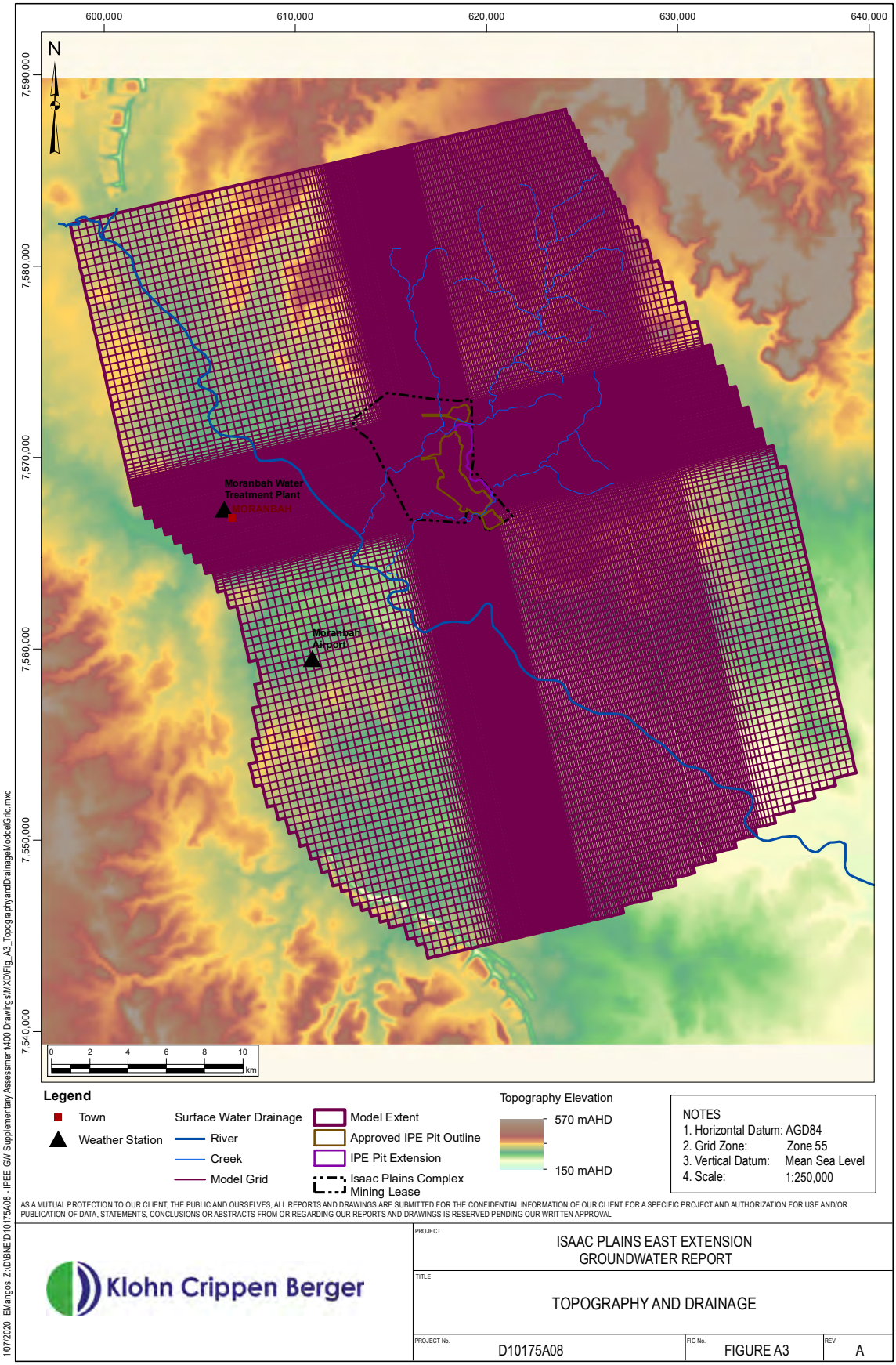

Figure A3: Model domain extent and grid refinement

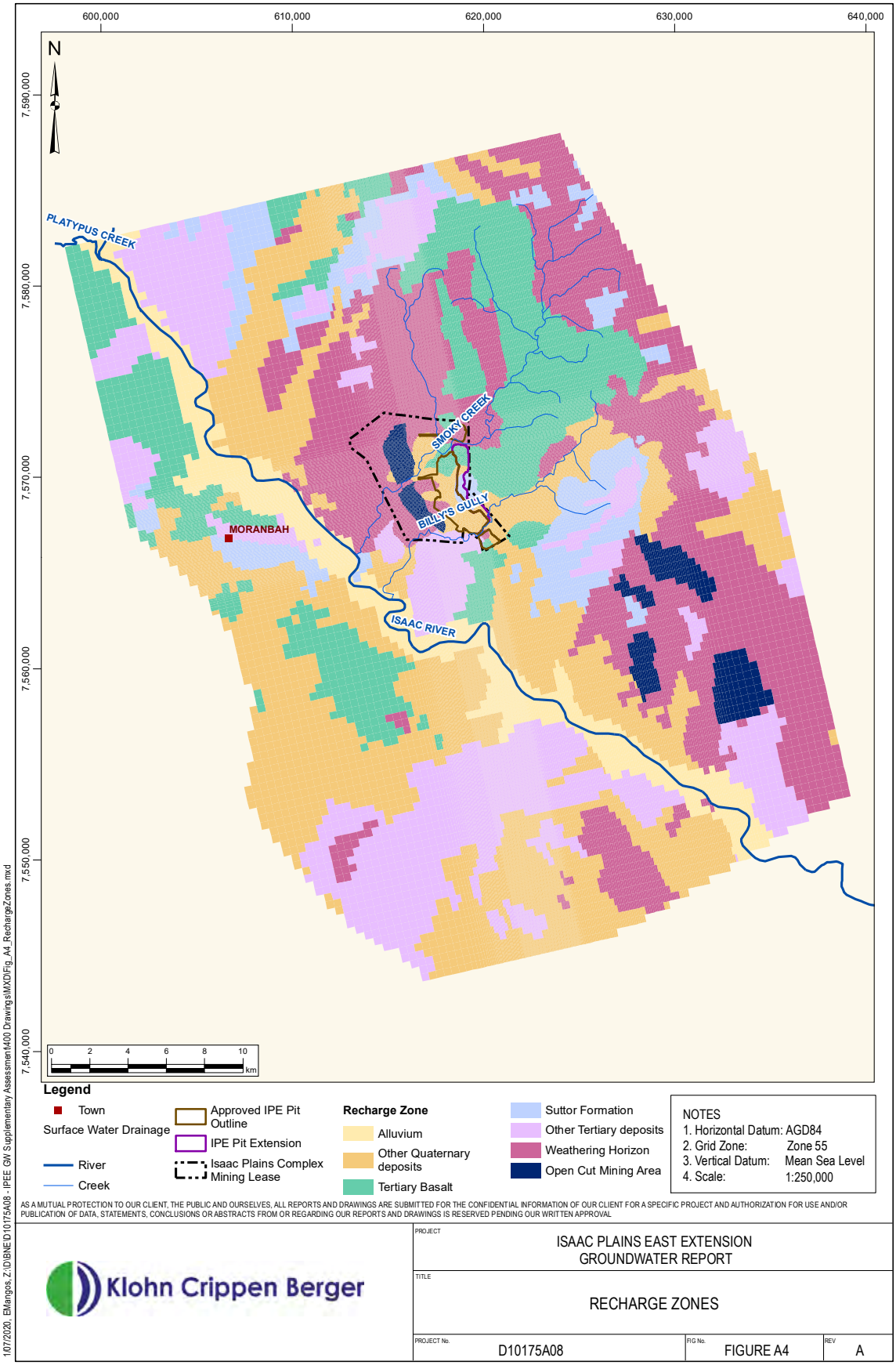

Figure A4: Numerical model recharge zones

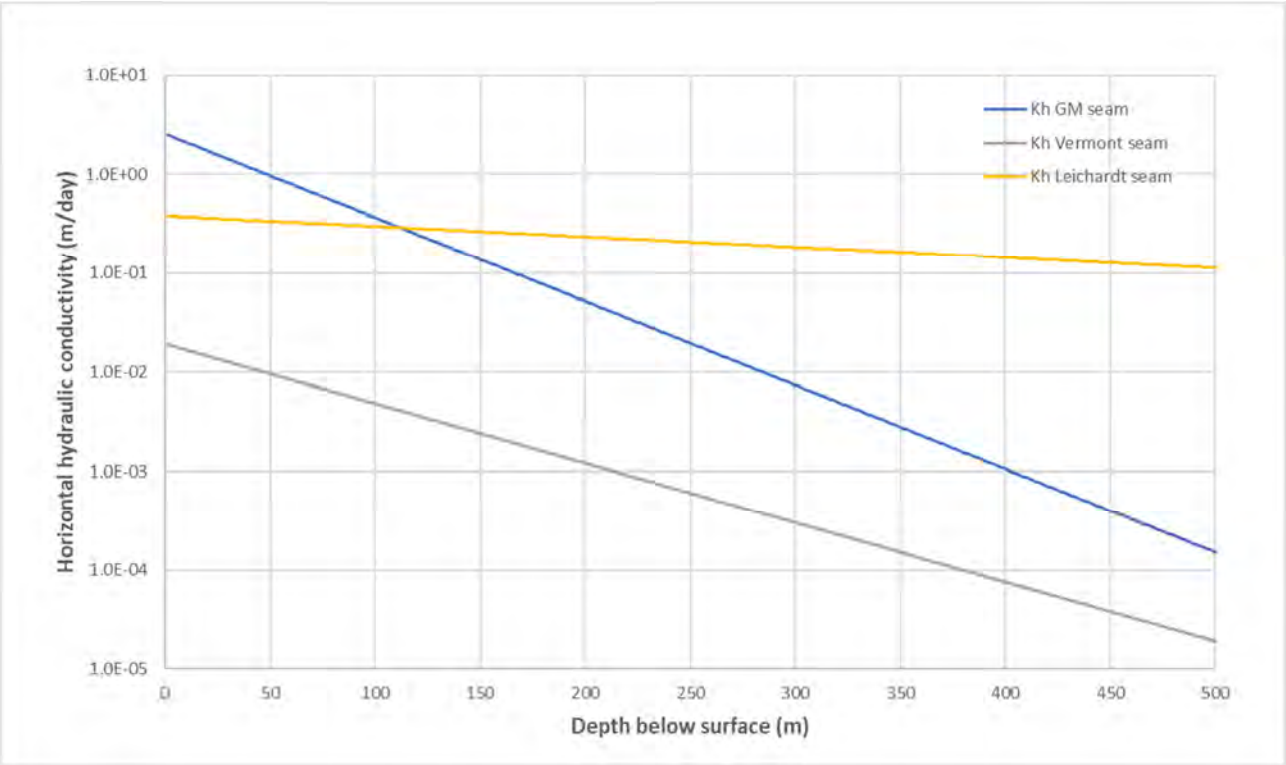

Figure A5: Depth dependent relationship implemented for distribution of hydraulic conductivities of coal seam layers

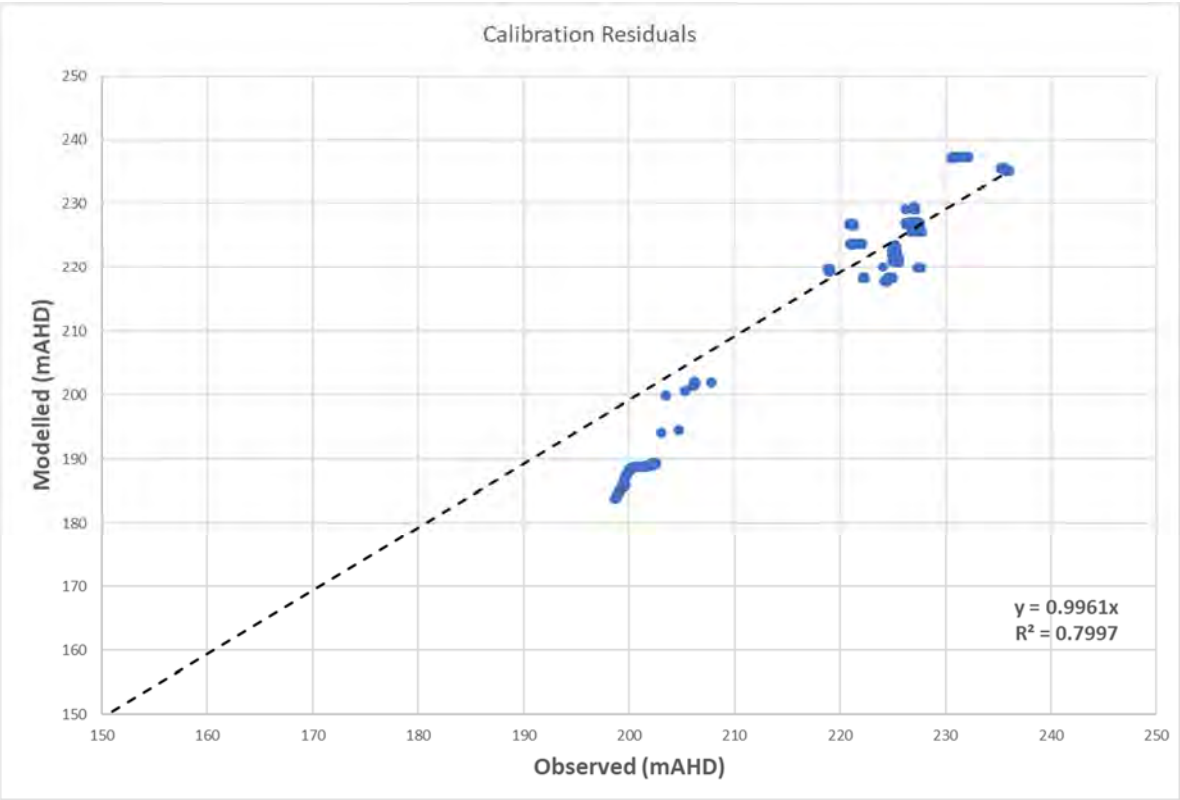

Figure A6: Correlation of modelled and observed groundwater levels

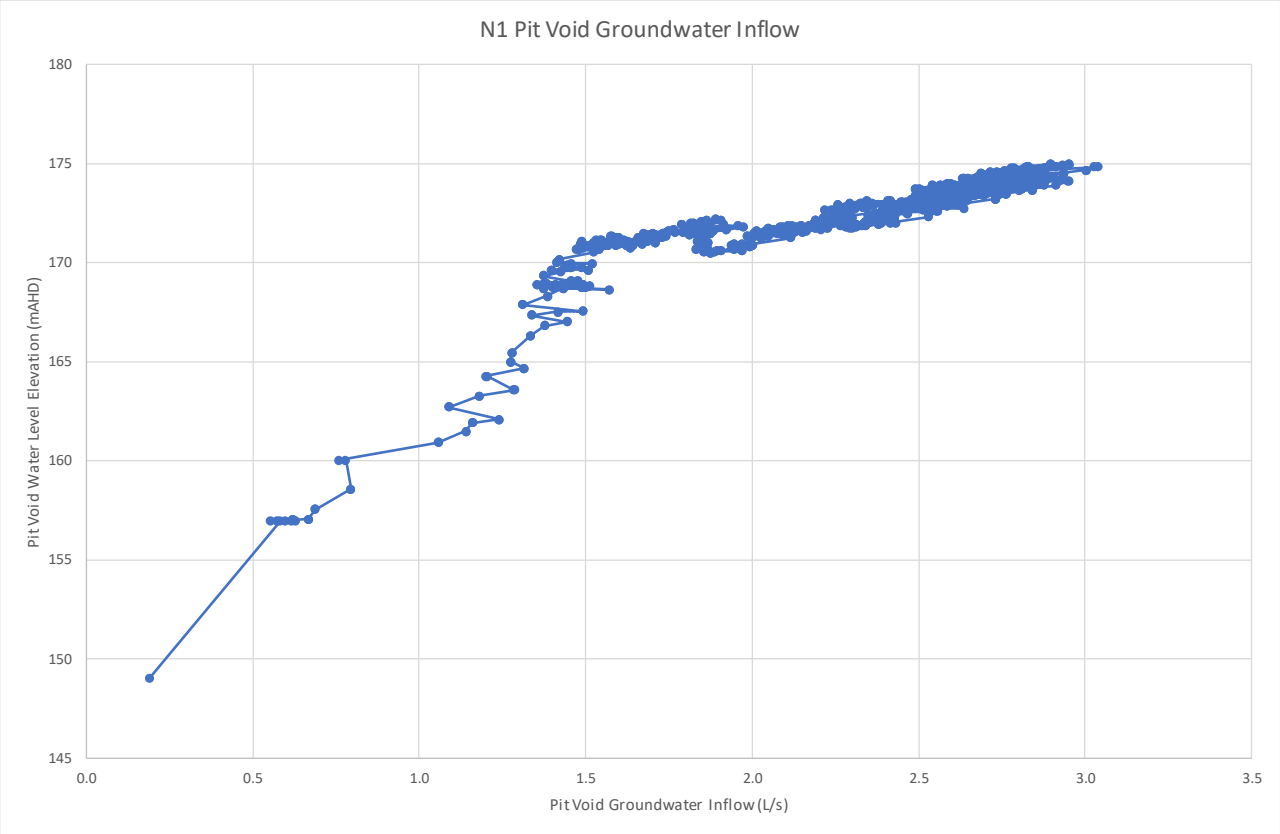

Figure A7: Post-closure groundwater inflow flux for N1 pit void

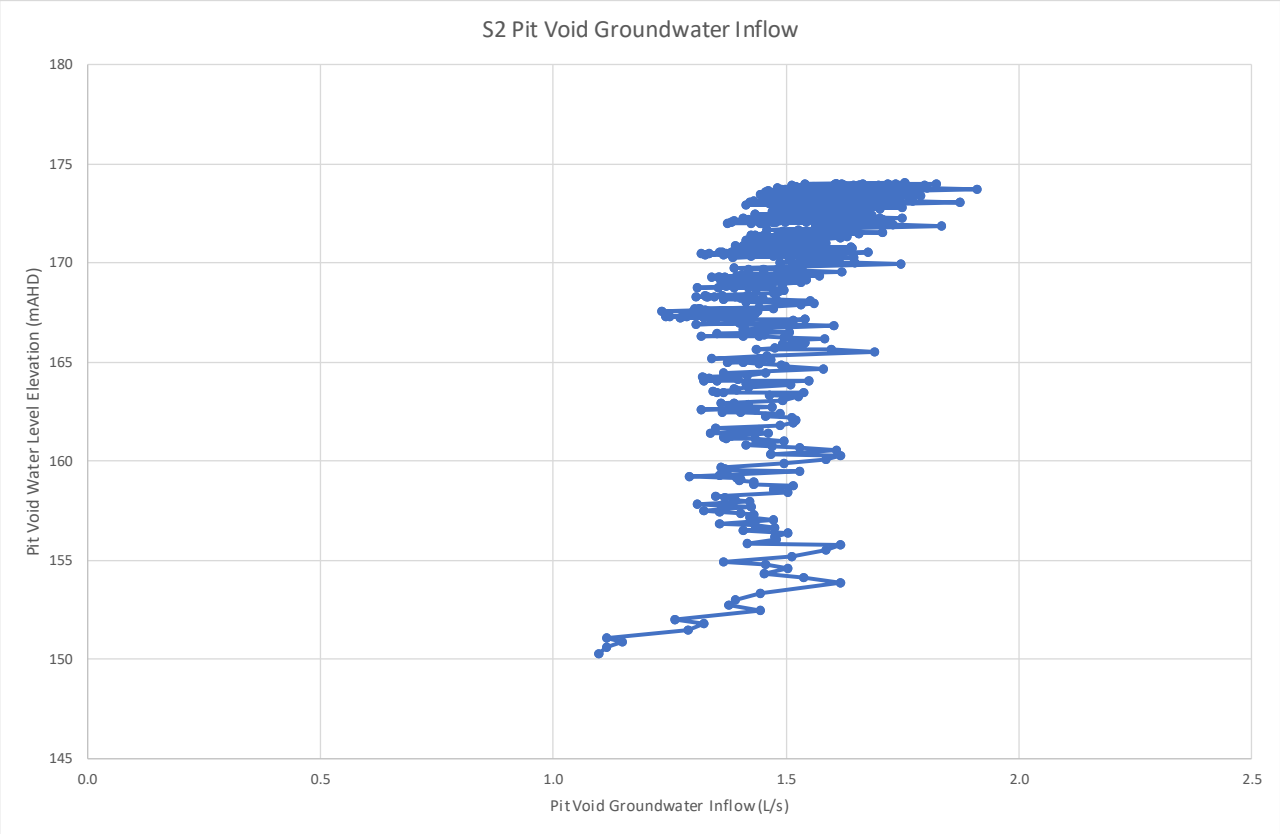

Figure A8: Post-closure groundwater inflow flux for S2 pit void

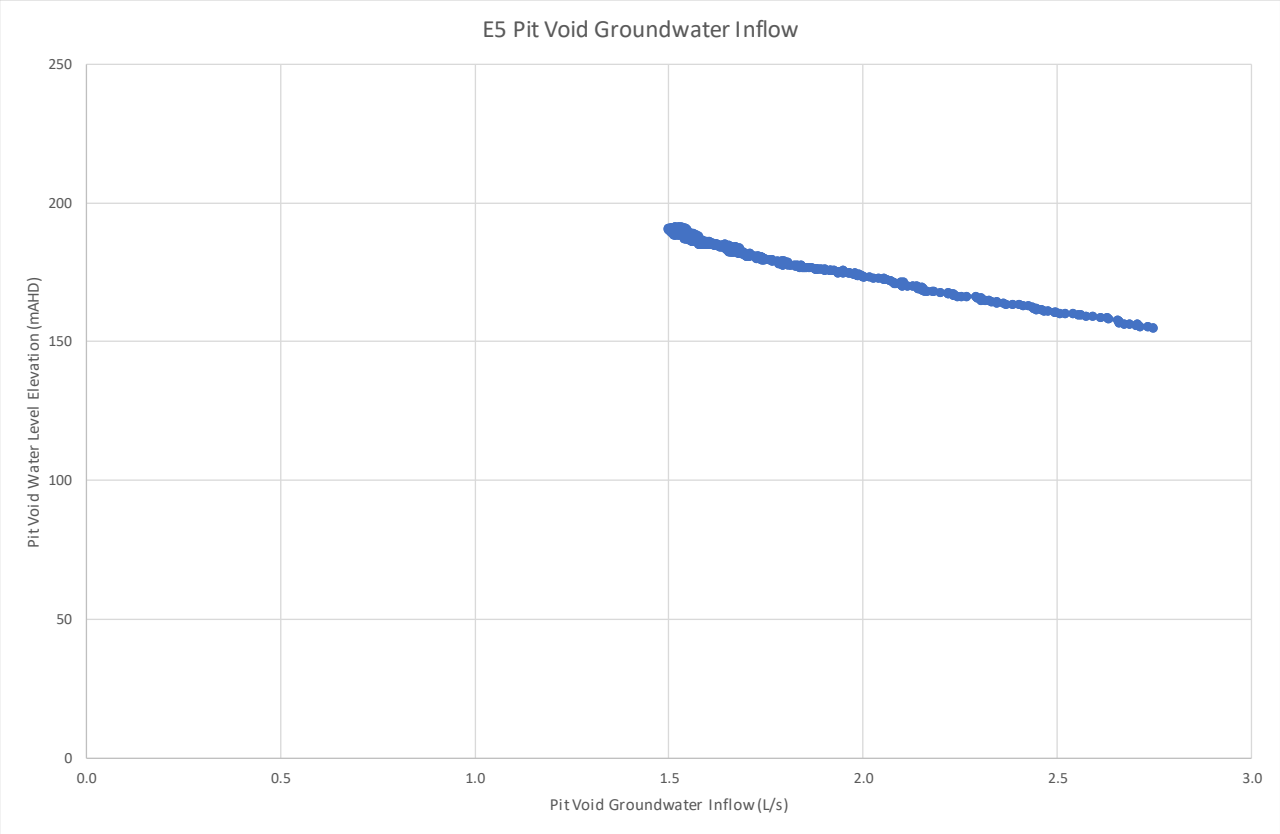

Figure A9: Post-closure groundwater inflow flux for E5 pit void

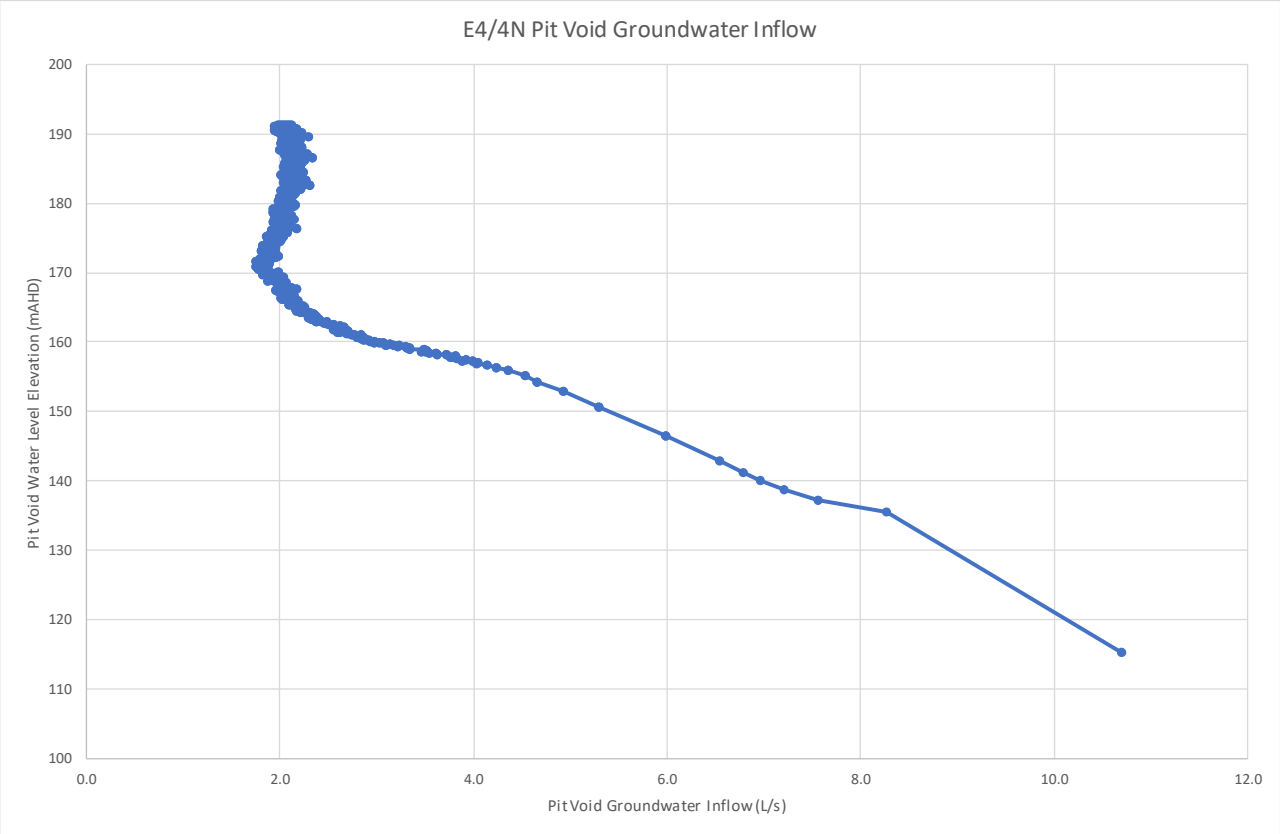

Figure A10: Post-closure groundwater inflow flux for E4/4N pit void

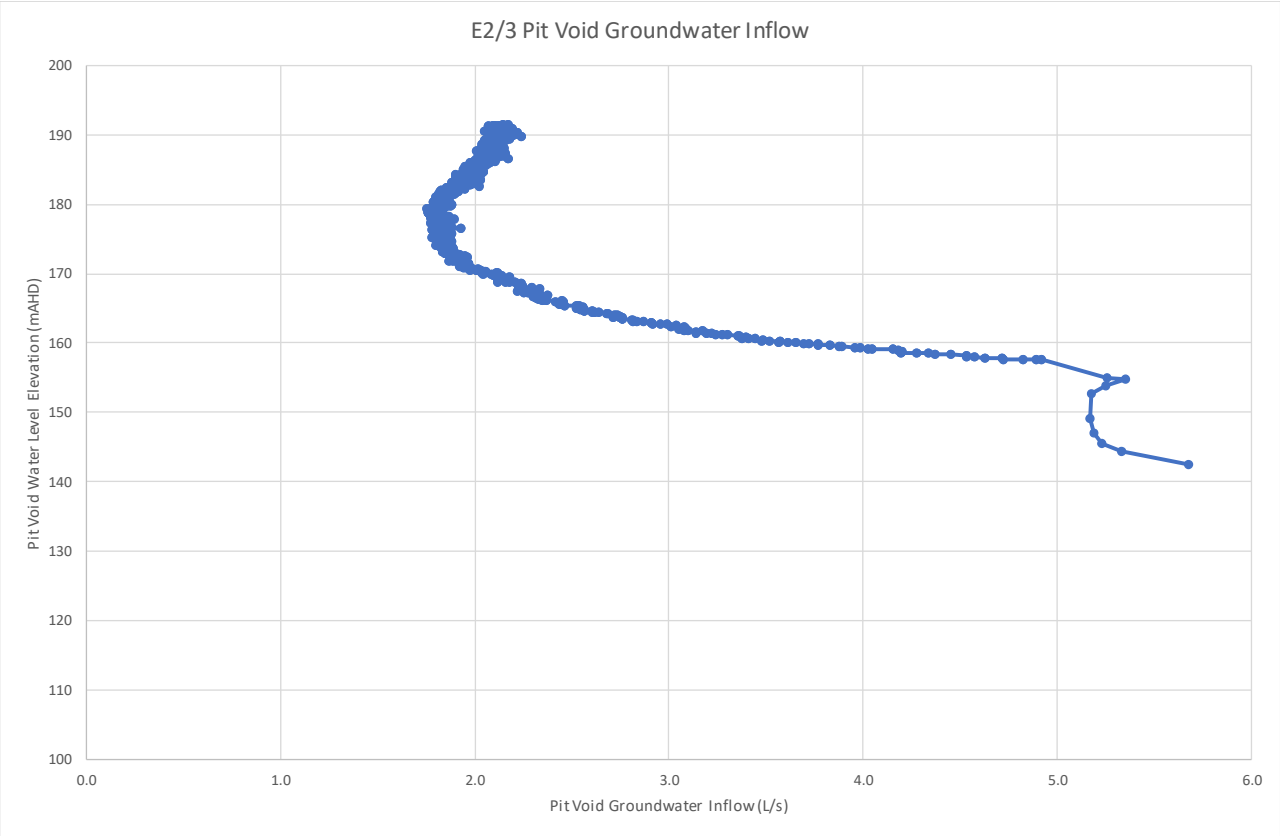

Figure A11: Post-closure groundwater inflow flux for E2/3 pit void

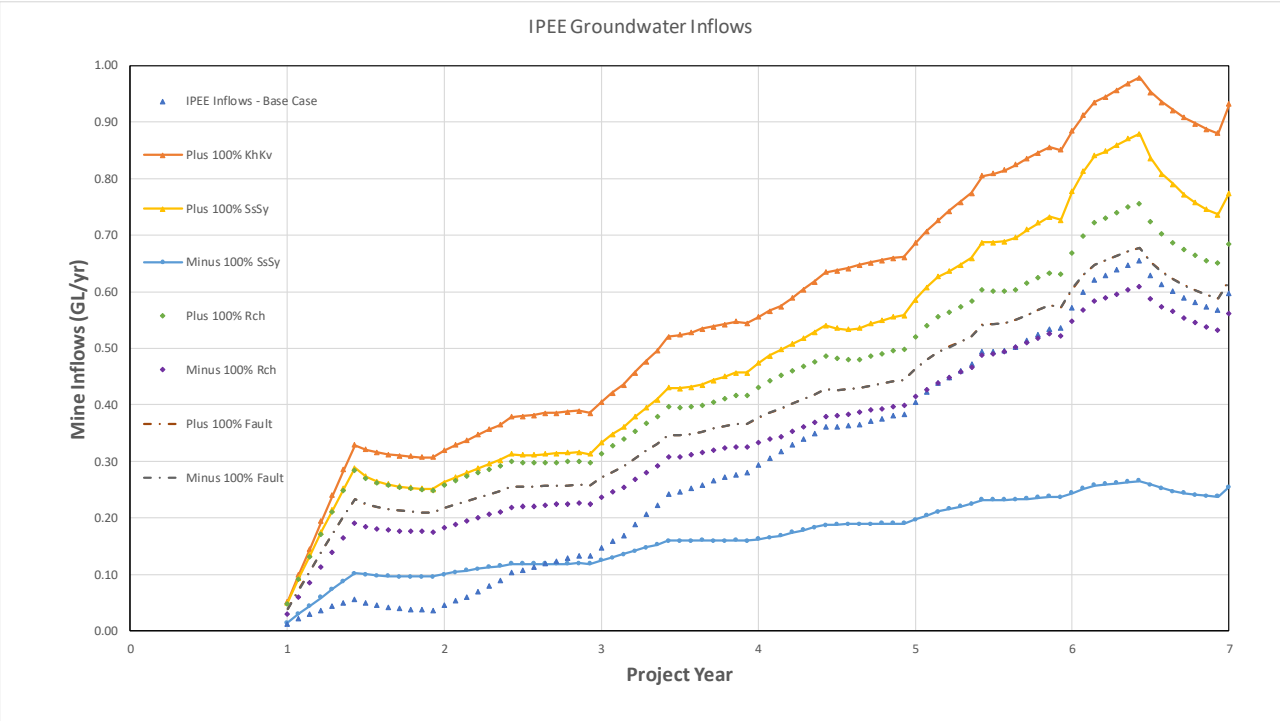

Figure A12: Sensitivity of predicted mine inflows

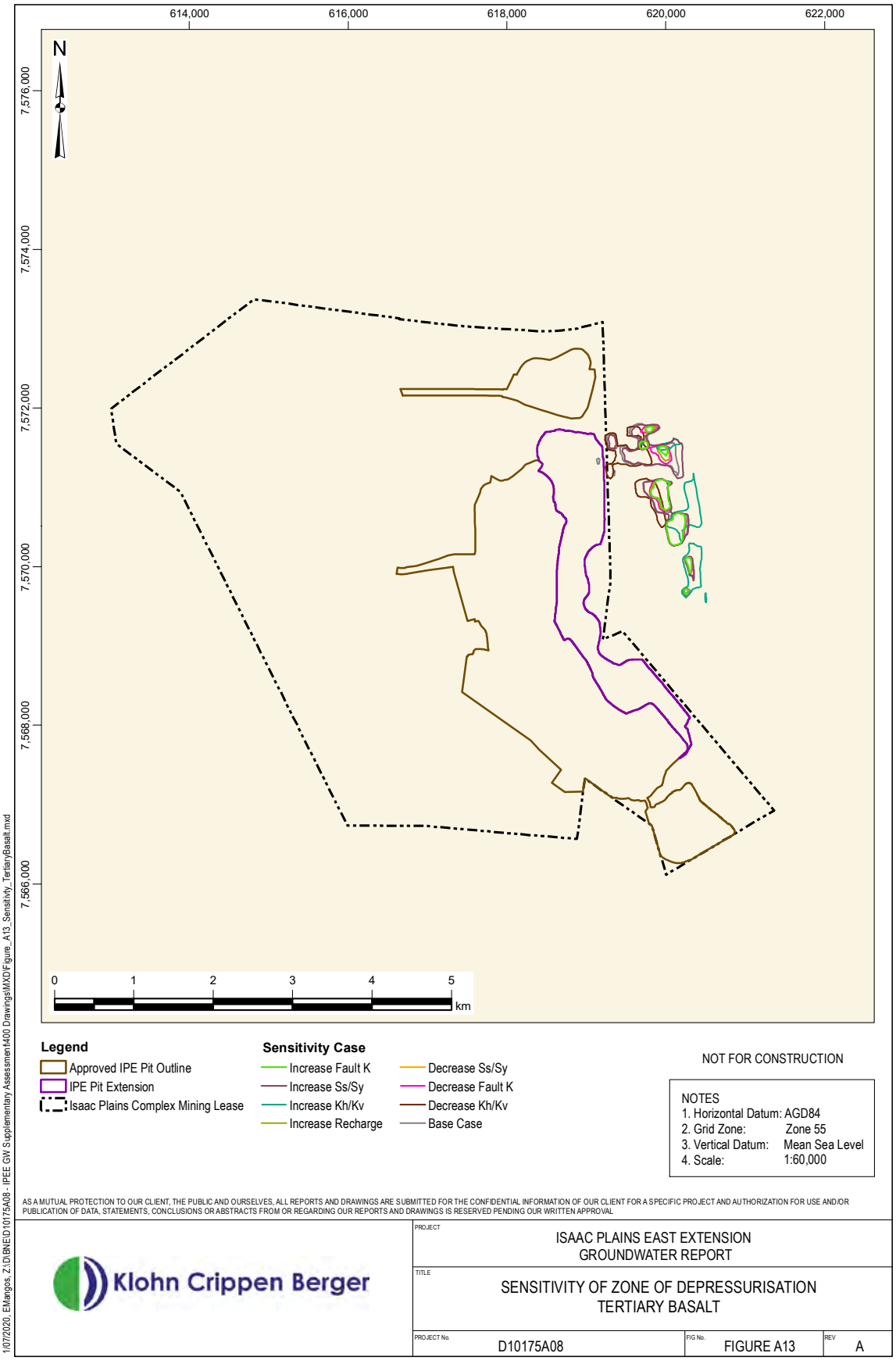

Figure A13: Sensitivity of zone of depressurisation – Tertiary Basalt

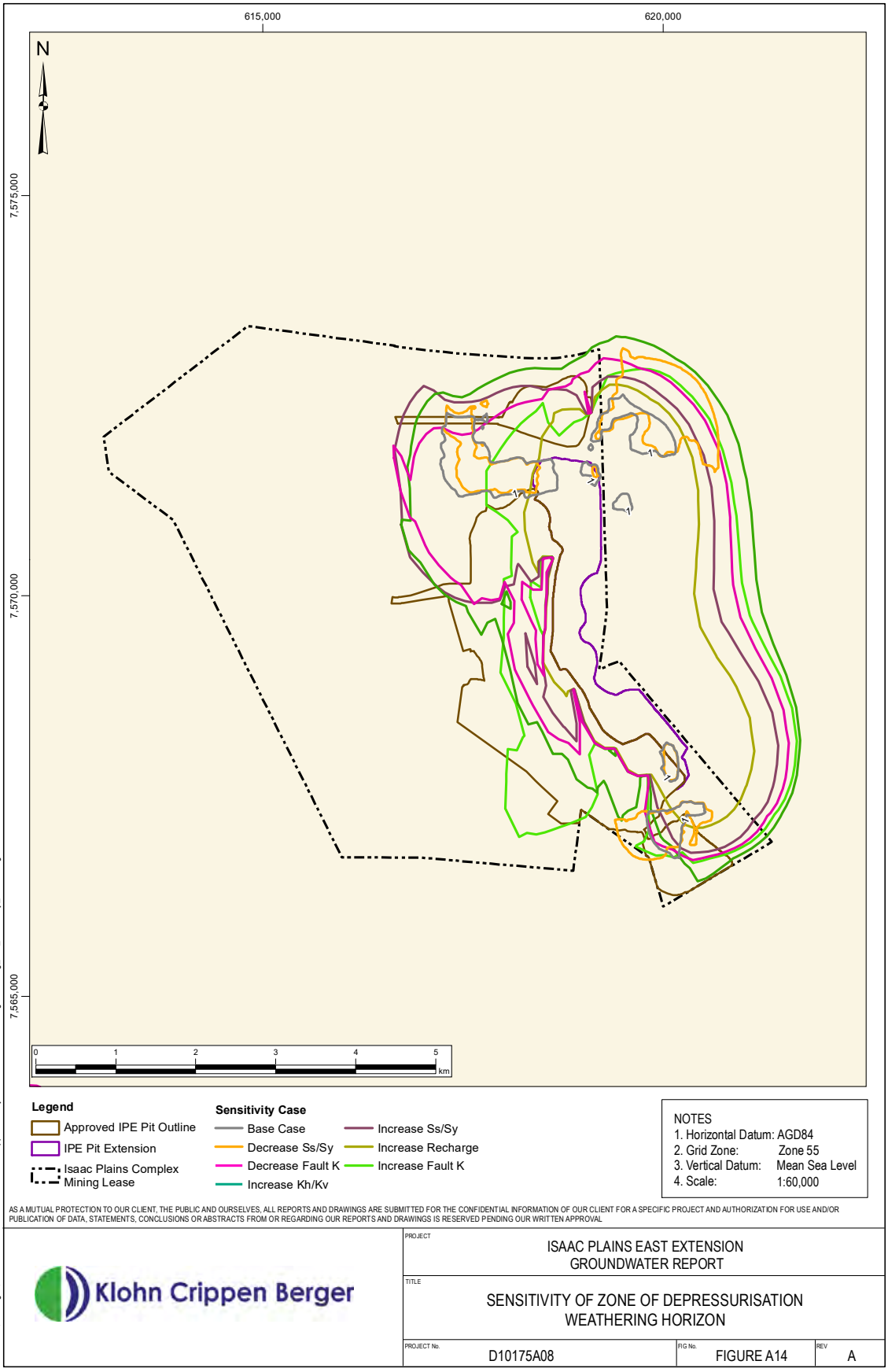

Figure A14: Sensitivity of zone of depressurisation – Weathered Horizon

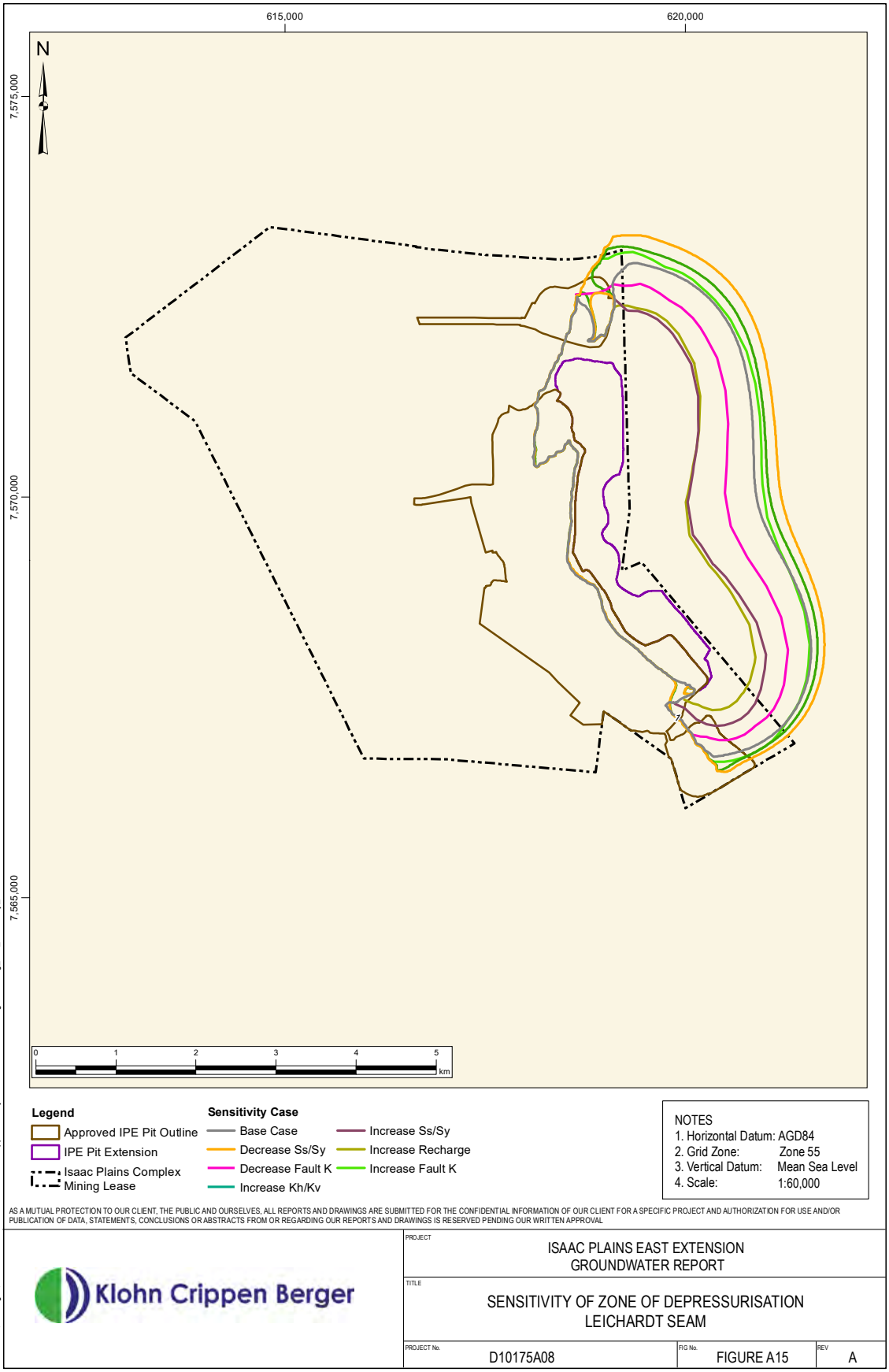

Figure A15: Sensitivity of zone of depressurisation – Leichardt Seam

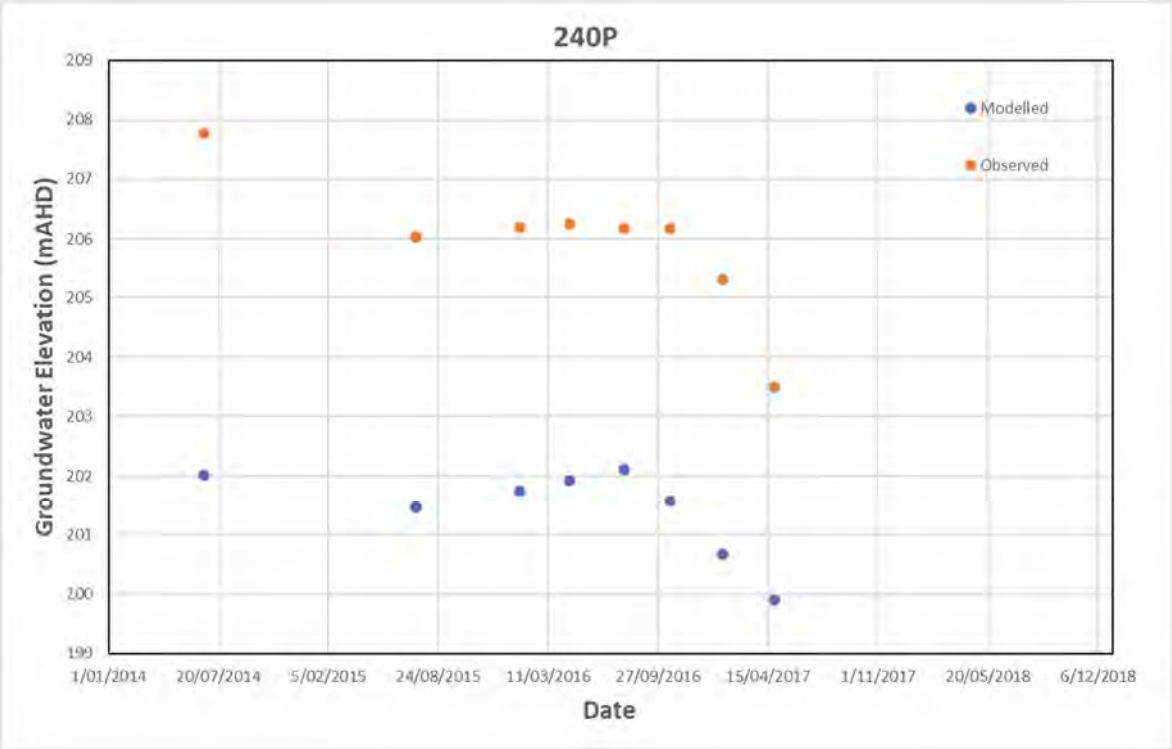

Figure A16: Modelled and observed groundwater levels from bore 240P

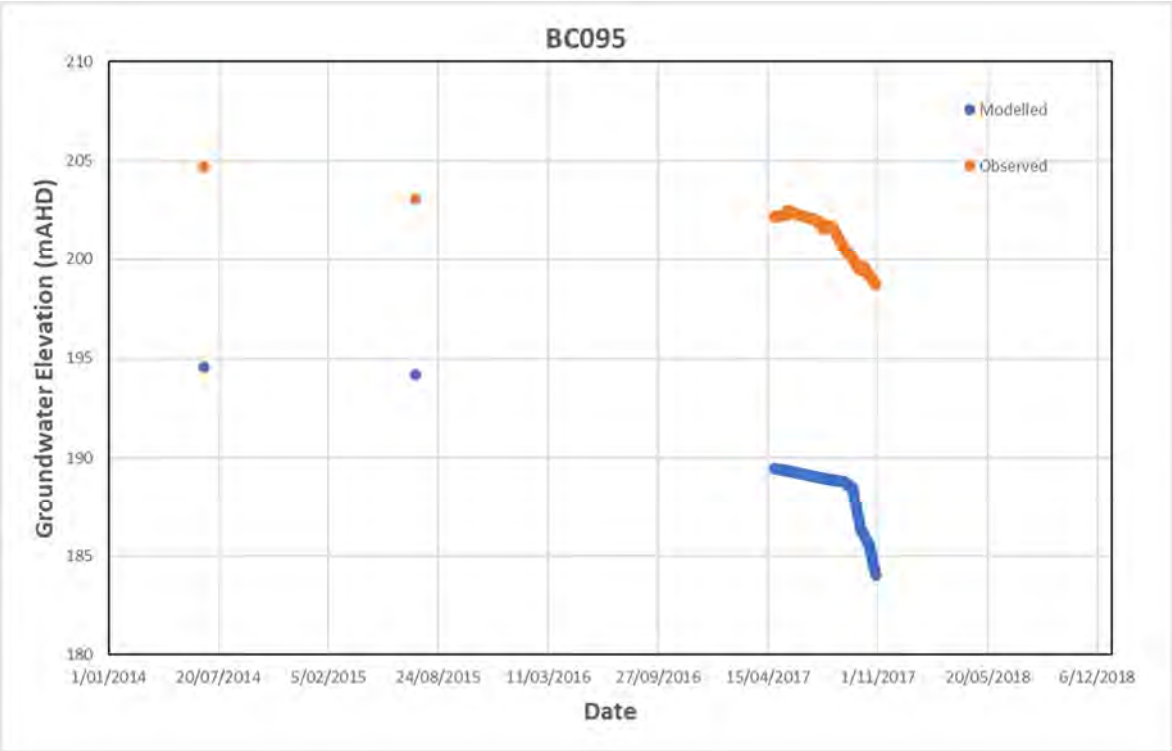

Figure A17: Modelled and observed groundwater levels from bore BC095

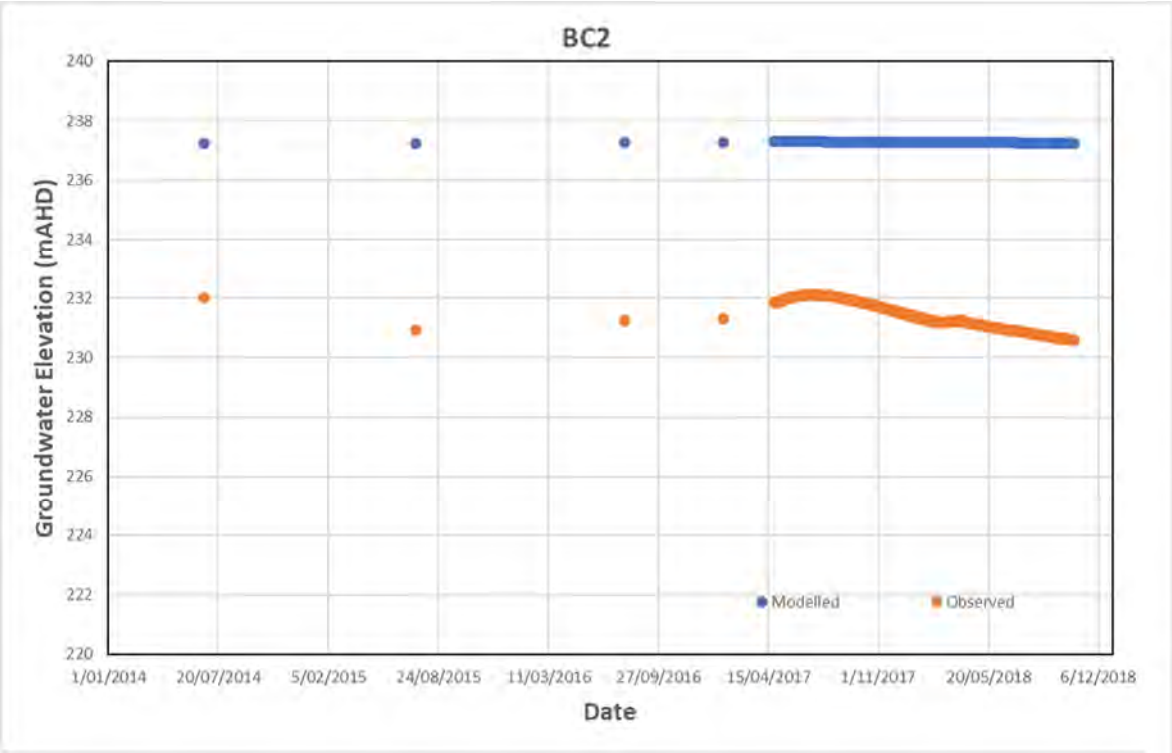

Figure A18: Modelled and observed groundwater levels from bore BC2

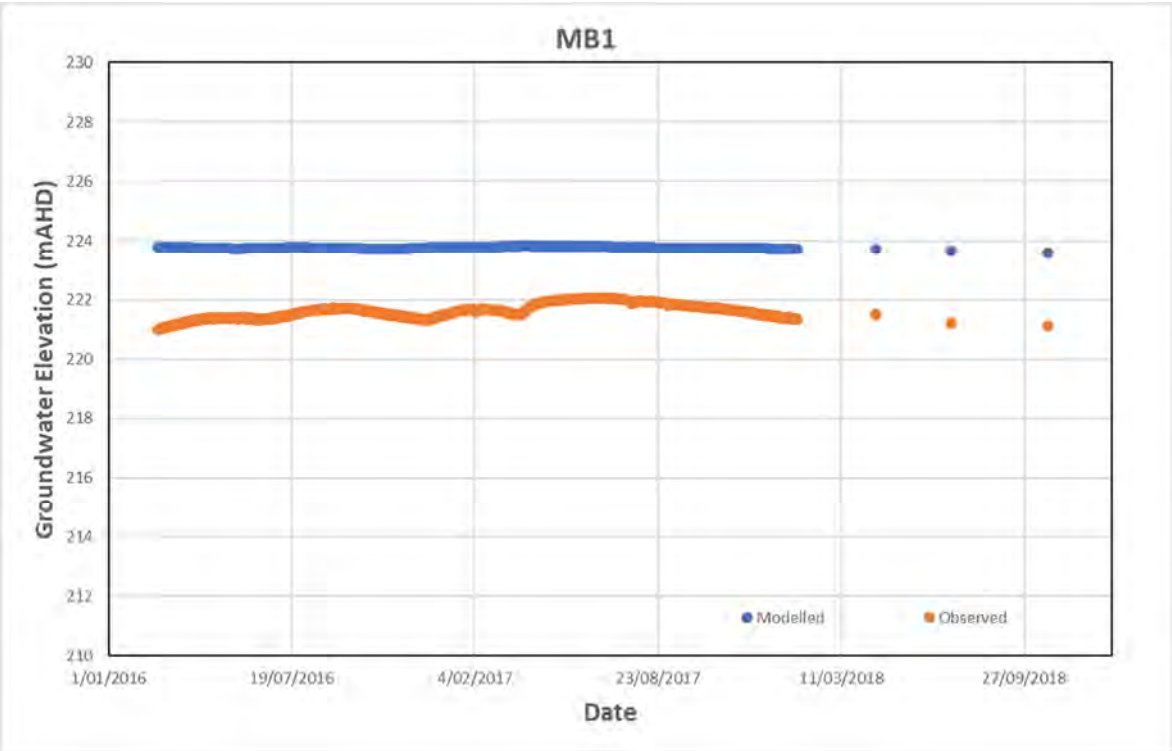

Figure A19: Modelled and observed groundwater levels from bore MB1

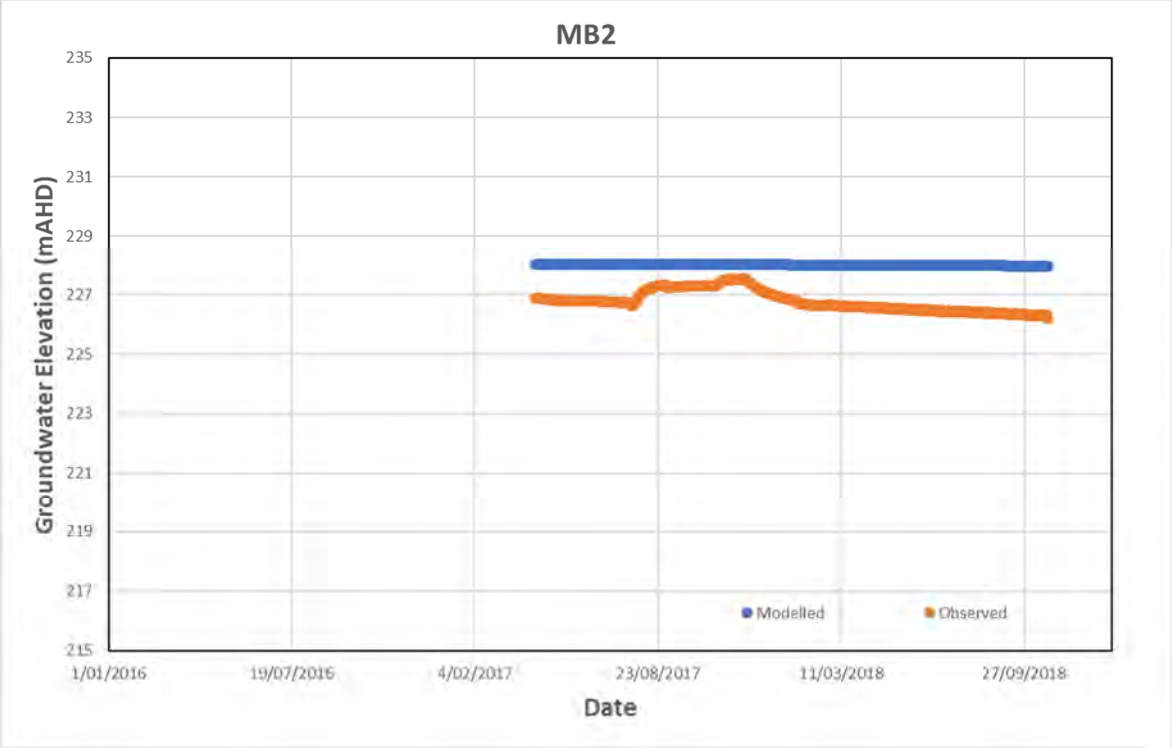

Figure A20: Modelled and observed groundwater levels from bore MB2

Figure A21: Modelled and observed groundwater levels from bore MB3

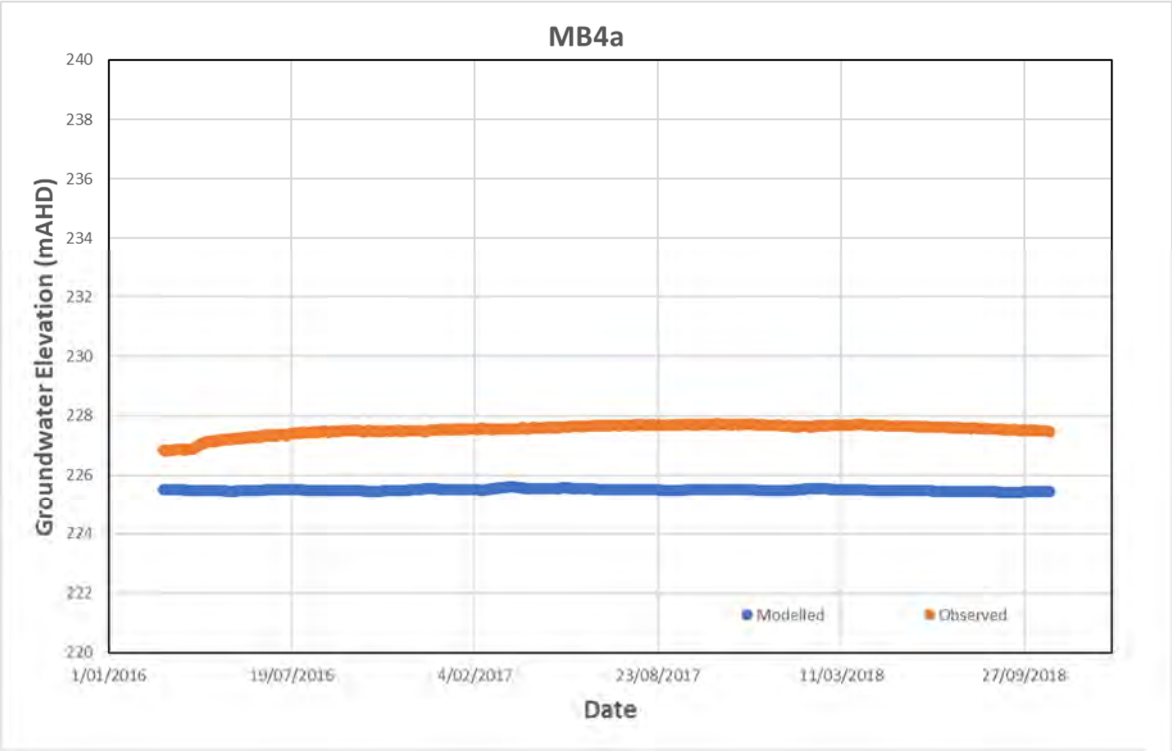

Figure A22: Modelled and observed groundwater levels from bore MB4a

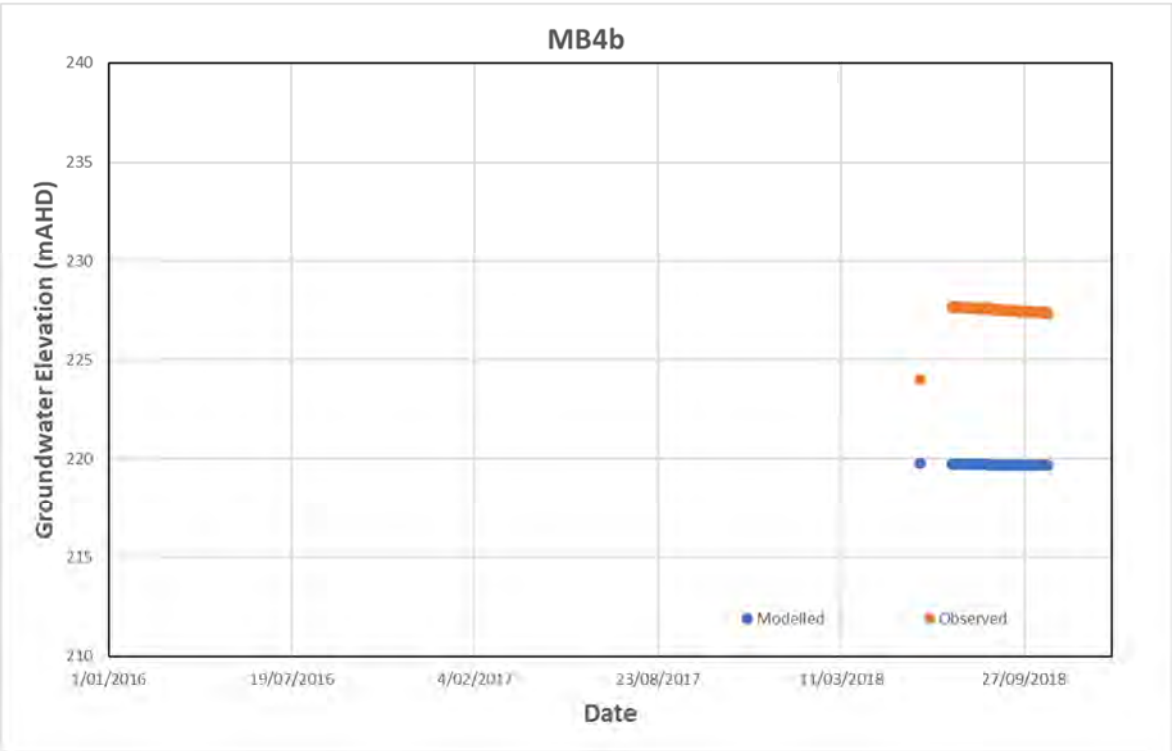

Figure 23: Modelled and observed groundwater levels from bore MB4b

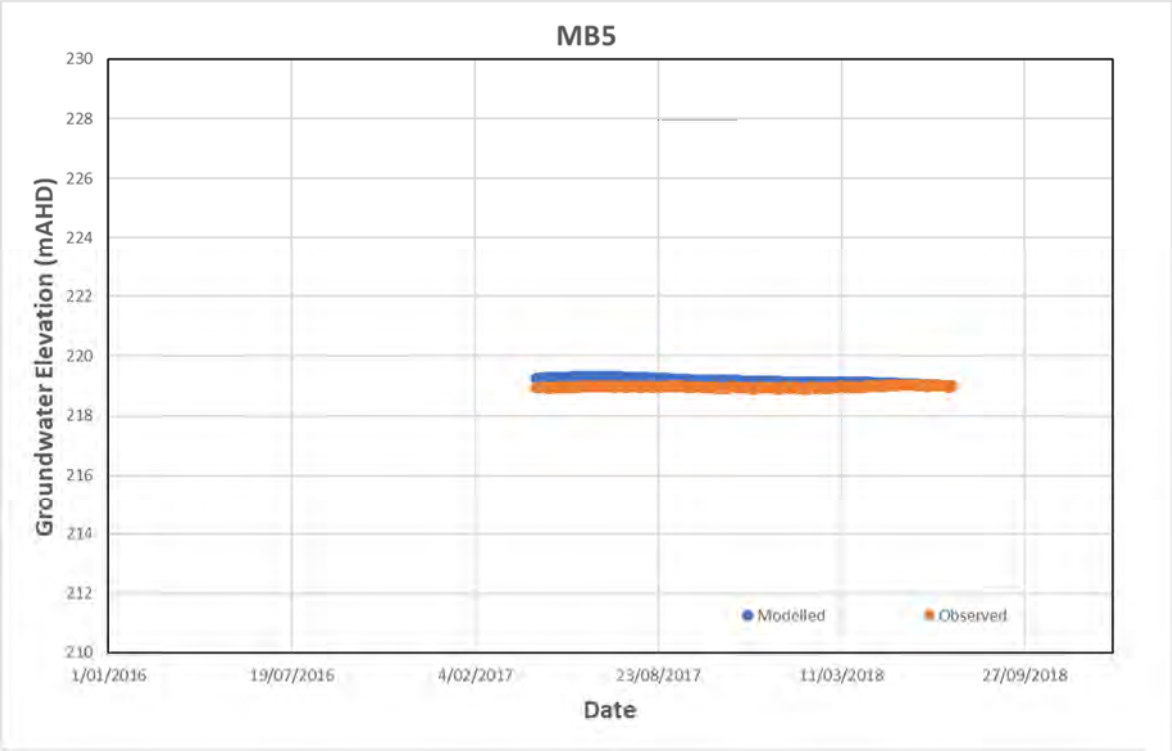

Figure A24: Modelled and observed groundwater levels from bore MB5

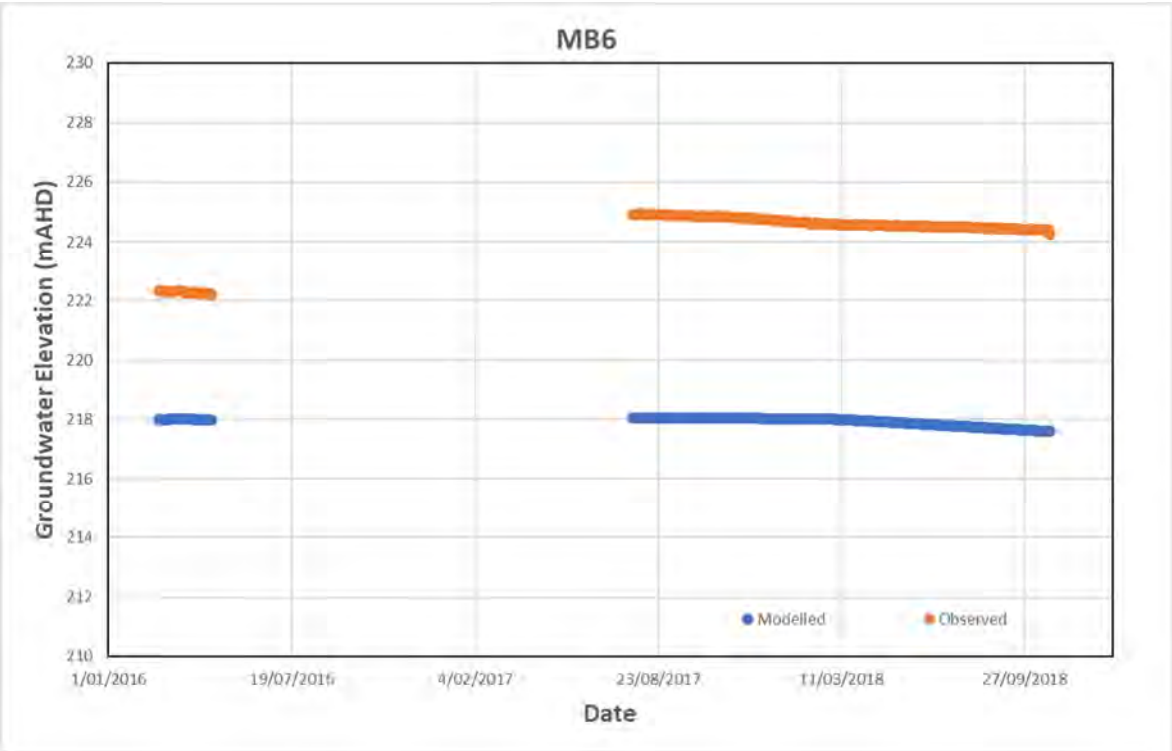

Figure A25: Modelled and observed groundwater levels from bore MB6

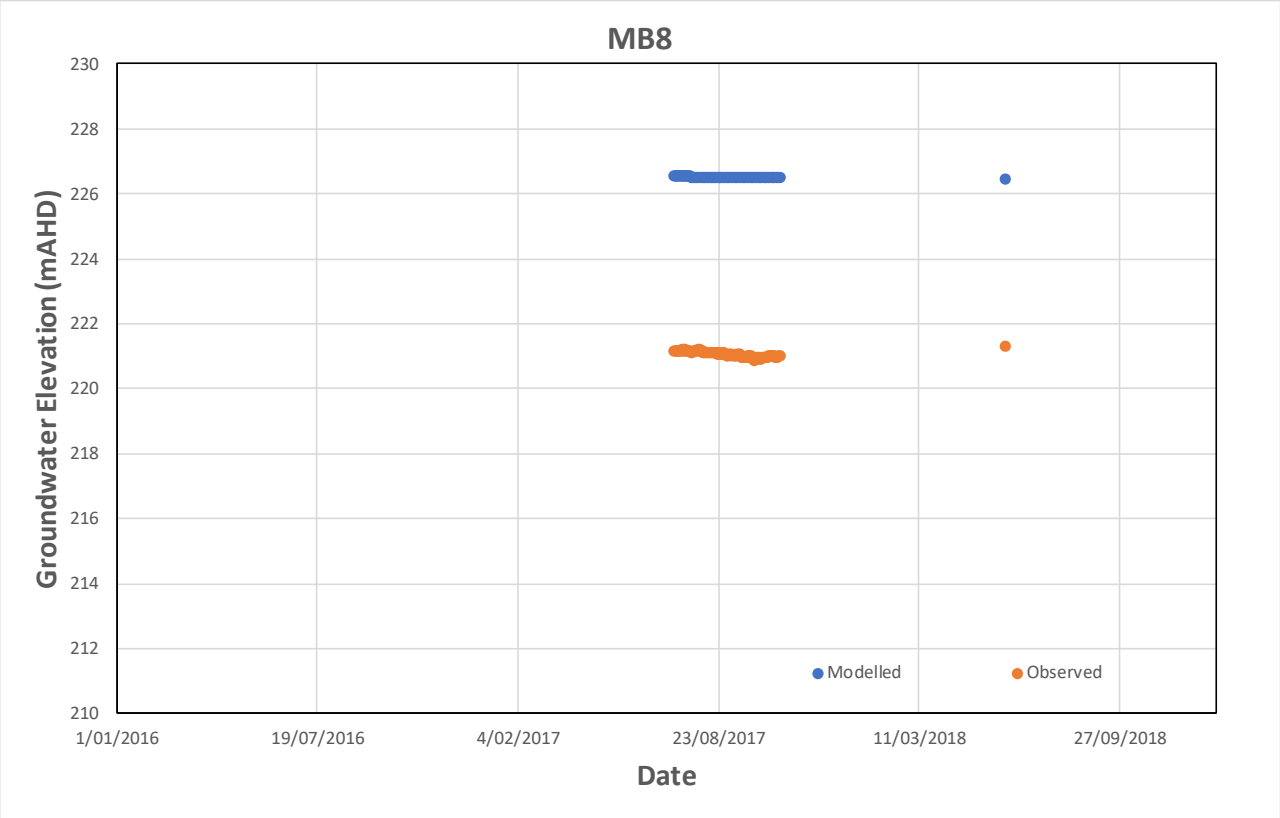

Figure 26: Modelled and observed groundwater levels from bore MB8

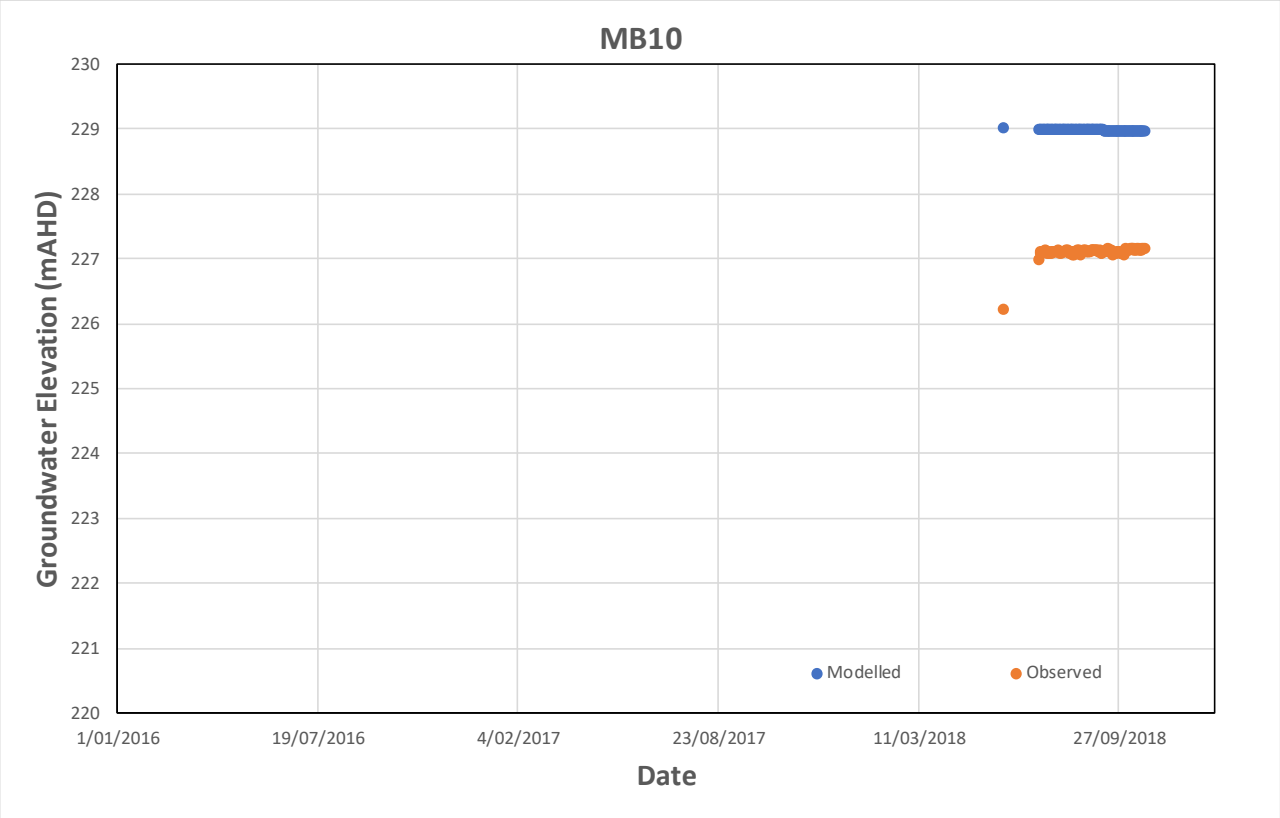

Figure 27: Modelled and observed groundwater levels from bore MB10

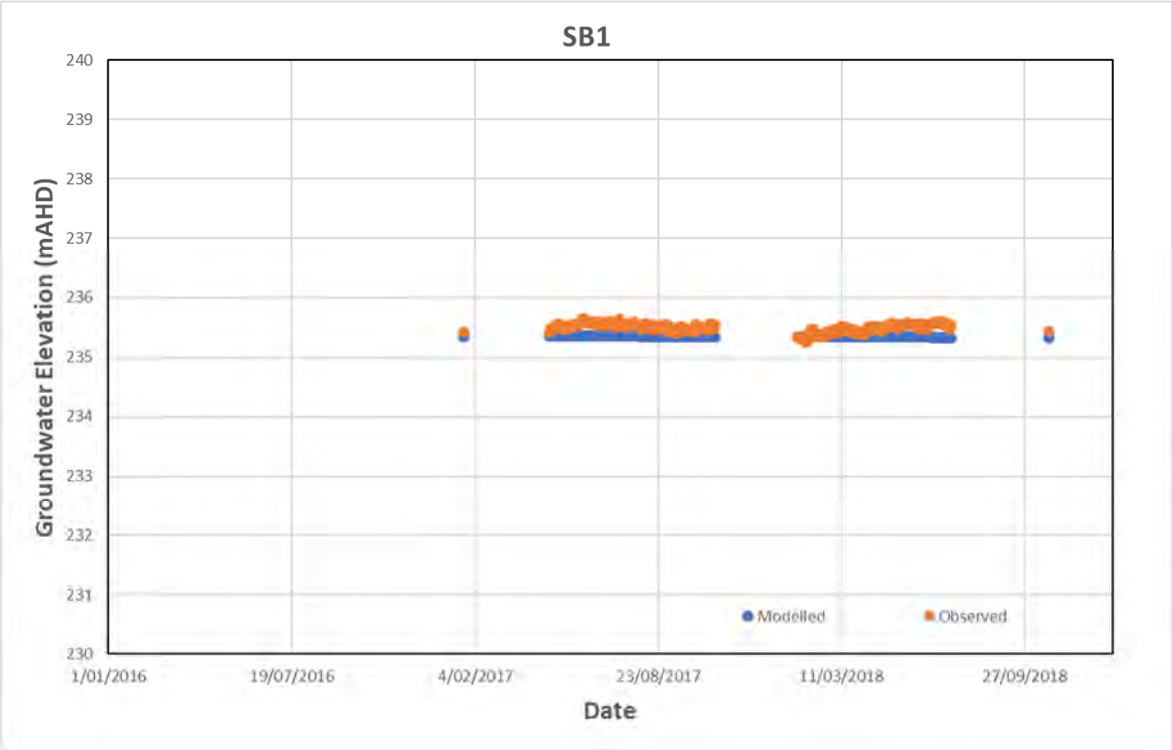

Figure A28: Modelled and observed groundwater levels from bore SB1

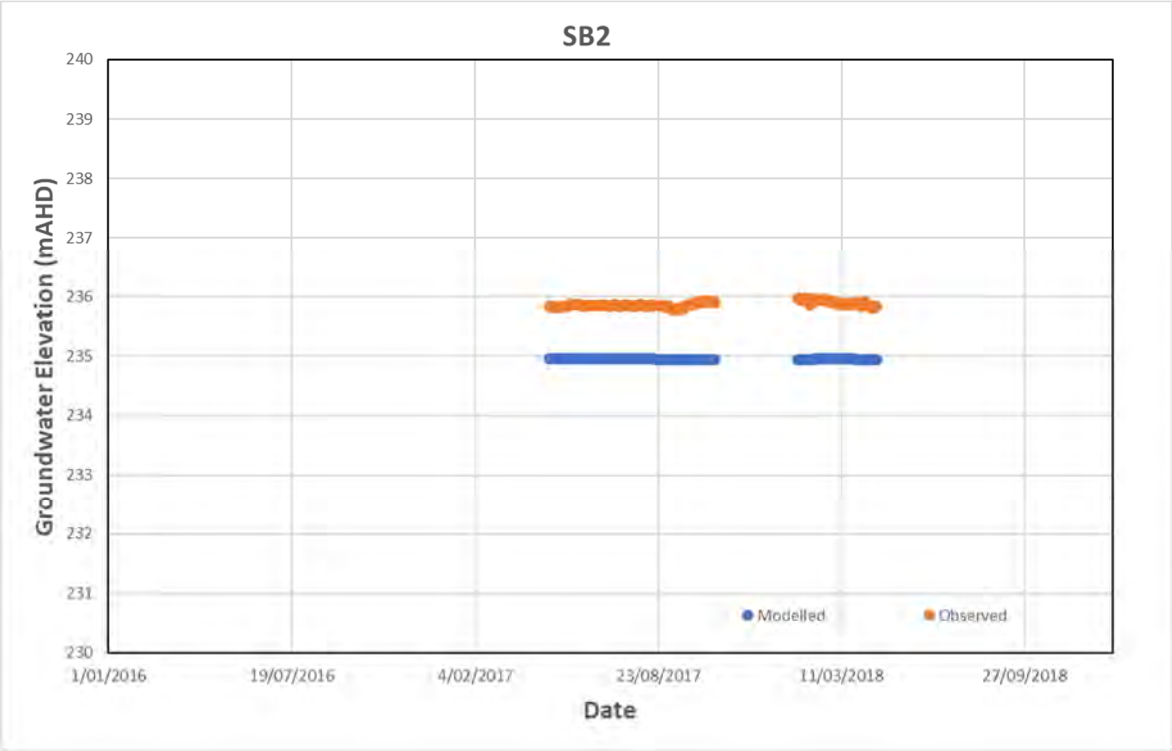

Figure A29: Modelled and observed groundwater levels from bore SB2

APPENDIX V

Groundwater Monitoring and Management Plan (GMMP)

Klohn Crippen Berger

20 September 2019

Stanmore Coal Limited
Email Delivery: Richard.Oldham@stanmorecoal.com.au

Dear Mr. Oldham:

Isaac Plains Mine
Groundwater Monitoring and Management Plan

Klohn Crippen Berger (KCB) is pleased to provide Stanmore IP Coal Pty Ltd (Stanmore) with this final Groundwater Monitoring and Management Plan (GMMP) for Isaac Plains Mine (IPM), Isaac Plains East (IPE) and the IPE Extension Project (IPEE), hereafter identified as Isaac Plains Complex (IPC).

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Chris Strachotta
Senior Hydrogeologist

Dean Erasmus
Hydrogeologist

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1 INTRODUCTION

1.1 Background

Klohn Crippen Berger Ltd (KCB) was engaged by Stanmore IP Coal Pty Ltd (Stanmore) to develop a Groundwater Monitoring and Management Plan (GMMP) for the Isaac Plains Mine (IPM), Isaac Plains East (IPE) Mine, IPE Extension Project (IPEE) and potential, future Isaac Plains Underground Project (IPU) (deferred until after open cut mining). These areas combined are hereafter identified as the Isaac Plains Complex (IPC), located approximately 5 km northeast of Moranbah in the Bowen Basin (Figure 1).

This document was prepared to address groundwater related conditions in support of an application to amend the Environmental Authority (EA) EPML00932713, and to update the GMMP by October 1, 2019, in accordance with EA conditions. The EA applies to locations where five Mining Leases (ML) have been granted (ML70342, ML700016, ML70017, ML70018, ML70019), which correspond to the area covered by the IPC. An Associated Water Licence (AWL), for IPC applies to four of the five MLs (ML700016, ML70017, ML70018, and ML70019), with a deemed water licence applying to ML70342.

1.2 Objectives and Scope of the GMMP

This GMMP has been developed as a “live” document that can be readily used and referred to during operations, which provides instructions for compliance with the EA conditions. A complete list of EA conditions for groundwater is included in Section 3.1.1.1.

To comply with the requirements of the relevant EA conditions, and the IPE associated water licence conditions, the monitoring program component of this GMMP has the following objectives:

- To assess the effects of extraction of authorised groundwater including the monitoring of:
  - impacts of any springs and watercourses dependent on groundwater flow
  - impacts of other groundwater users
  - groundwater level in all identified geological units across and adjacent to the IPC
  - groundwater inflows and discharges from mine workings
- To further refine and validate the groundwater flow model used to assess impacts to groundwater; and
- To take into account requirements of any regional groundwater monitoring and assessment program developed to address potential cumulative impacts.

1.3 GMMP Structure

This GMMP was prepared using the following structure:

- IPC Description;
- Regulatory and Policy Framework, applicable to the EA requirements;
- Physiographic Setting;
- Conceptual Hydrogeological System;
- Environmental Values;
- Groundwater Monitoring Program, including procedures and quality control measures;
- Trigger and Limit Exceedances; and
- References.

2 SITE DESCRIPTION

2.1 Overview

This GMMP is applicable to the area occupied by the IPC. Together, these developments are identified as IPC.

The Isaac Plains Mine is an operating open cut coal mine located approximately 5 km northeast of Moranbah in Central Queensland (Figure 1). IPM commenced operation in 2006 and produces export coking coal, however, the mine was placed into “care and maintenance” in early 2015.

IPM was acquired by the Stanmore in late 2015 and recommenced operations in early 2016. The open cut mining operations ceased in late 2018. Current mining operations include removal of overburden by dragline with truck and shovel pre-stripping. ROM coal is hauled by truck from the open cut pits to an on-site Coal Handling and Preparation Plant (CHPP) for washing and processing. Product coal is loaded to trains for transport from site via an on-site rail loop and train loading facility.

The potential, future IPEE project involves the extension of the approved IPE open cut coal pits 2 to 5 (Figure 2). IPE and IPEE will be operated as an extension of IPM and will utilise the existing IPM infrastructure, mining equipment and workforce. However, some infrastructure upgrades are required.

New infrastructure for the project will be limited to:

- Haul roads and access roads, including connections to the existing IPE road network;
- Minor laydown areas, powerlines;
- Modular CHPP upgrade, and
- Stormwater drains, pit water pipelines, sediment dams and sediment control works.

The potential, future IPU project (now deferred) involves the development of an underground bord and pillar mine at the Isaac Plains Complex. The project will use the existing IPC surface infrastructure, including the existing CHPP.

2.2 Mining Layout and Methods

Isaac Plains Mine (ML70342) comprises five open-cut pits (N1, N2, S1 (completely backfilled), S2, and S3 (partially backfilled)). These pits are located east of the Isaac River and upstream of the Isaac River-Smoky Creek confluence, with Smoky Creek bisecting the ML70342 lease area.

The IPE Project comprises five open cut pits within the IPC area. These open pits extend approximately 6 km along a north-south strike. The IPEE Project involves the extension of the existing IPE open cut pits. The proposed extension extends approximately 4 km along a north-south strike. The proposed maximum depth of mining is approximately 150 m below ground level along the final high wall. The project will extend the existing open cut pit by an average of approximately 500 m to the northeast.

Coal from the Leichardt seam will be mined from these pits. The Leichardt seam generally dips towards the east and mining will also progress down-dip in an easterly direction over the 14 year (includes IPEE and potential, future IPU) mine life.

Pit development will also involve the removal of overburden. Initial overburden will be stored in out-of-pit overburden emplacement areas situated adjacent to the open pits, or used to backfill existing pits at IPM and IPE. As the open cut pits develop, overburden will be placed in-pit. The overburden emplacement areas will be rehabilitated progressively as the mine develops.

The process of open cut mining will physically dewater groundwater held in the overburden and will act to depressurise the Leichardt seam. This will reduce water pressure and associated groundwater levels in the surrounding geology, beyond the mining area.

Numerical groundwater modelling carried out as part of the environmental assessment report (EAR) for the EA amendment application for IPEE (KCB 2019) indicates that depressurisation within the Permian coal measures and Rewan Group during mining will typically be constrained by faulting and existing depressurisation to the west of IPE. Depressurisation is predicted to extend approximately 2 km to the east of IPEE.

3 REGULATORY AND POLICY FRAMEWORK

3.1 State Legislation

3.1.1 Environmental Protection Act 1994

The *Environmental Protection Act 1994* (State of Queensland 2019) is an Act with the objective to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development).

This Act states that 'to carry out an environmentally relevant activity (ERA) an EA is required'.

Stanmore holds EA EPML00932713 for the IPC, covering five mining leases, as listed in Table 3.1.

Table 3.1: List of Mining Leases covered by the current GMMP

Site Identification	Mine Lease
Isaac Plains Mine (IPM) and Isaac Plains Underground Project (IPU)	ML70342
Isaac Plains East (IPE), Isaac Plains East Extension (IPEE) Project and IPU (ML700018 and ML700019 only)	ML700016 ML700017 ML700018 ML700019

3.1.1.1 EA Conditions

Schedule C of the IPC EA Conditions stipulates groundwater conditions for the project including the development, certification and implementation of the GMMP by October 1, 2019. Table 3.2 summarises the groundwater-related EA Conditions and the relevant sections within the current GMMP where those conditions are addressed.

Table 3.2: EA Conditions for Groundwater

EA Condition	Condition Description	GMMP Section
C42	**Groundwater** The holder of this environmental authority must not release contaminants to groundwater.	General Condition
C43	**Monitoring and reporting** A Groundwater Management and Monitoring Program for all stages of the authorised mining activities on site must: a) be developed, certified and implemented by an appropriately qualified person by 1 October 2018; b) have all determinations of groundwater quality monitoring and groundwater biological monitoring be performed by an appropriately qualified person; and c) be able to detect a change in groundwater quality values and levels due to activities that are part of the authorised mining activities.	All sections

EA Condition	Condition Description	GMMP Section
C44	The Groundwater Management and Monitoring Program required by Condition C43 and the data collected must be reviewed on an annual basis by an appropriately qualified person. The review must: a) include the assessment of groundwater levels and quality data; b) assess the suitability of the groundwater monitoring network, including an assessment of whether groundwater parameter trigger values or compliance bores are required for all groundwater aquifers potentially impacted by the authorised mining activities; and c) be in a report submitted to the administering authority within twenty-eight (28) days of receiving annual groundwater data.	All sections
C45	Groundwater must be monitored at the locations and frequencies defined in Table 11: Groundwater monitoring locations frequency for the standing water levels and the parameters identified in Table 12: Groundwater contaminant triggers. Results and analysis of groundwater monitoring must be submitted annually to the administering authority with the report required by Condition C44(c).	Section 7.1.1 and 7.1.2
C46	**Exceedance investigation** If groundwater quality characteristics in Burton Coal Bore 2 or Swamp Bore 2 exceed any of the trigger levels identified in Table 12: Groundwater contaminant triggers the holder of this environmental authority must: a) notify the administering authority via WaTERS or the pollution hotline within seven (7) days of receiving the analysis results; b) complete an investigation into the potential for environmental harm.	Section 8.4
C47	If groundwater levels for the bores identified in Table 13: Groundwater level monitoring exceed any of the trigger level thresholds identified in Table 13: Groundwater level monitoring the holder of this environmental authority must: a) notify the administering authority via WaTERS or the pollution hotline within seven (7) days of receiving the analysis results; b) complete an investigation into the potential for environmental harm.	Section 8.4
C48	An exceedance investigation under Condition C46 or Condition C47 must be completed and submitted to the administering authority via WaTERS within ninety (90) days of the notification made under Condition C46(a) or Condition C47(a).	Section 8
C49	If the exceedance investigation in Condition C46 or Condition C47 identifies environmental harm is occurring, the environmental authority holder must immediately implement appropriate abatement measures to prevent the continuation or re-occurrence of environmental harm to groundwater.	Section 8.3
C50	**Bore construction and maintenance and decommissioning** The construction, maintenance and management of groundwater bores (including groundwater monitoring bores) must be undertaken in a manner that prevents or minimises impacts to the environment and ensures the integrity of the bores to obtain accurate monitoring.	Section 7.1
C51	The following information must be determined and submitted to administering authority via an amendment to the environmental authority by 1 October 2019:	Section 7.1

EA Condition	Condition Description	GMMP Section
	a) Information for Table 11: Groundwater monitoring locations and frequency including: i. Location details for MB4; ii. Surface RL and Screening interval for Burton Coal Bore 2, Swamp Bore 1, MB4, MB8, MB8, MB10 and MB11, and b) The image for Appendix 1 (Figure 4 – Groundwater Monitoring Bore Locations).	
C52	The following information must be recorded in relation to all groundwater water sampling: a) the date on which the sample was taken; b) the time at which the sample was taken; c) the monitoring point at which the sample was taken; and d) the results of all monitoring.	Section 7.2

4 PHYSIOGRAPHIC SETTING

4.1 Location and Land Use

The IPC is located approximately 5 km northeast of Moranbah in Central Queensland's Bowen Basin (Figure 1); and, the mining leases occupy approximately 3,389 ha of gently undulating terrain.

Historical clearing for cattle grazing has been undertaken within the IPC and surrounding area. The dominant regional land uses within the vicinity of the IPC area are currently coal mining and cattle grazing.

Neighbouring, approved coal mines located in proximity to the IPC area are shown on Figure 3 and include:

- The Grosvenor Mine is an underground longwall mine, which commenced operations in May 2016. The Grosvenor Mine ML adjoins the western boundary of IPM.
- Moranbah North Mine (MNM) is an underground mine located approximately 9 km northwest of the IPC.
- The Burton, Broadlea and Ironbark No. 1 Mines located north of the project mining area;
- Carborough Downs Mine is an underground mine approximately 6 km east of the IPC.
- Millennium Mine is an open cut mine approximately 6 km to the southeast of the IPC.
- Poitrel Mine is an open cut mine located approximately 8 km to the southeast of the IPC.
- The Moranbah South Project and Caval Ridge Mine located southwest of the project mining area.

The Moranbah Gas Project, which is one of Australia's largest operating CSG projects, also extends over the Grosvenor Mine, Moranbah North Mine and surrounding areas. The Moranbah Gas Project is a joint venture between Arrow Energy and AGL.

In addition to the above resource development mines/projects surrounding the project area, a subsidiary of Stanmore, Stanmore IP South, is in the process of developing the Isaac Downs Project. The Isaac Downs Project is proposed to comprise the development of open cut pits for the mining of the coal associated with the Rangal Coal Measures; and is located approximately 5 km south of the project. Other non-approved projects that are in the process of being developed, within the vicinity of the project area include:

- The Winchester South Project, located approximately 30 km south of the project area, to be developed by Whitehaven Coal;
- The Olive Downs Project, located approximately 40 km south of the project area, to be developed by Pembroke Resources; and
- The Eagle Downs Project, located approximately 30 km southeast of the project area, to be developed by South32.

4.2 Topography and Drainage

IPC is traversed by Smoky Creek, its northern tributary and several minor drainage lines; and, Billy's Gully (Figure 4). Smoky Creek and its northern tributary converge to the west of the northern extent of the project mining area. Surface water flow within Smoky Creek is towards the southwest and joins the Isaac River approximately 7 km downstream of the project mining area boundary. Smoky Creek separates the approved Pit 4 and Pit 5 (south and north of Smoky Creek, respectively) of IPE. Billy's Gully flow towards the west-southwest and is located adjacent to Pit 2 which is at the southern extent of the IPE Extension (Figure 2). The Billy's Gully drainage line separates the approved Pit 1 (south of Billy's Gully) and Pit 2 (north of Billy's Gully) of IPE.

IPC comprises undulating terrain (Figure 4). In the northern part of the project mining area, the land slopes towards creek channels. The remainder of the project mining area slopes to the west.

The Isaac River, Smoky Creek, Billy's Gully and their tributaries are ephemeral and characterised by short-duration surface water flows that are typically restricted to periods during and immediately after rainfall events. Creek flows exhibit naturally elevated suspended sediment loads and the channels show extensive sediment deposition.

4.3 Climate

The climate at the IPC is sub-tropical continental, characterised by highly variable rainfall, temperature and evaporation, typical of the Central Queensland region.

Climate data has been collected from two Bureau of Meteorology (BoM) weather stations within the vicinity of IPC. These weather stations include:

- Moranbah Water Treatment Plant (Station 034028) – now decommissioned, operating from 1972 to March 2012. This monitoring station is located approximately 8 km southwest of the IPC; and
- Moranbah Airport (Station 034035) – operational, operating from March 2012 to present. This monitoring station is located approximately 11 km west of the IPC.

A summary of average temperatures, rainfall and evaporation from the Moranbah Water Treatment Plant station is presented in Table 4.1, while a summary of average temperatures and rainfall from the Moranbah Airport station is presented in Table 4.2.

Table 4.1: Climate Averages – Moranbah Water Treatment Plant (Station 034028)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean max temp (^{0}C)*	33.8	33.1	32.1	29.5	26.5	23.7	23.7	25.5	29.2	32.3	33.1	34.0	29.7
Mean min temp (^{0}C)*	21.9	21.8	20.2	17.6	14.2	11.2	9.9	11.1	14.1	17.6	19.4	21.1	16.7
Mean rainfall (mm)*	103.8	100.7	55.4	36.4	34.5	22.1	18.0	25.0	9.1	35.7	69.3	103.9	614.2
Mean daily evaporation (mm)**	8.0	7.4	6.8	5.7	4.3	3.5	3.7	4.9	6.6	8.0	8.5	8.5	6.3

* Data record from 1972 to 2012
** Data record from 1986 to 2012

Table 4.2: Climate Averages – Moranbah Airport (Station 034035)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean max temp (^{0}C)	35.0	33.4	32.3	29.8	27.0	24.3	24.7	26.9	30.4	32.8	34.7	35.1	30.8
Mean min temp (^{0}C)	21.3	21.1	20.2	16.5	13.0	9.6	8.6	8.3	12.5	15.8	18.8	20.3	21.3
Mean rainfall (mm)	86.2	103.6	97.7	26.2	27.4	16.3	32.1	8.7	8.4	26.3	46.2	63.3	563.4

Data record from 2012 to June 2019

The mean daily summer temperature across the project area ranges from 20.3^o C to 35.0^o C, while the mean winter temperatures range from 8.5 C to 26.9^o C.

Average annual rainfall at the Moranbah Airport and Moranbah Water Treatment Plant weather stations are 563.4 mm and 614.2 mm, respectively. Average monthly rainfall indicates a seasonal rainfall pattern with the majority (59% - 65%) of rainfall occurring in the summer months (December to March).

The available climate data shows distinct cycles of above average and below average rainfall. The Moranbah area has experienced below average rainfall between 2001 and 2006, and 2008 to 2010; with above average rainfall in 2007, and between 2010 and 2012. Rainfall from 2012 to present day has been consistent with the long-term average.

Evaporation rates have been recorded at the Moranbah Water Treatment Plant station between 1986 and 2012. Monthly evaporation rates exceed monthly rainfall for all months of the year, highlighting a net evaporative loss over a year.

4.4 Geology

4.4.1 Regional Geology

A summary of the geological setting in the vicinity of the IPC is presented in Section 5.2, which is prepared with information obtained from the following sources:

- KCB field investigation report detailing the absence of the Quaternary alluvium within the IPC area and surrounds (KCB 2018), provided as Appendix I. Localised Quaternary alluvium deposits are associated with the Isaac River, located approximately 6.5 km southwest of the project mining area.
- Geological data collected from the proponent's geology database of over 200 exploration drill holes within the project mining area and its surrounds, lithological logs from DNRME-registered and unregistered bores.
- High resolution geological model surfaces for the IPC;
- Geophysical (aeromagnetic) survey data collected at the IPM and its surrounds;
- Publicly available geological mapping;
- Geological data derived from the following information sources:
  - the Integrated Isaac Plains Project (IIPP) Initial Advice Statement;
  - the Grosvenor Project EIS;
  - the Moranbah South Project EIS; and

  - the Red Hill Project EIS;
- Geological data presented in the groundwater impact reports prepared for local CSG production activities; and
- Regional geological studies including:
  - The Bowen Basin Supermodel 2000 (Esterle et al. 2002);
  - The Queensland Coals – Physical and Chemical Properties, Colliery and Company Information 14th Edition (Mutton 2003); and
  - The Underground Water Impact Report for the Surat Cumulative Management Area – Consultation Draft (OGIA 2019).

The geological setting presented in this section provides context to the groundwater monitoring program presented in Section 7 and forms the basis for the conceptual hydrogeological model described in Section 5.

4.4.2 Project Site Geology

The IPC mining area is located on the northwestern flank of the Bowen Basin, a sedimentary basin comprising Permian to Triassic age geology (Figure 5). A veneer of more recent basalt and weathered sediments typically overlies the Bowen Basin strata (Figure 6).

KCB field investigations completed in 2018 identified an absence of Quaternary alluvium within the project mining area and its surrounds (Appendix I). Localised deposits of Quaternary alluvium, associated with the Isaac River, are located approximately 6.5 km southwest of the project mining area.

The ground-truthed surface geology relevant to the IPC is shown in Figure 6, and includes:

- A veneer of recent weathered sediments comprising the Suttor Formation and associated colluvium and regolith;
- Localised Tertiary basalt deposits;
- Triassic sediments of the Rewan Group; and
- Permian sediments of the Rangal Coal Measures (including the target Leichardt seam) and the deeper Fort Cooper Coal Measures and Moranbah Coal Measures.

These geological units are described in the following sections.

4.4.2.1 Tertiary Sediments

Figure 6 shows the presence of several late Tertiary sediments within the IPC and its surrounds, including:

- Mapped Quaternary colluvium comprising a heterogenous profile of clay, silt, gravel and soil;
- Tertiary Suttor Formation comprising quartz sandstone, conglomerate and sandy claystone; and,

- Late Tertiary (to early Quaternary) sediments exhibiting a high proportion of silts and clays, reflective of a low energy depositional environment at the periphery of the Isaac River system.

Published geological mapping confirms that the colluvium deposits transition to Suttor Formation sediments, indicating that these materials are frequently indistinguishable due to lithological similarities between these materials.

A surficial Tertiary weathering (regolith) profile is also present regionally. The weathering process has resulted in the formation of a thin, heterogenous layer of unconsolidated soils and weathered clays. Tertiary duricrusted palaeosols comprising partly-laterised, clayey sediments, ferricrete and silcrete are locally present regionally at the top of deep weathering profiles. The weathered and duricrusted profiles are lithologically indistinct from the other Tertiary materials.

In overview, these Tertiary/Quaternary sediments can be characterised as a heterogenous unit comprising unconsolidated to semi-consolidated, clay and silt dominated sediments.

Regionally, these Tertiary/Quaternary sediments form a veneer that overlies the Tertiary basalt and Permo-Triassic bedrock. The Tertiary/Quaternary sediments are up to 15 m thick within the project site and are thin or absent where the Tertiary basalt and Permo-Triassic bedrock outcrops.

The predominance of clay in the Tertiary/Quaternary sediments is a result of low energy deposition and weathering processes and is lithologically distinct.

4.4.2.2 Tertiary Basalt

Regionally, the Tertiary basalt occurs within paleo-channels incised into the underlying Permian-Triassic bedrock. Paleo-channels with associated basalt flows are located to the west and east of IPC and coalesce approximately 7 km southwest of the IPC. The basalt flow to the west of the project site is orientated on a northwest to southeast axis that broadly follows the current Isaac River alignment. The basalt flow to the east of the IPC is orientated on a north-south axis and extends over approximately 20 km from the Broadlea Mine in the north to the Isaac River in the south. The basalt flow within the centre of this paleo-channel is approximately 500 m wide and up to approximately 50 m thick (KCB 2016).

The IPC is located at the western extent of this north-south trending basalt flow, outside the centre of the paleo-channel (KCB 2016). Aeromagnetic survey data shows that basalt extends into the northern and southern parts of the project site. The basalt in these areas typically occurs as minor limbs of the main basalt flow and is therefore significantly thinner (in the range 10 m to 20 m) than the basalt within the main paleo-channel. Basalt is slightly thicker in the extreme south where the project site encroaches further into the basalt flow.

The Tertiary basalt across the project site and surrounding area is heterogeneous ranging from generally massive with medium grained texture to very vesicular with fine grained texture. The northern extent of the basalt paleo-channel comprises at least two lava flows with massive texture and thick clay layers, while towards the south the clay layers are thin and the basalt becomes vesicular. Weathering processes have also resulted in the development a highly weathered clay-rich zone in the upper profile of the basalt.

The Tertiary basalt is underlain by highly localised deposits of Tertiary sediment that were present within the paleo-channels at the time the basalt flows occurred. The Tertiary sediment comprises medium to coarse grained sand and is informally referred to as Tertiary basal sand due to its association with the base of the basalt unit. Where present, the Tertiary basal sand is less than 5 m thick and laterally discontinuous, forming discrete sandy lenses below the basalt. Previous investigations have confirmed that these materials are not extensive across the mapped Tertiary basalt extent.

4.4.2.3 Triassic Rewan Group

The Rewan Group is a thinly interbedded sequence of siltstone, claystone, fine grained sandstone and minor volcano-lithic pebble conglomerate. The Rewan Group subcrops against the overlying Tertiary/Quaternary sediments in the east of the IPC and dips to the east (Figure 5). The Rewan Group outcrops in the northeastern and southern parts of the IPC where the overlying sediments are absent.

The Rewan Group reaches a thickness of approximately 130 m to the east of the IPC.

The Rewan Group directly overlies the Rangal Coal Measures.

4.4.2.4 Permian Coal Measures

The Permian coal measures comprise, from youngest to oldest, the Rangal Coal Measures, FCCM and MCM. These coal measures combined are referred to as the Blackwater Group. The target coal measures for the project is the Leichardt seam of the Rangal Coal Measures.

A description of The Rangal Coal Measures is provided in the following section.

Rangal Coal Measures

The Rangal Coal Measures comprises calcareous sandstone, calcareous shale, mudstone, coal and concretionary limestone. Cemented sections are common in the sandstones.

The Rangal Coal Measures subcrop strikes generally north-south in the IPC vicinity and dips at a shallow angle to the east (Figure 4). The Rangal Coal Measures outcrop in the northeastern and southern parts of the IPC project area where the overlying sediments are absent (Figure 4).

The Rangal Coal Measures are typically 50 m to 200 m thick in the surrounding area of the IPC.

The shallower Leichardt seam and the deeper Vermont seam are the main coal seams of the Rangal Coal Measures. Mining within the IPC has historically targeted both seams. In the vicinity of the IPC, the Leichardt seam is located at depths of up to 210 m and reaches thicknesses of up to approximately 3.5 m.

4.4.3 Structural Features and Faults

The IPC is located adjacent to the Isaac Thrust Fault system. The Isaac Thrust Fault system is a regionally extensive fault system that is also referred to as the Jellinbah Fault system (Esterle et al. (2002)). The Isaac Thrust Fault system represents a major regional structure that extends over 30 km along a north-south orientation with significant vertical displacements of up to 800 m.

The main fault in the system is the Isaac Thrust Fault which is located approximately 5 km east of IPC. The Isaac Thrust Fault is typically steeply dipping and with a vertical displacement of 600 m to 800 m. This vertical displacement has resulted in contact between significantly different geological units, specifically the Triassic formations on the downthrown (western) side of the fault and the Permian formations on the upthrown (eastern) side of the fault (Figure 7).

Approximately 9 km north of the IPC, a fault splays from the main Isaac Thrust Fault (Figure 5). The Isaac Thrust Fault splay is orientated on a north-northwest to south-southeast axis and is steeply dipping. The fault splay follows the eastern boundary of IPM between the IPM and the IPE project. The Isaac Thrust Fault splay has resulted in approximately 50 m to 100 m of vertical displacement within the Permian coal measures.

The Permian geology in the vicinity of the IPC is therefore located in a fault-bounded setting, with significant fault displacement in all directions (Figure 7). Fault displacement has resulted in truncation of the coal seams of the Rangal Coal Measures (including the target Leichardt seam) and the lower seams of the MCM (including the Goonyella Middle seam) at the Isaac Thrust Fault, and its splay, causing the coal seams to be juxtaposed with Permian interburden. The coal seams to the east of IPM, within the proposed IPE project, are therefore laterally discontinuous with their equivalents located beyond the Isaac Thrust Fault and its splay.

Fractures associated with older, tectonically inactive faults (such as the Isaac Thrust Fault system) are typically sealed by mineralisation and precipitation (OGIA 2019). These faults are also likely to exhibit clay smearing due to the clay content of the sediments.

Section 5 provides a detailed description of the hydrogeology of these structures.

5 CONCEPTUAL HYDROGEOLOGICAL SYSTEM

5.1.1 Hydrostratigraphy

The following sections present a summary of the hydrogeological properties of the major hydrostratigraphic units identified across the IPC. This includes a discussion of their spatial distribution, associated potentiometric surface, groundwater flow directions, potential recharge mechanisms and range of yields and water quality.

5.1.1.1 Tertiary Sediments

The Tertiary sediments correspond to unconsolidated to semi-consolidated profile of heterogeneous sediments. A low primary porosity is expected for these sediments due to the high clay and silt content.

The average thickness of this hydrostratigraphic unit is 10 m within the vicinity of the IPC, reaching up to 50 m at elevated topography observed across the central portion of the IPE site.

The regional groundwater table is typically below the base of the Tertiary sediments, which indicates that this unit is predominantly unsaturated mainly to the north of Billy's Gully.

In the east and southwest reaches of Billy's Gully, which is incised and adjacent to the IPM site, a water table forms in these sediments, where groundwater is connected to the underlying groundwater associated with the Tertiary Basalts and Permian coal measures. However, no interaction with seasonal surface water flows in Billy's Gully is expected to occur with the Tertiary sediments (Hansen Bailey 2016).

Groundwater quality in the Tertiary sediments is expected to be of moderate to high salinity, consistent with recharge to the regional groundwater regime.

There is no record of groundwater supply bores screened across the Tertiary sediments in the vicinity of IPC, possibly as result of the limited groundwater distribution and expected low yields.

5.1.1.2 Tertiary Basalt

A heterogeneous profile comprised of vesicular and massive basalts with minor ash and tuff corresponded to the Tertiary basalts observed within the vicinity of IPC. The shallow basalt profile comprises a highly weathered zone of predominantly basaltic clay. This unit occurs predominantly along the southern and north eastern edges of the IPE site, associated with a paleochannel incised into the Permian coal measures east of IPE, where a maximum thickness of up to 50 m is observed. The Tertiary basalt is considered practically absent the IPC footprint.

The Tertiary basalt presents variable hydraulic properties, where low porosity and low yields are associated with both the weathered and fresh massive basalts that comprises the major proportion of this unit. Conversely, intervals of vesicular and fractured basalts within the fresh profile can result in highly porous and permeable compartmentalised intervals within this unit.

The recharge mechanisms in the basalts correspond mainly to seepage from overlying Tertiary sediments or direct rainfall infiltration where the unit outcrops. An intermittent recharge zone is expected to form along the zones where the Tertiary basalts occur below drainage features during

seasonal flow events. The main discharge mechanism occurs via seepage to underlying Permo-Triassic sediments.

The paleochannel alignment and the natural topography are considered the main drivers of the regional groundwater flow, which is generally towards the south.

Groundwater quality is considered moderately saline, nevertheless a water supply borefield has been established at distances between ~6 and 12 km northeast of the IPC, as part of the Broadlea Mine operations. An authorised groundwater abstraction rate of 400 ML/yr is associated with this borefield, which may cause reduction in groundwater levels and create a localised hydraulic gradient towards the borefield, which forms a discharge zone for the Tertiary basalt.

5.1.1.3 Triassic Rewan Group

The Rewan Group is composed of varied grain size sediments, ranging from lithic sandstone, pebbly lithic sandstone to an interbedded sequence of siltstone, claystone and minor fine-grained sandstone. This unit is absent within the boundaries of the IPM site, which is beyond its sub-crop extent. The Rewan Group outcrops in the northeast and to the south of the IPE site, where it overlies the Permian coal measures.

The Isaac Fault Splay to the north and the main Isaac Thrust Fault to the east of IPE project are two major structures present in vicinity of IPM, causing vertical displacement of this unit, as shown in Figure 7.

The Rewan Group is considered a low primary porosity unit and recognised to act as a confining unit (regional aquitard) overlying the Permian coal measures. Groundwater flow is controlled by local fractures, which correspond to the major secondary porosity. On a regional scale, the representative hydraulic conductivity of the unit is expected to be low.

The recharge mechanism associated with this unit correspond to direct rainfall infiltration in areas of the unit outcrop; and, from seepage from the overlying units (including the Tertiary basalt and Tertiary sediments).

5.1.1.4 Permian Coal Measures

The Permian coal measures comprise a sedimentary sequence with interbedded layers of sandstone, siltstone and coal seams, including the Rangal Coal Measures, the FCCM, the MCM and the underlying Back Creek Group.

The Leichardt seam, within the Rangal Coal Measures is the coal target layer. A weathered clay cap has been identified in the upper part of the profile along the sub-cropping section of this unit.

The FCCM is composed of a sequence of sandstone, carbonaceous mudstone, coal and tuffaceous material and is recognised as a regional aquitard. The FCCM separates the Rangal Coal Measures from the MCM, limiting hydraulic interaction between the overlying Rangal Coal Measures and the underlying MCM (and associated coal seams).

Groundwater storage and movement occurs within the coal seam cleats and fissures and within open fractures that intersects the seams. The sedimentary units positioned above and in between the coal seams are known as overburden and interburden and are considered hydraulically ‘tight’, forming thick confining layers within the coal measures.

The Permian coal measures are uniformly saturated at depth, and may become unsaturated where the outcrop or subcrop above the regional groundwater table. Groundwater flow within this unit is from east to west and is a subdued reflection of topographic.

Recharge mechanisms correspond to downward seepage from the overlying Tertiary basalt and, to a lesser extent, from the low permeability Rewan Group and Tertiary sediments. Where the coal measures outcrop at the surface, direct recharge may resulted from direct rainfall infiltration. The predominant groundwater discharge mechanism comprises discharge to mining areas as part of mine dewatering/depressurisation activities. Discharge to overlying formations is considered negligible in the vicinity of the IPC (Hansen Bailey 2016).

The Permian coal measures in the vicinity of IPC are fault bounded by the Isaac Thrust Fault and the associated fault splay. Faulted strata may exhibit a range of hydraulic characteristics, and in extreme cases, act either as a barrier or enhance to groundwater flow. The faults in the vicinity of IPC are likely to constrain horizontal groundwater flow when compared to un-faulted areas (OGIA 2019), based on the following:

- In the region where the IPC is located, the fractures associated with the faults are typically sealed by mineralisation and precipitates (OGIA 2019);
- There is a significant likelihood for clay smearing across the fault plane due to the high clay content of the Permian coal measures, which cause a reduction of the permeability in the faulted areas by several orders of magnitude when compared to un-faulted areas;
- The thin coal seams (~3.5m) corresponds to a small proportion of the overall thickness of the Permo-Triassic sediments (<1%), which indicates that there is a high probability that fault displacement has resulted in a coal seam being juxtaposed with less permeable Permian interburden or Rewan Group sediments on the opposing side of the fault; and
- Coal seams are typically highly compartmentalised by faulting based on previous mining experience in the Bowen Basin.

5.2 Groundwater-Surface Water Interaction

The numerical groundwater model developed for the IPEE EAR (KCB 2019), which simulates groundwater conditions across the IPC and surrounds, indicate that the regional groundwater table does not intersect the ground surface within watercourses or drainage features across the IPC, including Smoky Creek, associated tributaries and Billy's Gully. There is therefore no expected surface expression of the regional groundwater table and no direct groundwater-surface water connectivity observed in the vicinity of IPC.

Groundwater is typically located several metres below the bed of these watercourses and drainage features and is therefore disconnected from surface water flows. Section 6 of the EAR prepared to support the IPE EA amendment (Hansen Bailey 2016) concluded that no direct groundwater-surface water interconnection occurs within the IPC vicinity; which is further supported by the findings of Aquatic Ecology Report (C&R Consulting 2016) that confirmed Smoky Creek is sediment laden with no evidence of groundwater-fed pools or springs present across the IPC site.

Surface water drainage across the IPC and the wider Isaac River catchment is highly ephemeral with no measurable or sustained baseflow from groundwater seepage. As such, the IPC operations would not result in reduction of baseflow within Smoky Creek, Billy's Gully or the Isaac River.

5.3 Groundwater Receptors

5.3.1 Third-Party Groundwater Users

A water supply bores census was conducted in 2015 to support the Groundwater Impact Assessment prepared for the EAR for the IPE project (KCB 2016). The census extended to an approximate 5 km radius around the IPC site. The Queensland groundwater database was reviewed in February 2019 (DNRME 2019), which identified three landholder water supply bores within a 5 km buffer of the site (Figure 3). Details of these bores are provided in Table 5.1.

Table 5.1: Summary of Water Supply Bores within 5 km of the Project Site

Bore ID	Registered Bore Number	Easting (AGD84 Z55)	Northing (AGD84 Z55)	Property	Target Aquifer
Smoky Creek	81909	620090	7573318	Broadlea	Rewan Group
Burton Coal Bore 1	162810	620384	7573599	Broadlea	Rewan Group
Swamp Bore 1	162812	621518	7568790	Wotonga	Rewan Group

In mid-2018 a detailed bore assessment was undertaken to confirm the status of Burton Coal Bore 1 and Swamp Bore 2. In addition, the bore assessment investigated Burton Coal Bore 2, Swamp Bore 1 and Smoky Creek Bore. The bore assessment concluded that:

- Burton Coal Bore 1 is damaged and inaccessible. No pumping equipment is installed in this bore.
- Burton Coal Bore 2 and Swamp Bore 2 are EA groundwater monitoring bores. These bores are not installed with pumping equipment and are not used for water supply.
- Swamp Bore 1 is an operating water supply bore located approximately 2 km east of the project mining area. This bore is screened in the Rewan Group.
- Smoky Creek Bore was unable to be located during the detail bore assessment. However, signage located adjacent to the Burton Coal Bores identified the bores as Smoky Creek Bore. Therefore, it is interpreted that there has been confusion regarding the bore IDs for Smoky Creek Bore, Burton Coal Bore 1 and Burton Coal Bore 2. To avoid confusion, the Smoky Creek Bore ID is not referenced in the remainder of this report.

A borefield comprising seven production bores was identified to provide a source of mine water supply for the Broadlea Mine, located between 3 km east and 9 km northeast of the Sites. The Broadlea water supply borefield is an authorised water supply under the Water Act and is licensed to abstract up to 400 ML/year from the Tertiary basalt aquifer.

5.3.2 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) are defined by DoEE (2015) as 'Natural ecosystems which require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological

processes and ecosystem services (Richardson et al. 2011). The broad types of GDE are (Eamus et al. 2006): ecosystems dependent on surface expression of groundwater; ecosystems dependent on subsurface presence of groundwater; and, subterranean ecosystems.'

A review of the potential for Groundwater Dependent Ecosystems (GDE) in the vicinity of the IPC was undertaken as part of a Terrestrial Ecology Assessment (Ecological Survey & Management 2016) to support the EAR for the IPE Project.

Ecological Survey & Management (2016) assessment identified that the GDE mapping provided in the GDE Atlas (Bureau of Meteorology) is not consistent with the hydrogeological setting of the IPE area (i.e. the IPE area does not contain a suitable shallow groundwater supply). Therefore, it was concluded that there are no GDEs within the vicinity of the project area.

However, Stanmore noted that the existing IPM (operational since 2005) has open pits located immediately to the north and south of Smoky Creek. Vegetation within Smoky Creek has not shown evidence of decline in health until November 2017, providing evidence of the lack of dependence on groundwater associated with the creek (Stanmore IP Coal 2017). On the contrary, vegetation is more likely to rely on seasonal flows within the creek system. The document Stanmore IP Coal (2017) presents photos of the Smoky Creek vegetation between the two mine pits to the north and south of the creek showing that the system remains healthy.

Due to salinity levels recorded in the shallow aquifer (5,000 – 24,000 µS/cm), considered to be unsuitable to support the vegetation found in the vicinity of IPM, Ecological Survey & Management (2016) concluded that no GDEs were present within the IPE, which can be extended to the IPM area. In addition, data collected at bore MB4 (Stanmore IP Coal 2017), located in the colluvium near Billy's Gully, on two occasions since 2017, displayed EC values greater than 50,000 µS/cm. This indicates high salinity groundwaters which are unsuitable to support vegetation, which is further supported by information presented in the Aquatic Ecology Report (C&R Consulting 2016) confirming that Smoky Creek is sediment laden with no evidence of groundwater-fed pools or springs present in the IPM area.

Information gathered during a recent bore census (KCB 2016) confirmed that there are no water supply bores in the Quaternary alluvium due to difficulties in sourcing stock watering supply from alluvial groundwater due to limited yields and/or salinity. This provides additional evidence of the lack of suitability of groundwater for vegetation.

6 ENVIRONMENTAL VALUES

6.1 Isaac Plains Sub-Basin

The IPC is located in the upper reaches of the Isaac River sub-basin, which forms part of the larger Fitzroy River Basin. Figure 7 presents the location of the IPC in the context of the catchments and sub-catchment boundaries.

Environmental Values (EV) and Water Quality Objectives (WQO) for the Isaac River Sub-Basin are outlined in the Environmental Protection (Water) Policy 2009 Isaac River Sub-basin Environmental Values and Water Quality Objectives, Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River) (DEHP 2011).

6.1.1 Environmental Values

The *Environmental Protection (Water) Policy 2009* provides defined EVs and water quality objectives (WQOs) for the Isaac River sub-basin under Schedule 1 of the policy and are detailed in Department of Environment and Heritage Protection (DEHP) (2011). EVs for the Isaac River groundwaters are presented in Table 6.1.

Table 6.1: Environmental Values for the Isaac River Sub-Basin groundwaters at the IPC

Groundwaters	Environmental Values											
	Aquatic Ecosystem	Irrigation	Farm Supply / Use	Stock Water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
Isaac groundwaters	✓	✓	✓	✓			✓			✓		✓

6.1.2 Water Quality Objectives - Groundwater

Water Quality Objectives (WQOs) for groundwater are also outlined by the DES (DEHP 2011) to protect EVs. A summary of the WQOs for groundwater in the Isaac River are provided below:

- WQOs for aquatic ecosystems applicable to groundwater where groundwater interacts with surface waters, the groundwater quality should not compromise identified EVs and WQOs for those waters.
- For drinking water, local WQOs exist which relate to before and after water treatment and are based on a number of guidelines / legislation including the Australian Drinking Water Guidelines (NHMRC 2011).
- WQOs to protect or restore indigenous and non-indigenous cultural heritage should be consistent with relevant policies and plans.
- For irrigation, WQOs exist for metals, pathogens and other indicators in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000).

- For stock watering, objectives exist for faecal coliforms, total dissolved solids, metals, and other objectives based on guidelines presented in ANZECC & ARMCANZ (2000).
- For farm use / supply, objectives are as per the guidelines in ANZECC & ARMCANZ (2000).

WQOs for Fitzroy Basin groundwaters are provided according to their chemistry zone and depth category as presented in plan WQ 1310 and Table 14 of DEHP (2011).

7 GROUNDWATER MONITORING PROGRAM

7.1 EA Monitoring Bore Network

The groundwater monitoring program for the IPC includes measurements of groundwater levels, in-situ field groundwater quality parameters and groundwater sample collection for laboratory analysis.

The groundwater monitoring program must be carried out by an suitably qualified person, as defined in page 9 of the EA (DEHP 2018) and in agreement with the following guidance documents (and any updates thereof):

- Monitoring and Sampling Manual 2009, version 2 (DES 2018).
- Australian and New Zealand Water Sampling Guidelines – Part 11 Guidance of sampling of groundwater (AS/NZS 5667.11 1998).
- Australian Groundwater's Sampling and Analysis – A Field Guide (Sundaram et al. 2009).

The details of the bores included in the groundwater monitoring program as stipulated in the EA Condition C43 are summarised in Table 7.1, with their spatial distribution shown in Figure 8. The bores listed in Table 7.1 (EA Table 11) are designated as 'Reference Bores' and have been selected to provide ongoing baseline data during mine operations at the IPC.

A recent review by C&R Consulting identified that MB5 has been destroyed with the advancement of mining operations (C&R Consulting, 2019). A further three monitoring bores (MB1, MB3 and MB4b) are likely to be decommissioned as they are located within the mining footprint of IPE, whilst MB8, MB9, and MB10 occur within the footprint of IPE Extension. To ensure ongoing monitoring of groundwater conditions in key formations, five new monitoring bores are proposed along the eastern margin of the IPC tenement, namely MB12, MB13, MB14, MB15, and MB16 to replace these monitoring bores.

Surveying of the top of casing and surface RL at the proposed new monitoring bores is required for geographic position (easting, northing) and elevation (in AHD) to obtain accurate groundwater elevation levels, in accordance with the relevant EA condition (notes under Table 11 of the EA).

All existing bores were drilled in the aquifer type required by the EA, apart from MB 11, which was required to be installed within the Quaternary alluvium. A report regarding the assessment of alluvium in the vicinity of IPC is provided in Appendix I. This report indicates that the original mapping of alluvium, as presented in the IPE Project EA amendment application, was based on State regional geology mapping (Mount Coolon 1:250,000 map sheet). At the selected MB 11 bore location there was an absence of alluvium, with drilling encountering Tertiary sediments from the surface; therefore, this bore was screened within the Tertiary sediments. Subsequent field reconnaissance of Smoky Creek, indicating a lack of alluvium associated with the water course.

Table 7.1: Monitoring Bore Network Details and Rationale

Monitoring Bore	Location[a]		Surface RL	Total Depth	Screen Interval	Hydrostratrigraphic Unit	Monitoring Frequency	Status	Rationale
	Easting	Northing							
Burton Coal Bore 2	620383	7573599	240.8	37.0	30.3 – 34.6	Rewan Group	Quarterly	Existing	As per EA condition C43
Swamp Bore 2[b]	621518	7568790	245.9	55.0	24 – 55.1	Rewan Group	Quarterly	Abandoned but useable	As per EA condition C43
MB1	618793	7572214	236.4	29.2	22.5 – 28.4	Rangal Coal Measures	Quarterly	To be decommissioned. Replaced by MB12	Advance of mine operations.
MB2	619074	7573137	242.7	51.9	48.7 – 51.6	Rangal Coal Measures	Quarterly	Existing	Monitoring groundwater in the target coal
MB3	619047	7568473	253.0	52.6	49.7 – 52.6	Rangal Coal Measures	Quarterly	To be decommissioned. Replaced by MB9	Advance of mine operations.
MB4a	620351	7567479	237.6	11.0	7.8 – 10.7	Quaternary colluvium/ Tertiary sediments	Quarterly	To be decommissioned, replaced by MB4b.	Insufficient water column
MB4b	619740	7567253	233.9	12.4	9.4 – 12.4			To be decommissioned. Replaced by MB16	Advance of mine operations.
MB5	618507	7570878	235.7	39.4	36.4 – 39.3	Rangal Coal Measures	Quarterly	Destroyed. Replaced by MB8.	Advance of mine operations.
MB8	619105	7571149	245.9	126.3	117.3 – 120.3	Rangal Coal Measures	Quarterly	To be decommissioned. Replaced by MB13	Advance of mine operations.
MB9	620368	7568049	239.5	80.5	77.5 – 80.5	Rangal Coal Measures	Quarterly	To be decommissioned. Replaced by MB15	Advance of mine operations.
MB10	620368	7568046	239.5	27.0	21.0 – 27.0	Tertiary basalt	Quarterly	To be decommissioned. Replaced by MB14	Advance of mine operations.
MB11	618832	7571924	232.3	5.0	3.0 – 4.0	Tertiary sediments	Quarterly	Existing, Dry.	Requested by DEHP.
MB12	619210	7572000	239.5[c]	129[d]	126 – 128[d]	Rangal Coal Measures	Quarterly	To be commissioned. MB1 replacement.	Monitoring groundwater in the target coal
MB13	619367	7571035	249.7[c]	98[d]	95 – 97.0[d]	Rangal Coal Measures	Quarterly	To be commissioned. MB8 replacement.	Monitoring groundwater in the target coal
MB14	620263	7571132	257.3[c]	24[d]	20 – 23[d]	Tertiary basalt	Quarterly	To be commissioned. MB10 replacement.	DEHP requested monitoring of the Tertiary Basalts
MB15	620633	7568080	242.9[c]	120[d]	115 – 119[d]	Rangal Coal Measures	Quarterly	To be commissioned. MB9 replacement.	Monitoring groundwater in the target coal.
MB16	620670	7568599	245.6[c]	12[d]	8 – 11[d]	Tertiary sediments	Quarterly	To be commissioned. MB4b replacement.	Monitoring groundwater in the Tertiary Sediments.

Notes: Surface RL must be measured to the nearest 5 cm from the top of the bore casing.
(a) Coordinate System: GDA94 Zone 55
(b) Swamp Bore 2 is identified as Swamp Bore 1 in the EA.
(c) Estimated using digital elevation model (DEM). Values to be revised following a bore survey.
(d) Total depth and screening interval estimated based on the regional aquifer thickness at the proposed monitoring point. To be confirmed during bore drilling.

7.1.1 Water Level Monitoring

Measurement of groundwater level is required for all bores listed in Table 7.1 to identify possible changes in groundwater levels and identify if any changes are a result of the mining operations. Monitoring of groundwater levels is required to meet the groundwater level trigger level threshold for monitoring bores "Burton Coal Bore 2", "Swamp Bore 1", "MB4", "MB10", and "MB11". However, from Table 7.1:

- Swamp Bore 1 should be recorded as Swamp Bore 2 (to correct a name swapping error)
- MB4 will be replaced by MB16
- MB10 will be replaced by MB14
- MB11 is dry and targets the non-existent alluvium, and is therefore not required.

Table 13 of the EA is proposed to be updated as per Table 8.4 below.

In the proposed groundwater monitoring bores, water level monitoring must occur after a minimum of seven days following the bore construction and development to allow full recovery of the standing groundwater level to "steady-state" conditions.

7.1.2 Water Quality Monitoring

Groundwater quality monitoring is required to be conducted in all bores listed in Table 7.1 to track changes in groundwater quality and to identify if any changes are associated with mining operations.

Requirements for the monitoring of groundwater quality are stipulated in EA Condition C45, with required parameters listed in Table 12 of the EA (DEHP 2018), with associated groundwater contaminant trigger values identified for Burton Coal Bore 2 and Swamp Bore 1 (noting name correction to Swamp Bore 2) as discussed in Section 8.

The analytical parameters required to be analysed from groundwater samples collected from the monitoring bores shown in Figure 8 are summarised in Table 7.2 with indicative laboratory detection limits suitable to meet the trigger values defined in Table 12 of the EA (DEHP 2018). The metals listed in Table 7.2 below correspond to dissolved elements and require filtering to be carried out in the field (refer to Section 7.2.3).

Table 7.2: Water Quality Monitoring Parameters and Indicative Detection Limit

Analytical parameter	Indicative Laboratory Detection Limit (mg/L) *
Aluminium	0.1
Antimony	0.01
Arsenic	0.01
Calcium	1.0
Chloride	1.0

Analytical parameter	Indicative Laboratory Detection Limit (mg/L) *
Carbonate	1.0
Total Dissolved Solids	10
Electrical Conductivity (EC)	1.0
Bicarbonate	1.0
Iron	0.05
Magnesium	0.05
Mercury	0.0001
Molybdenum	0.001
Total Petroleum Hydrocarbons C6-C9	0.02
Total Petroleum Hydrocarbons C10-C36	0.05
pH	0.1
Potassium	1.0
Selenium	0.01
Silver	0.01
Sulfate	1.0
Sodium	1.0
Suspended Solids (Total)	1.0

Note: * except pH (pH units) and EC (µS/cm)

All analytical parameters must be analysed in an analytical laboratory with physico-chemical parameters (pH, EC and temperature) also measured in-situ using field water quality meter instruments at the time of sample collection, as described in Section 7.2.3.

7.2 Field Procedures

7.2.1 Monitoring Equipment

For groundwater sampling, the adopted methodology (and associated equipment) is required to address all requirements under the EA Conditions and the prescribed water sampling guidelines, as listed in Section 7.2. Consultants/contractors conducting the groundwater sampling must comply with the methodology described in this plan. The equipment used must be under serviceable conditions and be operated as per manufacturer's instructions. Decontamination procedures should be adopted before and between each sampling location, where reusable items are required, including pumps and pumping tubing.

Equipment Calibration

The monitoring equipment should be calibrated and maintained according to manufacturer's instructions. Calibration records should be kept by the company responsible for the monitoring program for a minimum period of five years and provided to Stanmore upon request. The minimum information to be recorded in the calibration sheet includes instrument name and model, serial number, list of parameters calibrated, values of standards used and results, standard deviation, date and name of the technician in charge of the calibration and calibration results.

7.2.2 Water Level Measurement

Water level measurements can be carried out either manually, by automated loggers or both. Data retrieved from loggers should be used in conjunction with manual measurements for data verification.

Manual measurement of water level within a bore should be conducted at each monitoring event. The presence of an automated level logger should not preclude the manual record of water level. Two measurements are required to determine groundwater depth below ground level (bgl) as per below:

- bore top of casing (TOC) = height to ground level;
- depth to water within the bore from TOC; and
- Groundwater depth (bgl) = water level from TOC – height of TOC to groundwater level.

It is also recommended to measure and record the total depth of the bore from TOC, which can be undertaken using the water level sensor (interface or dip meter), so that an indication of possible sediment build up at the bottom of the bore can be assessed.

The water level measurement sensors (interface or dip meters) must be serviced and maintained in accordance with the manufacturer's instructions.

Groundwater level loggers (pressure transducers) may be present within monitoring bores to record level and temperature at set time intervals. These data loggers are typically installed below the average groundwater level within the bore casing at a set depth from TOC. Data is stored on internal memory and can be downloaded into software specific to the logger manufacturer.

7.2.3 Groundwater Purging and Sampling

The groundwater sampling task should be completed at a minimum of seven days after the installation and development of new proposed monitoring bores (Table 7.1) to allow for recovery of the standing groundwater level to steady-state conditions.

Samples collected from monitoring bores, for the purpose of groundwater quality monitoring, are intended to be representative of the groundwater within the monitored hydrostratigraphic unit. Therefore, appropriate purging of the monitoring bore prior to sampling is required to remove stagnated groundwater within the bore and promote representative aquifer water to be introduced into the water column.

The selection of the adopted purging method will be based on the specific bore characteristics and field conditions encountered at the time of the purging event. Purging options to be adopted include air-lift purging, submergible pump (including low flow/micro purge) or hand bailing. The chosen method or exceptions and reasons for exception (weather, equipment failure, blockage) should be recorded in the field notes. Typically, a minimum of three bore volumes will be purged, along with the stabilisation of monitored physico-chemical parameters, prior to the collection of a groundwater sample.

If low-flow sampling method is adopted, groundwater sampling should be carried out in accordance with the procedure developed by USEPA (2017): Low stress (low flow) purging and sampling procedure for the collection of groundwater samples from monitoring wells.

The pump intake should be lowered to the mid-point of the saturated screen length.

In-Situ Field Water Quality Parameters

In-situ field groundwater physico-chemical parameters are not required for EA compliance. Nevertheless, the collection of in situ physico-chemical parameters should be recorded to

demonstrate the efficiency of the purging process, indicated by the stabilisation of the parameters following bore purging. In-situ parameters (pH, EC) can also be used as quality control when compared to the laboratory results.

Using a calibrated water quality meter, the following in situ physico-chemical parameters should be measured during the purging process and recorded on the field sheet, including values for pH, EC and temperature, as a minimum, and dissolved oxygen, oxidation-reduction potential (ORP), and turbidity, if the low flow sampling method is adopted.

If the low-flow method is adopted, purging is considered complete and sampling may begin when the three consecutive readings of physico-chemical parameters are within the limits indicated in Table 7.3 as per USEPA (2017).

Table 7.3: Physical-Chemical Parameters – Criteria for Sampling (USEPA, 2017)

Parameter	Stabilisation Criteria
Turbidity	10% for turbidity > 5NTU If three consecutive readings are <5NTU, consider the values as stabilised
DO	10% for DO > 0.5 mg/L If three consecutive readings are <0.5 mg/L, consider the values as stabilised
EC	3%
pH	±0.1 pH unit
ORP	±10 millivolts

Sample Preservation

Groundwater samples must be stored in appropriate sample containers and preserved according to the analytical parameters listed in Table 12 of the EA (Section 7.1.2).

The selection of appropriate sample containers, preservation procedures, sample storage requirements and holding times must be undertaken in accordance with those recommended by Standards Australia AS/NZS 5667.11 (1998) and Australian Standard AS 4482.1 (2005), as appropriate.

All primary and associated QA/QC samples must be shipped to the laboratory within required holding times. The laboratory should be notified of the shipment of samples and their expected arrival time.

All samples must be stored in cooler boxes packed with ice or cooling blocks during the course of the working day prior to dispatch to the laboratory. During transport to the laboratory, preservation should be maintained by the continued use of cooling blocks or transport within a refrigerated vehicle. The temperature of samples should be maintained within the recommended range indicated by the laboratory to be used for testing of the analytes listed in Table 7.2.

7.3 Quality Control/Quality Assurance

The following Quality Control/Quality Assurance (QC/QA) procedures should be adopted for the implementation of the groundwater quality monitoring under the current GMMP:

- Use of Chain of Custody forms for sample dispatch to the analytical laboratory;

- Appropriated trained and experienced sampler;
- Decontamination of sample collection equipment prior and between each bore;
- Use of disposable gloves for each sampling event;
- Storage of samples on ice according to laboratory recommended preservation;
- Delivery of samples to the analytical laboratory within the holding time;
- Selection of a National Association of Testing Authorities (NATA) accredited laboratory with management systems that comply with the requirements of ISO 9001; and
- Collection of duplicates, trip blanks and rinsate blanks.

7.3.1 Field Quality Control/Quality Assurance

The interface or dip meter probe used for groundwater level measurements must be decontaminated with Decon 90 solution and rinsed with water between gauging of monitoring bores. Dedicated tubing for each sample location should be used and disposed of following completion of sampling. If bladder pump is employed for low-flow sampling, reuse of bladders should be avoided between sampled bores.

Quality control samples must be collected to reduce the extent of uncertainty in the water quality data and to comply in full with the EA conditions and relevant Australian Standards. The definition of types of control samples to be collected is presented in Table 7.4.

Table 7.4: Definition of Quality Control Samples

Quality Sample	Description
Trip blank	Used to assess if contamination is introduced during shipping and field handling procedures. A sample of analyte-free water is taken from the laboratory to the sampling site and returned to the laboratory without being exposed to the sampling procedures. Only analysed for volatile compounds (TPH C6-C9)
Duplicate	Used to document the precision of the sampling process. Independent samples which are sampled as close as possible to the primary sample in space and time. They are separate samples taken from the same bore and stored in separate containers and analysed independently
Rinsate blank	Used to assess the adequacy of the decontamination of the sampling equipment. A sample of analyte free water will be poured over the decontaminated interface probe prior to the collection of the next sample. The sample will be analysed for the same suite as the primary samples

Groundwater QC samples should be collected at the following frequencies:

- 1 duplicate (blind replicate) groundwater sample per 20 primary samples;
- 1 rinsate water sample per sampling program from the decontaminated sampling apparatus (dip meter or submersible pump) prior to the beginning of the sampling; and,
- 1 trip water blank per laboratory batch to the laboratory.

The analytical results of the duplicates will be compared to the primary sample results using Relative Percent Difference (RPD) calculation. The RPD is defined as the absolute difference between two values, divided by their mean values and expressed as a percentage. Where either the primary of duplicate samples report concentrations below the laboratory's limit of reporting (LOR), the RPD is not calculated. RPD values of less than 40% are generally considered acceptable.

7.3.1.1 Documentation and Data Management

Field Sheets

A project specific field sheet template should be prepared and provided by Stanmore to the consultant/contractor for use in groundwater monitoring and sampling. One field sheet should be completed for each monitoring bore location, including those found dry upon inspection. The minimum data required to be included in the groundwater sampling field sheet include:

- Sampler and company name, date/time of the sampling and weather conditions;
- Monitoring bore identification and bore conditions, including pipe material, diameter, thickness and length of TOC above ground surface;
- Bore water level and total depth;
- Datalogger download procedure and files directory address where data is saved;
- Purging method and volume of water extracted prior to sampling;
- Visual inspection of the water (turbidity, colour) prior to sampling;
- Groundwater level and physico-chemical parameters recorded at regular intervals during the purging and immediately prior to sampling; and
- List of laboratory analytes requested for analysis.

Sample Labels

Each sample label must include the following information:

- The consultant/contractor and sampler's name;
- The unique sample number;
- The date;
- The time of sampling;
- The name or initials of the sampler; and
- The sample sequence within a batch number (e.g. 1 of 7, 2 of 7).

Laboratory Documentation

Chain of Custody

A project specific Chain of Custody (CoC) form template should be developed or sourced from the chosen laboratory for the analytical testing and provided by Stanmore to be completed and submitted with every sample batch to the laboratory by the consultant/contractors. The CoC should be used exclusively for groundwater samples collected during each monitoring event. For each sampling event, the consultant/contractor should meet the following requirements:

- The CoC form should be completed in dark ink pen;
- All information requirements should be completed on the form;

- The CoC form must convey instructions to the laboratory (e.g. filtering of water sample for through a 0.45µm filter prior to acidification and/or analysis if field filtering was not undertaken);
- On delivery to the appointed laboratory, the recipient should inspect the cooler boxes, note the presence or otherwise of ice or freezer bricks if specified on the CoC form, measure and record the temperature of the sample container on the relevant CoC form;
- The completed CoC form should be transmitted to consultant/contractor within 24 hours of the delivery of samples to the laboratory for confirmation of instructions; and
- CoC forms will be presented with the original laboratory certificates in the report.

Holding Times

All holding times must comply with the requirements set out by the selected analytical laboratory commissioned for the testing of the collected groundwater samples.

The selected laboratory for the water quality testing must be instructed to retain all the sampling extracts obtained for the analysis of organic parameters to be kept under refrigeration for at least 30 days after the issue of the laboratory report. This will allow time for the laboratory report to be reviewed; and, for repeat tests, or additional tests, to be conducted within the sample holding period.

NATA accredited laboratories commonly have a thorough QA/QC process which reports the full sequence of laboratory sample receipt, handling, processing/reporting and storage against specified storage times ensuring the samples can be tracked and compared against the standards.

Laboratory Analytical Reports

Laboratory reports should be issued in accordance with the requirements of NATA endorsement and should include the following information appended within the report:

- The test results for the collected samples;
- The test results for the laboratory's in-house duplicates;
- The test results for the laboratory's in-house surrogate and matrix spike recovery determinations; and,
- The extraction (where applicable) and analysis dates which would be used to determine compliance with permitted holding times.

Data Management

Following a quality check, the analytical results associated with each groundwater monitoring event, as per the EA Conditions, must be stored on a groundwater monitoring database and retained for a minimum of five years. Each sampling point and event should include the combined recorded manual/automated groundwater level and laboratory results.

7.3.2 Laboratory Quality Control/Quality Assurance

The laboratory selected to undertake the analysis of groundwater samples must be:

- Accredited by the NATA;
- Certified by NATA to conduct the specific tests required, unless NATA does not certify a particular analysis or method specified in this GMMP; and
- Able to demonstrate that it can achieve the required analytical limits of reporting, typically an order of magnitude below the trigger values for the analyte.

Laboratory reporting for each laboratory including data management information will be provided in the report, as described in Section 8.4.

7.3.3 Reporting Quality Control Data

Analytical data validation is the process of assessing if data are in compliance with the EA conditions. The primary objectives of this process are to ensure that data of known quality is reported, and to identify if the data can be used to address the EA conditions.

The QC data reporting should involve the checking of analytical procedure compliance and an assessment of the accuracy and precision of analytical data from a range of QC measurements, generated from both the field sampling and analytical programs.

The water quality monitoring report must include tables assessing:

- Holding time compliance tables;
- Field QC sample results;
- Duplicate relative percentage difference compliance tables; and
- Laboratory QC compliance tables.

8 TRIGGER AND LIMIT EXCEEDANCES

8.1 Groundwater Contaminant Triggers and Level Threshold Triggers Summary

The trigger level values currently established in the IPC EA for the proposed groundwater monitoring bore network are provided in Table 8.1 (for groundwater quality) and Table 8.2 (for groundwater levels).

Table 8.1: Groundwater Contaminant Triggers (from EA EPML00932713)

Parameter	Unit	Trigger Values – Swamp Bore 1	Trigger Values – Burton Coal Bore 2	Limit Values
Aluminium	µg/L	10	10	Maximum
Antimony	µg/L	1	1	Maximum
Arsenic	µg/L	1	4.8	Maximum
Calcium	mg/L	570	170	Maximum
Chloride	mg/L	3500	1900	Maximum
Carbonate	mg/L	1	7.9	Maximum
Total Dissolved Solids	mg/L	7600	3900	Maximum
Electrical Conductivity	µS/cm	9500	6700	Maximum
Bicarbonate	mg/L	98	800	Maximum
Iron	µg/L	1000	270	Maximum
Magnesium	mg/L	170	230	Maximum
Mercury	µg/L	0.1	0.1	Maximum
Molybdenum	µg/L	1	1.1	Maximum
Total Petroleum Hydrocarbons C6-C9	µg/L	20	20	Maximum
Total Petroleum Hydrocarbons C10-C36	µg/L	50	50	Maximum
pH	pH units	7.2 - 7.8	7.0 - 8.6	Minimum/Maximum
Potassium	mg/L	25	8.5	Maximum
Selenium	µg/L	10	10	Maximum
Silver	µg/L	1	1	Maximum
Sulfate	mg/L	155	123	Maximum
Sodium	mg/L	1300	931	Maximum
Suspended Solids (Total)	mg/L	43	30	Maximum

Table 8.2: Groundwater Level Trigger Threshold for Monitoring Bores

Monitoring Point	Trigger Level Threshold (m)
Burton Coal Bore 2	2
Swamp Bore 1	5
MB4	8
MB10	16
MB11	5

A number of hydrogeological investigations/assessments have been undertaken across the IPC site since the update of the IPC EA with the groundwater quality and level trigger summary tables. These investigations/assessments comprise groundwater monitoring programs, and associated monitoring reports; and, groundwater impact assessments associated with mine expansions. Results from these investigations/assessments indicate that groundwater quality trigger

concentration and groundwater level trigger threshold for monitoring bores should be updated based on additional groundwater monitoring records; and, updated groundwater model predictions as a result of future mine expansions, respectively. A summary of the proposed updated groundwater contaminant triggers and groundwater level trigger thresholds, and the associated justification for update in the EA, is provided in the below sections.

8.1.1 Groundwater Contaminant Triggers Update

Groundwater contaminant triggers for Swamp Bore 1 and Burton Coal Bore 2, presented in Table 12 of EA EPML00932713, were previously developed from 23 groundwater monitoring data points collected between September 2013 and July 2017; and, were determined by calculating the 80th Percentile plus one standard deviation of the data set. Since July 2017 an additional seven data points have been collected from these bores. The monitoring results since July 2017 indicate limited changes to the majority of parameters for both bores, with the exception of Total Dissolved Solids (TDS), and associated major ionic constituents, where a trend of slightly increasing concentrations is observed. Statistical analyses of the groundwater quality data set (including the seven data points after July 2017) have been undertaken by C&R Consulting as part of an annual groundwater monitoring review (C&R Consulting 2019) and an updated groundwater contaminant trigger list for Swamp Bore 1 and Burton Coal Bore 2 have been developed (Table 8.3). This updated contaminant triggers list should be updated in EA EPML00932713, along with the bore ID for Swamp Bore 1, which should be updated to Swamp Bore 2 due to a current naming error in the EA document.

Table 8.3: Updated Groundwater Contaminant Triggers

Parameter	Unit	Trigger Values – Swamp Bore 1[a]	Trigger Values – Burton Coal Bore 2	Limit Values
Aluminium	µg/L	10	10	Maximum
Antimony	µg/L	1	1	Maximum
Arsenic	µg/L	2	4	Maximum
Calcium	mg/L	580	195	Maximum
Chloride	mg/L	3500	2050	Maximum
Carbonate	mg/L	1	7	Maximum
Total Dissolved Solids	mg/L	7585	4500	Maximum
Electrical Conductivity	µS/cm	9500	7320	Maximum
Bicarbonate	mg/L	94	820	Maximum
Iron	µg/L	1000	230	Maximum
Magnesium	mg/L	165	265	Maximum
Mercury	µg/L	0.1	0.1	Maximum
Molybdenum	µg/L	1	1.0	Maximum
Total Petroleum Hydrocarbons C6-C9	µg/L	20	20	Maximum
Total Petroleum Hydrocarbons C10-C36	µg/L	50	50	Maximum
pH	pH units	7.1 - 7.8	7.0 - 8.3	Minimum/Maximum
Potassium	mg/L	25	8.0	Maximum
Selenium	µg/L	10	10	Maximum
Silver	µg/L	1	1	Maximum
Sulfate	mg/L	150	130	Maximum
Sodium	mg/L	1275	990	Maximum
Suspended Solids (Total)	mg/L	37	52	Maximum

(a) Swamp Bore 1 bore ID to be updated in next EA amendment to Swamp Bore 2

8.1.2 Groundwater Level Trigger Update

Groundwater level triggers provided in Table 13 of EA EPML00932713 (presented in Table 8.2 of this report) were adopted from the groundwater model prediction of drawdown at specific monitoring bores (Burton Coal 2, Swamp Bore 1, MB4, MB10 and MB11). The predicted drawdown from this groundwater model was based on the development of IPE only.

Subsequent groundwater model updates have been undertaken to support the groundwater impact assessment of mine developments and extensions within IPC. These model updates include the assessment of cumulative drawdown impacts associated with each of the mine developments and extensions; and, existing operations. Therefore, the predicted cumulative drawdown from the most recent update of the groundwater model (includes IPM, IPE, IPU and (deferred) and IPEE) would differ from the groundwater level trigger thresholds presented in EA EPML00932713.

Furthermore, as a result of the mine developments/extensions (current and proposed) a number of the monitoring bores identified in Table 13 of EA EPML00932713 have been, or will shortly be, decommissioned. Replacement bores have been identified for the decommissioned/to be decommissioned bores (Table 7.1), and a selected number of these replacement bores have been adopted as groundwater trigger level monitoring bores (Table 8.4). Trigger level thresholds for the monitoring bores presented in Table 8.4 are based on the most recent numerical model prediction (including the development/operation of IPM, IPE, IPU and IPEE) of cumulative groundwater level drawdown.

Table 8.4: Groundwater Level Trigger Threshold for Monitoring Bores

Monitoring Bores	Trigger Level Threshold (m)	Monitored Unit
Burton Coal Bore 2	2	Rewan Group
Swamp Bore 2	5	Rewan Group
MB14 (replacement for MB10)	1	Tertiary basalt
MB16 (replacement for MB4a/b)	5	Tertiary sediments

8.2 Investigations into Exceedance of Trigger or Limit Values

Where the results (groundwater level or quality) of a monitoring bore has exceeded the trigger value for either groundwater level or quality an investigation is required.

The investigation process should include:

- Details of the exceedance
  - Bore ID and date of sample/measurement
  - The exceedance result, and comparison against trigger/limits and reference bores
- Examination into the cause of the trigger exceedance
  - Non-mining causes, associated with sampling/measurement or analytical errors, climatic interference, natural/seasonal variation as indicated by comparison with historical datasets

  - Mining related causes, associated with spills, dewatering or other site operations
- Examination of consequence
  - Is the exceedance a result of any unauthorised environmental harm and evaluation of any associated environmental impacts?

If the investigation indicates that the root cause of the exceedances is non-mining related, no further actions are required. Otherwise, if concluded that exceedances are related to mine activities, a review of the EA trigger and limit values may be undertaken. Further, if it is confirmed that the exceeded caused unauthorised environmental harm which has resulted in identified environmental impact, then actions to minimise/mitigate/manage the impacts associated with the environmental harm should be implemented. Such actions intend to prevent further occurrences of unauthorized harm and associated environmental impacts.

An exceedance investigation must be completed and submitted to the administering authority via WaTERS within ninety (90) days of the notification made, as per Condition C48 of the EA.

8.3 Actions to Minimise Impacts

According to EA Condition C49, if environmental harm is identified as a result from exceedances of groundwater trigger values for groundwater level and/or quality, Stanmore must immediately implement appropriate abatement measures to prevent the continuation or re-occurrence of environmental harm to groundwater.

Actions to minimise impacts may comprise:

- Review and assessment of the detailed site hydrogeological conceptual and/or numerical model;
- Review of mining procedures;
- Replacement of monitoring bores;
- Review of mine rehabilitation plans;
- Review of the GMMP;
- Compensation; and/or
- Implementation of a contaminated land assessment and remediation.

Site specific actions will depend on the local groundwater values, specific impacts and the identified cause.

A detailed response plan, and more comprehensive investigation, may be required, which may include a full risk assessment, development of contamination conceptual model, characterisation of source, pathways and receptors and the assessment of inter-aquifer leakage rates. Further, an assessment of the potential impacts to the receiving environment, through the execution of an ecological risk assessment may also be warranted.

Specific conditions associated with emergencies and incidents related to spills and seepage must be addressed separately in the EA conditions, requiring specific conditions for reporting, management, investigation and remediation.

8.4 Notification and Reporting

Notification and reporting requirements to the DES are defined in condition C46 and C47 of the EA and correspond to the requirement to notify the administering authority via WaTERS or the pollution hotline within seven (7) days of receiving the analysis results, followed by an investigation into the potential for environmental harm.

8.5 Responsibilities

Stanmore, or their appointed representatives, is responsible for the implementation of, and adherence to, this GMMP and ongoing performance against the GMMP objectives, commitments and approval conditions. Where required, Stanmore will engage appropriately qualified consultants and contractors to carry out required activities in compliance with this GMMP.

Regular monitoring data reviews and management reviews of the GMMP will be forwarded to DES and DNRME, if such a requirement accompanies any authorisation to extract groundwater during the project.

9 CLOSING

This report is an instrument of service of Klohn Crippen Berger (KCB). The report has been prepared for the exclusive use of Stanmore IP Coal Pty Ltd (Client) for the specific application to the Groundwater Monitoring and Management Plan, and it may not be relied upon by any other party without KCB's written consent.

KCB has prepared this report in a manner consistent with the level of care, skill and diligence ordinarily provided by members of the same profession for projects of a similar nature at the time and place the services were rendered. KCB makes no warranty, express or implied.

Use of or reliance upon this instrument of service by the Client is subject to the following conditions:

1. The report is to be read in full, with sections or parts of the report relied upon in the context of the whole report.

2. The observations, findings and conclusions in this report are based on observed factual data and conditions that existed at the time of the work and should not be relied upon to precisely represent conditions at any other time.

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4. KCB should be consulted regarding the interpretation or application of the findings and recommendations in the report.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Chris Strachotta
Senior Hydrogeologist

Dean Erasmus
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11 GLOSSARY

Aquifer: Permeable earth material such as porous sediments or fractured hard rock, saturated with groundwater. The permeability should be such that it is capable of conducting and yielding usable quantities of groundwater to a borehole(s) and / or springs. An aquifer is 'a geological formation which has structures or textures that hold water or permit appreciable water movement through them'.

Aquitard: A confining bed that retards, but does not completely stop the flow of water to or from an adjacent aquifer. Although it does not readily release water to boreholes or springs, it may function as a storage chamber for groundwater.

Confined aquifer: An aquifer which is overlain by a confining layer of low permeability. The groundwater is confined under pressure greater than atmospheric pressure such that if the aquifer is penetrated the water level may rise above the top of the aquifer.

Confining layer/unit: Geologic material with little permeability or hydraulic conductivity.

Contamination: The introduction into the environment of any substance by the action of man.

Dewatering: The process of removing water from an underground mine or open pit, or from the surrounding rock or non-lithified materials.

Geology: The study of the earth, its history and the changes that have occurred or are occurring and the rocks and non-lithified materials of which it is composed and their mode of formation and transformation.

Groundwater: The water in the aquifer.

Hydraulic conductivity: Describes the ease with which water can move through pore spaces or fractures. It depends on the intrinsic permeability of the material and on the degree of saturation. Saturated hydraulic conductivity, Ksat, describes water movement through saturated media.

Hydraulic gradient: The change in hydraulic head or water level over a distance.

Hydraulic head: The height above a datum (such as sea level) of the column of water that can be supported by the hydraulic pressure at a given point in a groundwater system.

Model: A formalised expression of a theory, event, object, process or system used for prediction or control; an experimental design based on a casual situation that generates observed data. A model can be viewed as a selective approximation which by the elimination of incidental detail, allows some fundamental, relevant or interesting aspect of the real world to appear in a generalised form.

pH: The negative logarithm to the base 10 of the hydrogen ion activity $[H^+]$ in solution.

Recharge: The addition of water to the saturated zone, either by the downward percolation of precipitation or surface water and/or the lateral migration of groundwater from adjacent aquifers.

Saturated zone: That part of the geological stratum in which all the voids are filled with water under pressure greater than that of the atmosphere.

Unconfined aquifer: An aquifer whose upper surface (water table) is free to fluctuate.

Unsaturated zone: That part of the geological stratum above the saturated zone in which the voids contain both air and water.

Water Table: The top of an unconfined aquifer, where the aquifer is fully saturated and the water pressure is equal to atmospheric pressure. Usually measured in metres below ground level or below top of casing.

Weathering: The processes by which *particles, rocks* and *minerals* are altered on exposure to surface temperature and pressure and atmospheric agents such as air, water, and biological activity.

APPENDIX I

Smoky Creek Alluvium Assessment (KCB 2018)

June 27, 2018

Stanmore Coal IP
Level 8 – 100 Edward Street
Brisbane, QLD
4000

Richard Oldham
Approvals Manager

Dear Mr. Oldham:

Isaac Plains East Project
Smoky Creek Alluvium Assessment

1 INTRODUCTION & BACKGROUND

Klohn Crippen Berger Ltd (KCB) was commissioned by Stanmore Coal IP (Stanmore) to provide hydrogeological support for the installation and hydraulic testing of five monitoring bores at the Isaac Plain Complex (IPC). The monitoring bore installations were required to address conditions identified in the Environmental Authority (EA) for the Isaac Plains Mine (EPML00932713). These five bores are identified in Table 11 of the EA, and were proposed to be screened across the Quaternary alluvium, Tertiary basalt and Permian coal measures.

All five monitoring bores were installed within the vicinity of their proposed locations identified in the EA. All bores were constructed with a screened interval adjacent to their proposed target lithology, with the exception of MB11. The proposed target lithology for MB11, in the EA, is alluvium, however, drilling at the proposed location did not encounter alluvium.

This letter provides a summary of the site investigations undertaken to identify the occurrence of alluvium within the vicinity of MB11 and the adjacent Smoky Creek.

2 SITE INVESTIGATIONS & INTERPRETATION

The target lithology for MB11 was the Quaternary alluvium. The selection of this target lithology for this monitoring bore location was based on the mapped alluvium presented in the Mount Coolon 1:250,000 map sheet, which is mapped as having an extent of up to ~500 m adjacent to Smoky Creek. The mapped geology at this location is presented in Figure 2-1. The mapped alluvium at this location is described on the Mount Coolon 1:250,000 map sheet as a flood-plain deposit, consisting of clay, silt, sand and gravel.

Drilling of MB11 was undertaken at the location identified in the EA, however, alluvium was not encountered during drilling. As a result, reconnaissance of the alluvium within the vicinity of

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MB11 was undertaken to identify and confirm the extent of the alluvium. Accessible locations along the Smoky Creek water course (highlighted section shown in Figure 2-1) was inspected, and comprised an extent of 1.25 km downstream and 0.5 km upstream of MB11.

Figure 2-1 presents a topographic profile through the creek and the location of MB11. This profile highlights the relatively steep gradients adjacent to the creek (also highlighting the incised nature of this water course), which does not reflect the typical geomorphology of a flood-plain type deposit, as identified by the Mount Coolon 1:250,000 map sheet.

Photographs from the reconnaissance are provided in Figure 2-2. These photographs show that unconsolidated sediments occur within the water course channel of Smoky Creek (channel width of approximately 3 m). The extent of the sediments was identified to be limited to the water course channel as the channel is deeply incised, with the creek banks comprising weathered bedrock. Furthermore, outcrops of weathered bedrock occur within the channel (presented in photo in Figure 2-2) of Smoky Creek, identifying the limited depth of unconsolidated sediments.

As no alluvium was encountered along Smoky Creek a groundwater monitoring bore screened within the alluvium, within the vicinity of Smoky Creek, was unable to be installed.

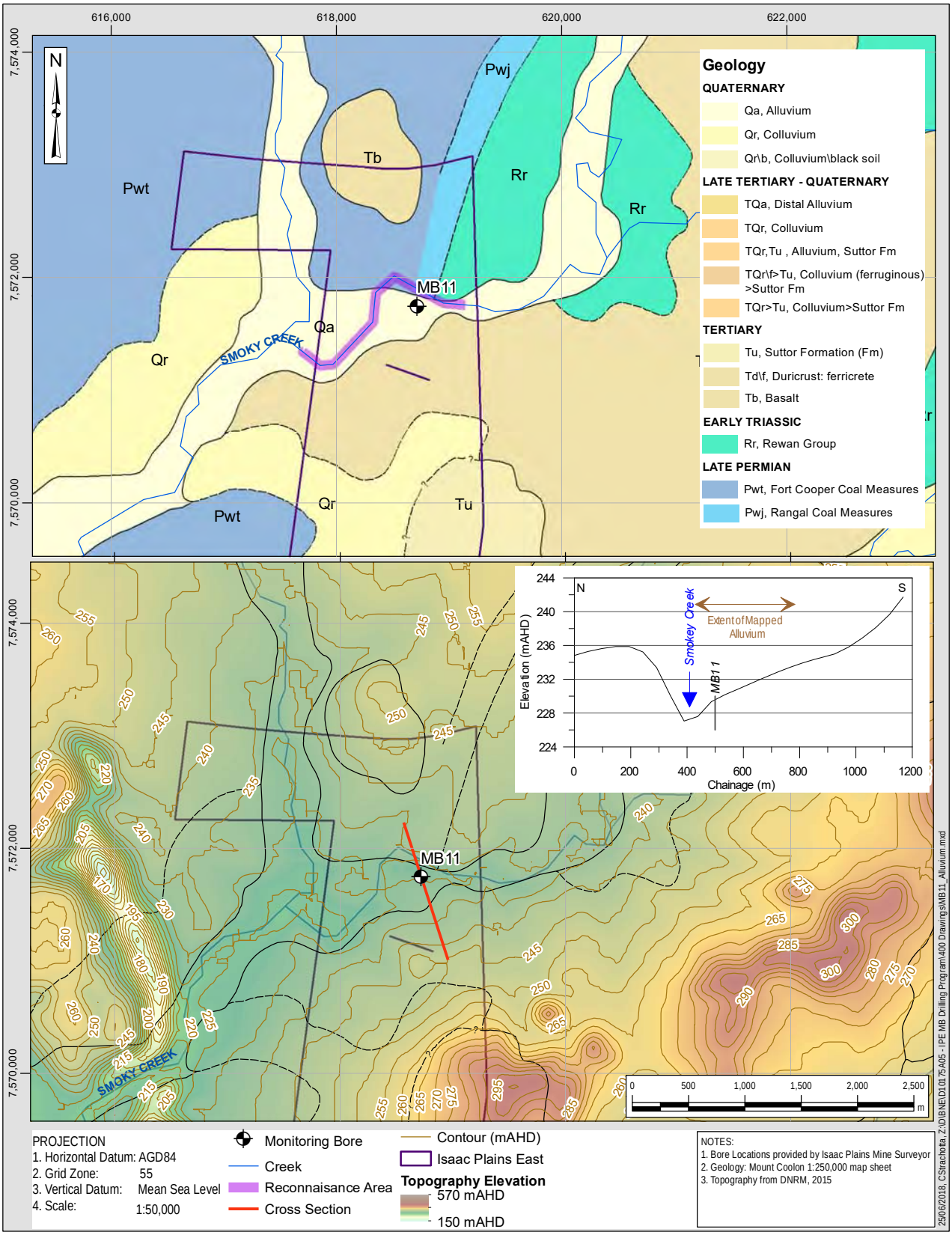

Figure 2-1: Regionally Mapped Geology and Topographic Profile at MB11

Figure 2-2: Smoky Creek in the vicinity of MB11

3 CLOSING

This letter is an instrument of service of Klohn Crippen Berger Ltd and has been prepared for the exclusive use of Stanmore IP Coal for the specific application to the assessment of alluvium associated with Smoky Creek within the vicinity of monitoring bore MB11. The letter's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. In this report, Klohn Crippen Berger has endeavoured to comply with generally-accepted professional practice common to the local area. Klohn Crippen Berger makes no warranty, express or implied.

KLOHN CRIPPEN BERGER LTD.

Chris Strachotta, RPGeo
Senior Hydrogeologist, Associate

CS:CS

APPENDIX II

Figures

Figure 1: Site Location
Figure 2: Site Layout
Figure 3: Surrounding Coal Mines and Groundwater Bores
Figure 4: Topography and Drainage
Figure 5: Solid Geology
Figure 6: Surface Geology
Figure 7: Conceptual Hydrogeological Cross Section
Figure 8: Groundwater Bore Monitoring Locations

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Klohn Crippen Berger

PROJECT

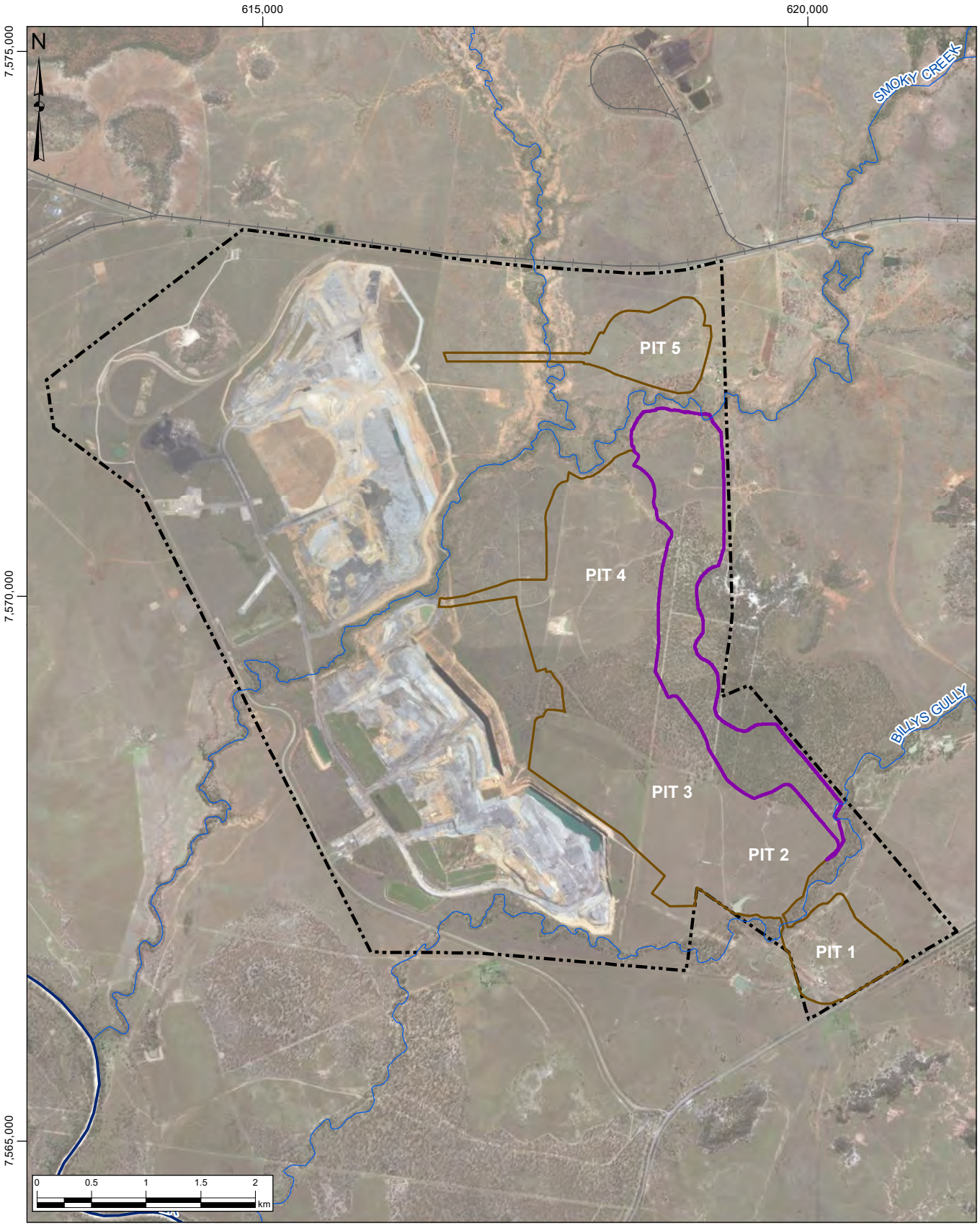
ISAAC PLAINS MINE
GROUNDWATER MONITORING AND MANAGEMENT PLAN

TITLE

PROJECT LOCATION

PROJECT No.	FIG No.	REV
D10175A07	FIGURE 1	A

1/08/2019, nturner, Z:\D\BNE\D10175A07 - IPM GMMP Update\400 Drawings\ArcGIS\Issued\Figure 01 Sites Locations.mxd



Legend

- River
- Creek
- Railways
- Isaac Plains Complex Mining Lease
- Approved IPE Outline
- IPE Pit Extension

NOTES:
1. Background image courtesy of ESRI ArcGIS

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:50,000

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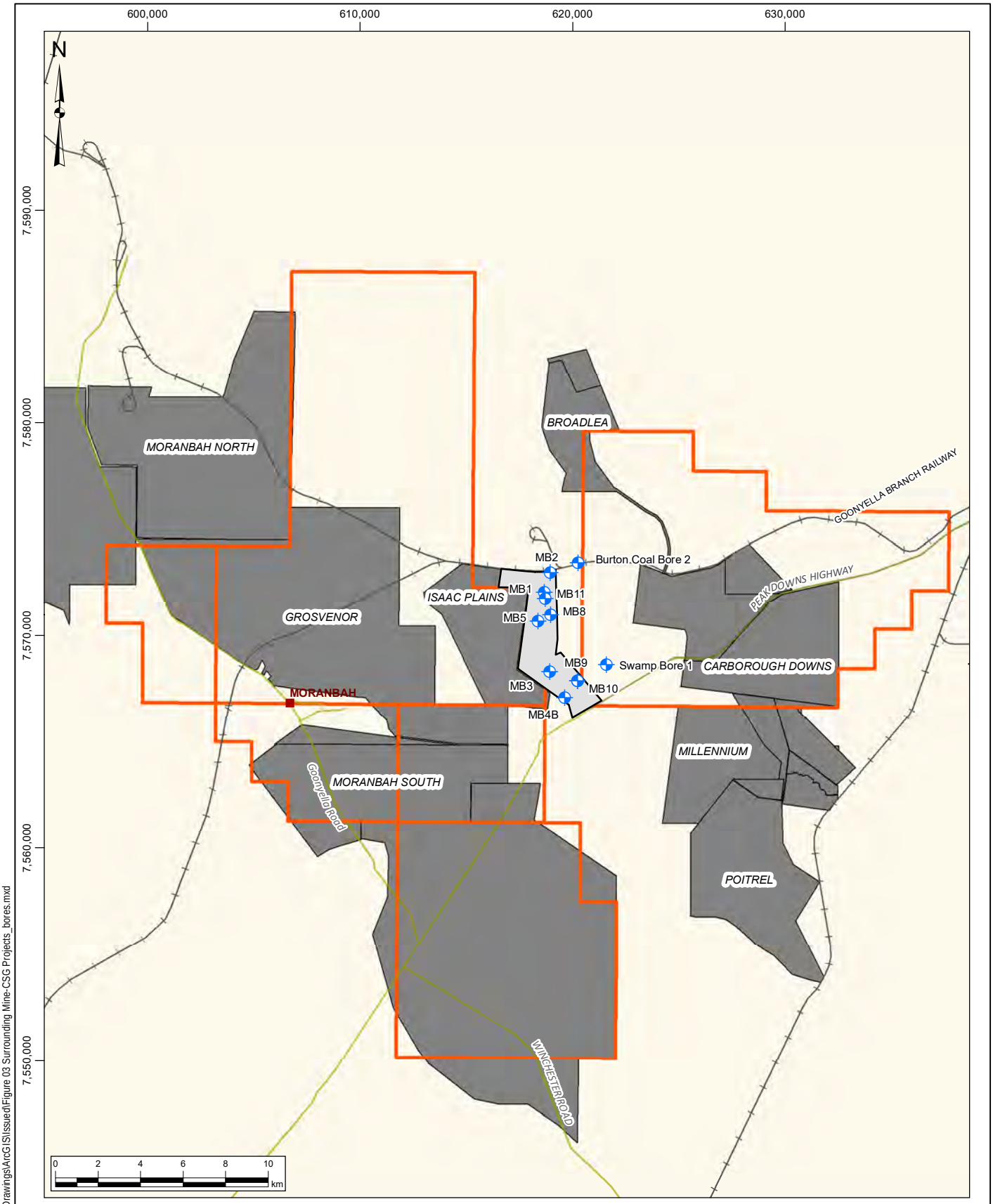
PROJECT
ISAAC PLAINS MINE
GROUNDWATER MONITORING AND MANAGEMENT PLAN

TITLE
SITE LAYOUT

PROJECT No.	FIG No.	REV
D10175A07	FIGURE 2	A

16/09/2019, KCorbett, \\int.klohn.com\ProjData\D\BNE\D10175A07 - IPM GMMP Update\400 Drawings\ArcGIS\Issued\Figure 02 Sites layout v2.mxd



Legend

- Town
- Monitoring Bore
- Isaac Plains East
- Moranbah Gas Project Leases

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:250,000

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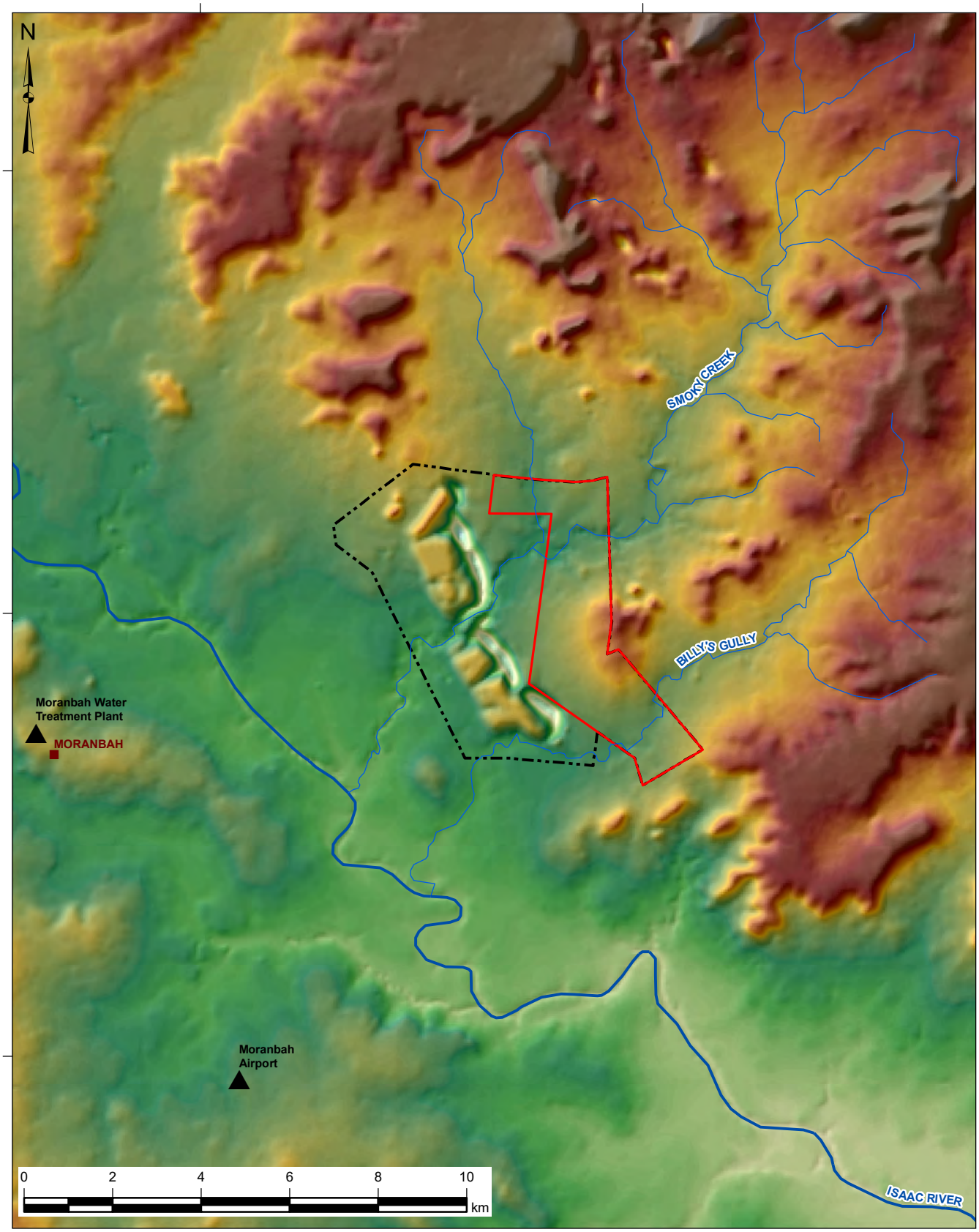
PROJECT
ISAAC PLAINS MINE
GROUNDWATER MONITORING AND MANAGEMENT PLAN

TITLE
SURROUNDING COAL MINE SITES AND GAS PROJECTS AND WATER SUPPLY BORES

PROJECT No.	FIG No.	REV
D10175A07	FIGURE 3	A

22/08/2019, DErasmus, Z:\D\BNE\D10175A07 - IPM GMMP Update\400 Drawings\ArcG1S\Issued\Figure 03 Surrounding Mine-CSG Projects_bores.mxd



Legend

- Town
- Weather Station
- Surface Water Drainage
  - River
  - Creek
- IPC ML
- Isaac Plains East

Topography Elevation

570 mAHD

150 mAHD

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:125,000

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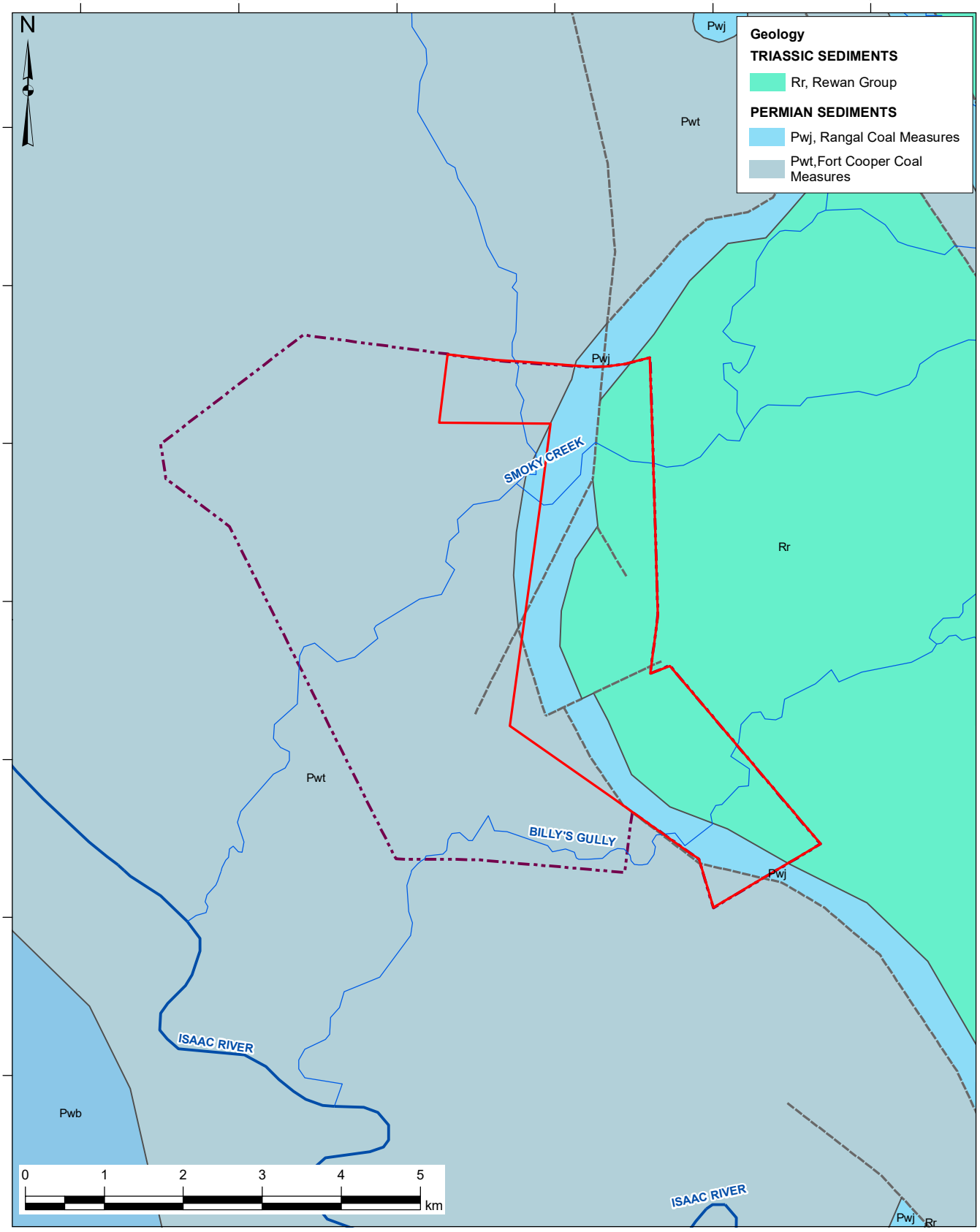
PROJECT
ISAAC PLAINS MINE
GROUNDWATER MONITORING AND MANAGEMENT PLAN

TITLE
TOPOGRAPHY AND DRAINAGE

PROJECT No.	FIG No.	REV
D10175A07	FIGURE 4	A

22/08/2019, DErasmus, Z:\DBNE\D10175A07 - IPM GMMP Update\400 Drawings\ArcGIS\Issued\Figure_04_TopographyandDrainage.mxd



Legend

- River
- Creek
- IPC ML
- Isaac Plains East

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:70,000

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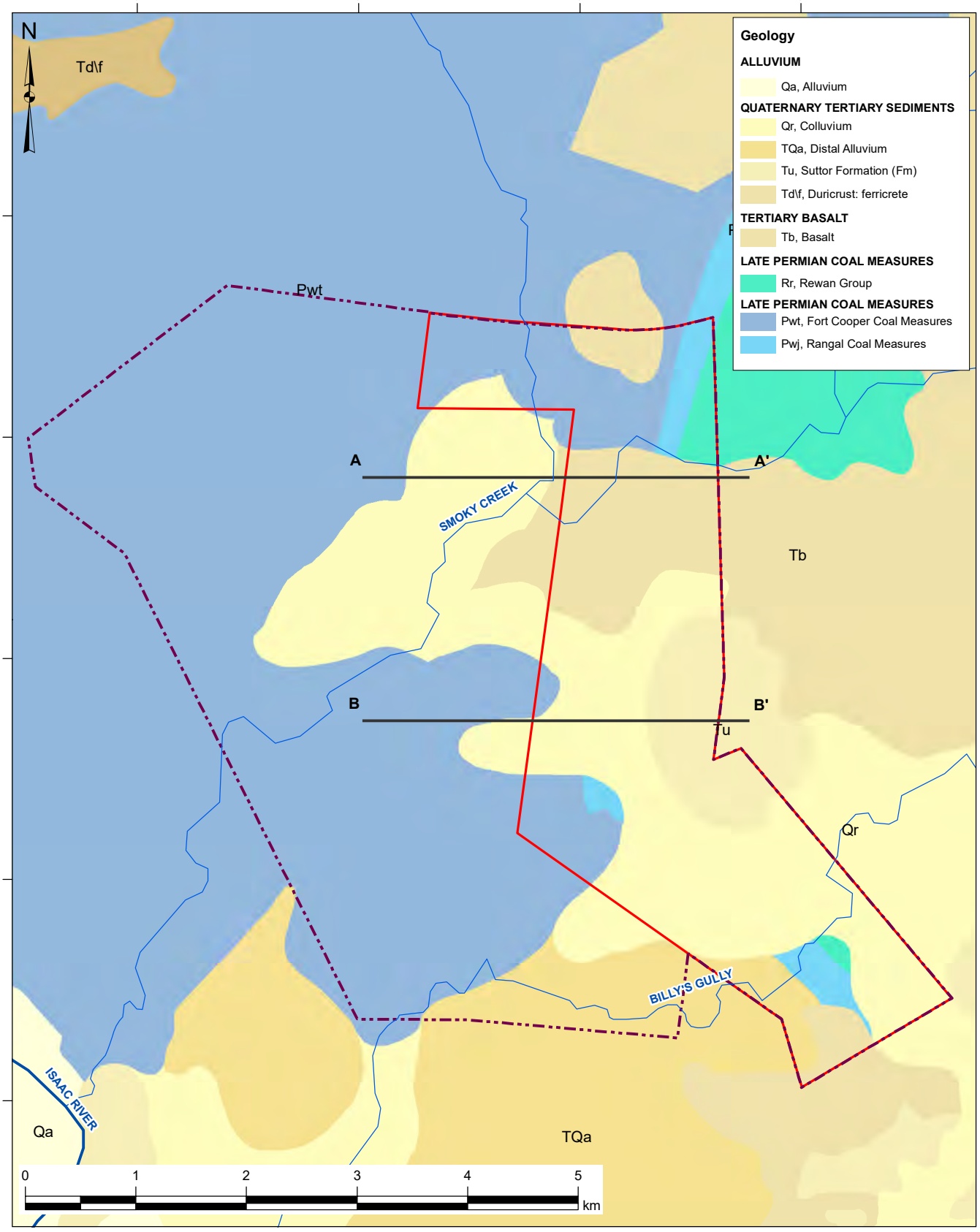
PROJECT
ISAAC PLAINS MINE
GROUNDWATER MONITORING AND MANAGEMENT PLAN

TITLE
SOLID GEOLOGY

PROJECT No.	FIG No.	REV
D10175A07	FIGURE 5	A

22/08/2019, DErasmus, Z:\DIBNE\D10175A07 - IPM GMMP Update\400 Drawings\ArcG\SIssued\Figure_05_SolidGeology.mxd



Legend

- River
- Creek
- Cross Section
- IPC ML
- Isaac Plains East

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:50,000

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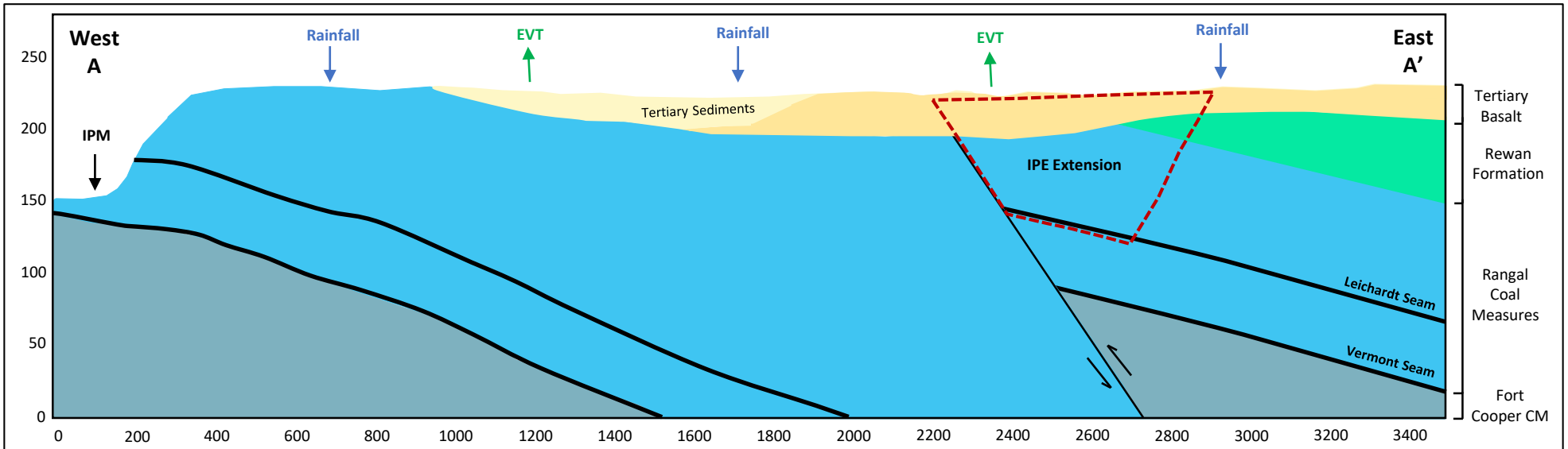
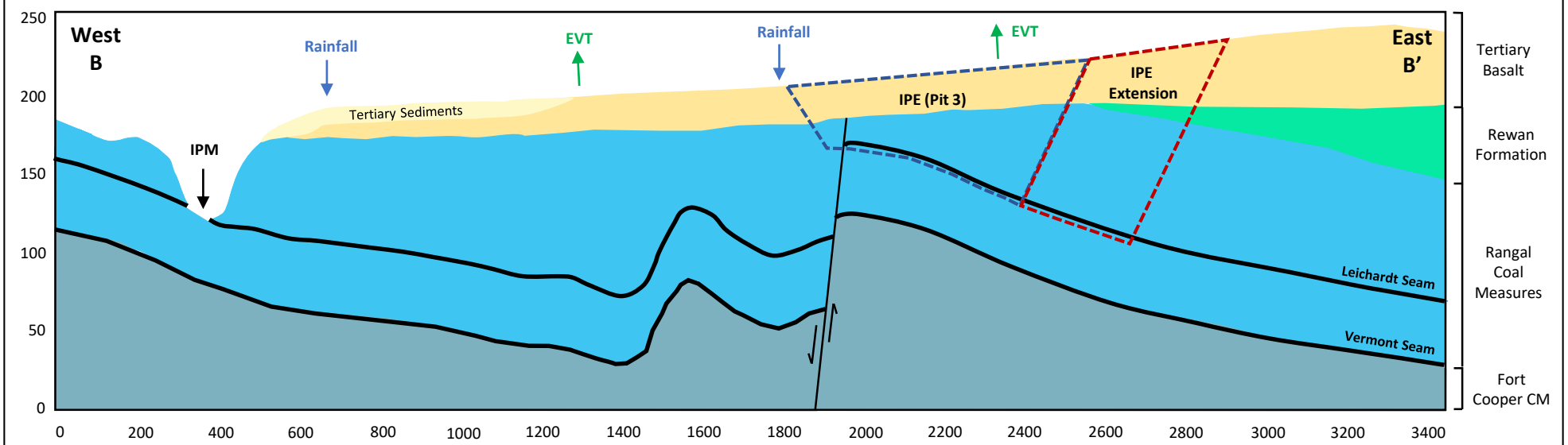
PROJECT
ISAAC PLAINS MINE
GROUNDWATER MONITORING AND MANAGEMENT PLAN

TITLE
SURFACE GEOLOGY

PROJECT No.	FIG No.	REV
D10175A07	FIGURE 6	A

22/08/2019, DErasmus, Z:\D\BNE\D10175A07 - IPM GMMP Update\400 Drawings\ArcG\Issued\Figure_06_SurfaceGeology.mxd





Legend

- - - Fault Inferred
—— Fault Location
⇄ Fault Slip Sense

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Klohn Crippen Berger

PROJECT
ISAAC PLAINS COMPLEX GROUNDWATER MONITORING AND MANAGEMENT PLAN

TITLE
CONCEPTUAL GEOLOGY CROSS-SECTION SECTION A – A'

PROJECT No.	FIG No.	REV
D10175A07	FIGURE 7	A

Legend

- Existing Monitoring Bore
- To be Decommissioned
- Decommissioned
- Replacement Bore
- Isaac Plains Mine Mining Lease
- Isaac Plains East

NOTES:
1. Background image courtesy of ESRI ArcGIS

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:55,000

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Klohn Crippen Berger

PROJECT
ISAAC PLAINS MINE
GROUNDWATER MONITORING AND MANAGEMENT PLAN

TITLE
GROUNDWATER MONITORING PROGRAM

PROJECT No.	FIG No.	REV
D10175A07	FIGURE 8	A

16/09/2019, KCorbett, \\int.klohn.com\Proj\Data\D\BNE\D10175A07 - IPM GMMP Update\400 Drawings\ArcGIS\Issued\Figure_8_GroundwaterMonitoringProgramv2.mxd

APPENDIX VI

Smoky Creek Alluvium Assessment (KCB 2020)

Klohn Crippen Berger

TECHNICAL MEMORANDUM

TO: Richard Oldham **DATE:** June 3, 2020

FROM: KCB **FILE NO:** D10175A08

SUBJECT: Smoky Creek Site Investigation

1 INTRODUCTION

A walkover of Smoky Creek was undertaken on July 2018 to identify the presence, extent, and characteristics of alluvium associated with this watercourse. This site investigation document supports the conceptualisation of the hydrogeological system presented in the groundwater impact assessment for the Isaac Plains East Extension.

2 GEOLOGY AND GEOMORPHOLOGY

Alluvium is absent from the majority of the Isaac Plains Complex (IPC) footprint and surrounds, with its distribution limited to the channel of Smoky Creek and Billy's Gully. Discussion regarding the alluvium associated with Billy's Gully is provided in the hydrogeological conceptualisation section of the Groundwater Report (KCB, 2020). Lithological data along Smoky Creek, collected as part of this site investigation (see Table 3.1), indicates that the alluvium is up to 1 m thick within the center of the Smoky Creek drainage channel. This drainage channel is incised into the landscape resulting in exposed bedrock along the creek banks; and, within the creek bed at two locations within the IPC. A variable alluvium thickness is anticipated along the creek beds within the vicinity of IPC. Based on site investigations completed to date, an alluvium thickness of up to 2 m has been encountered within the drainage channel of the surrounding water courses. Alluvium is not present outside of this localised area of the creek bed.

The alluvium within the drainage channels adjacent to IPC is contiguous with the Quaternary alluvium of the Isaac River channel and its immediate surrounds. However, the catchment size and associated flow within the Isaac River is greater than Smoky Creek and Billy's Gully. As a result, the distribution and composition of the alluvial deposits associated with the Isaac River are distinctly different to the alluvium associated with Smoky Creek, with broad floodplains and river terraces resulting in an alluvium thickness of over 25 m within the vicinity of the Isaac River.

The alluvium associated with Smoky Creek and Billy's Gully is characterised by a high proportion of coarse sand and gravel and correspondingly low proportion of fine sediments such as clay and silt. The composition of the alluvium reflects the grading of the alluvium under the relatively high-energy, short-duration flow conditions experienced within these creeks. Alluvial sands and gravels will typically settle from the water column over short-distances and will be re-deposited on the creek bed, while alluvial silts and clays are typically transported significant distances in the water column. This is consistent with the presence of sand sheet deposits in these creeks and lack of observed bedform features.

3 SMOKY CREEK

Description

Smoky creek is an ephemeral creek that occurs through IPC. During periods of flow, the creek flows towards the southwest to the Isaac River. The Creek channel is covered with coarse sand and gravel along with low proportion of fine sediments such as clay and silt. Smoky Creek flows into the Isaac River approximately 5 km downstream of the IPC.

Watercourse Field Observations

The following watercourse observations were observed during the field investigation:

- Creek channel bed predominantly consisted of coarse sand, gravels and in some parts clay or mud.
- Debris (fallen trees) were encountered in the channel beds at several points along the creek.
- The creek morphology generally consisted of shallow banks (0.5 to 3 m high), strongly meandering and varies between 5 to 8 m wide. The vegetation density increases towards the south.
- Medium to fine sized pebbles, cobbles were distributed along the base of the creek bed.
- Test pits indicated soil generally varies between 0.01 to 0.5 m and covers more competent bedrock material (sandstone and siltstone) towards the north.

Twenty-three (23) sites form part of the investigation with 12 test pits (0.6 to 3 m deep), dug within and along Smoky Creek. The test pits were dug until the base of the alluvium was confirmed. A summary of each locations is provided in Table 3.1 and presented in Figure 3.1 and Figure 3.2.

.

Table 3.1 Smoky Creek investigation – Northeast to Southwest

Location	Easting	Northing	Description	Test Pit Depth (m)	Photograph
Site 1	617834	7571483	**Creek Bank**: Weathered medium grained lithic sandstone along the banks. **Creek Bed**: Coarse sand and gravel (~18 – 20 cm deep) within the creek bed. Oxidised mudstone in channel.	0.2	
Site 2	617834	7571510	**Creek Bank**: Stratified unconsolidated sediments. Cobbles (2-20 cm), upward fining into clayey/sandy sediment. **Creek Bed**: sand and gravel bars.		
Site 3	617843	7571531	**Creek Bank**: compacted mudstone and siltstone. Erosion present along bank. **Creek Bed**: Within meander bend, unconsolidated sandy silt.		
Site 4	617807	7571621	**Creek Bed**: Creek infill, coarse sand, silt and gravel.	0.6	
Site 5	617767	7571694	**Creek Bank**: Stratified bank with sandstone mudstone lenses and siltstone. **Creek Bed**: Creek infill material, sand and gravel.		
Site 6	617693	7571721	**Creek Bank**: Stratified bank with sandstone, mudstone lenses and siltstone. **Creek Bed**: Cross-bedding, pebbly/muddy sand with sandy cobbles (>10 cm)	1	
Site 7	617624	7571647	**Creek Bank**: Terraced banks, heavy vegetated. Thin layer of mud overlaying banks. **Creek Bed**: sand, upward fining sandy silt.	0.6	
Site 8	617590	7571509	**Creek Bank**: Terraced banks, heavy vegetated. Thin layer of mud overlaying banks. **Creek Bed:** Alternating layers (~5 cm) of sand and gravel with silt.	0.6	
Site 9	617546	7571533	**Creek Bank**: Terraced banks, heavy vegetated. Thin layer of mud overlaying eastern bank. **Creek Bed**: Significant meander with large pointbar.	0.5	

Location	Easting	Northing	Description	Test Pit Depth (m)	Photograph
Site 10	617593	7573159	**Creek Bank**: Completely exposed weathered sandstone. Highly weathered at the top of the embankment.		
Site 11	617516	7572890	**Creek Bank**: Silt and soil, erosion and drainage network. **Creek Bed**: Creek infill, sand, silt, gravel and clay.		
Site 12	617670	7572809	**Creek Bank**: Silt and soil, erosion and drainage network. **Creek Bed**: Within meander bend stratified course sand/gravel with silt in pointbar.	0.5	
Site 13	617691	7572684	**Creek Bank:** Weathered sandstone, turning into soil and silt. Erosion and drainage network.		
Site 14	617593	7572583	**Creek Bank**: Weathered sandstone		
Site 15	617693	7572480	**Creek Bank**: Terraced weathered, fine to medium grained sandstone. Significant erosion.		
Site 16	618788	7572213	**Creek Bed:** ~0.05 m soil overlaying weathered sandstone.	0.2	
Site 17	618819	7572084	**Creek Bank:** Bedrock, little vegetation present. Local erosional gullies.		
Site 18	618699	7572010	**Creek Bank (cut outside meander bend)**: Highly weathered sandstone, ~3 m soil profile with roots. Outcrop obscured by dense vegetation at the bottom of embankment.		
Site 19	618404	7571939	**Creek Bank (~15 m from creek)**: ~0.05 m weathered siltstone downward increasing in competent siltstone.	0.2	
Site 20	618450	7571951	**Creek Bank (~6 m from creek)**: Exposed bedrock, sandstone orientated downward with alternating layers of siltstone. **Creek Bed**: ~0.01 m soil, grading into weathered siltstone. Highly vegetated.	0.3	
Site 21	616988	7571270	**Creek Bank**: Consolidated siltstone and sandstone upward fining to soil covering top of embankment. **Creek Bed**: Dark grey mud spread over creek bed. Large lithic sandstone clasts found along edges of creek bed. Gravelly sand at top of creek grading to consolidated/compacted gravel.	0.5	

Location	Easting	Northing	Description	Test Pit Depth (m)	Photograph
Site 22	616786	7570620	**Creek Bank**: Layer of mud overlaying banks. **Creek Bed**: Significant soil profile ~3 m. Trees, shrubs and grass growing within soil. Semi-consolidated cobbles, sand and silts within the first 1 m.	3	
Site 23	615691	7569542	**Creek Bank**: ~3-4 m high covered in eroded mud. **Creek Bed**: ~0.5 m eroded mudstone and siltstone with trees present in the channel soil.		

Figure 3.1 Photographs of Creek Bank along Smoky Creek

Figure 3.2 Photograph of Creek Bed along Smoky Creek

4 CONCLUSIONS

The Smoky Creek site investigation, conducted in July 2018, identified no alluvium beyond the extents of the creek channel. Weathered bedrock (sandstone) outcrops occur along the creek banks with minor soil cover. Alluvium (coarse sand/ gravel and silt) is limited to the creek channel beds with varying thickness between 0.1 and 3 m.

APPENDIX G GROUNDWATER REPORT (IPU)

Klohn Crippen Berger

Hansen Bailey Pty Ltd

Isaac Plains Underground Project

Groundwater Report

CANADA'S BEST MANAGED COMPANIES Platinum member

ISO 9001
ISO 14001
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D10073A03

January 2019

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1 INTRODUCTION

Klohn Crippen Berger Ltd (KCB) was commissioned by Hansen Bailey on behalf of Stamore IP Coal Pty Ltd to complete a groundwater impact assessment as part of the Environmental Assessment Report (EAR) for the Isaac Plains Underground Project (the 'project'). The EAR is being used in support of an application to amend the Isaac Plains Complex Environmental Authority (EA).

1.1 Project Description

The Isaac Plains Complex is an operating open cut mine located approximately 4.5 km north-east of Moranbah Township in Central Queensland (Figure 1). The Isaac Plains Complex commenced operations in 2006 and produces export coking and thermal coal. The Isaac Plains Complex EA (EPML00932713) prescribes a maximum coal extraction rate of 4 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal.

Open cut mining operations involve the removal of overburden by dragline, with truck and shovel pre-stripping. Coal is excavated from the active pits and hauled by truck to an on-site CHPP for washing and processing (Figure 2). Product coal is transported from the Isaac Plains Complex, via an on site rail loop and train load out facility (Figure 2). Product coal is railed to the Dalrymple Bay Coal Terminal, for export.

The project involves the development of an underground bord and pillar mine at the Isaac Plains Complex. The project mining area is located within the existing Isaac Plains Complex MLs and therefore a new ML will not be required for the project (Figure 2). The project will use the existing Isaac Plains Complex mine infrastructure, including the existing Coal Handling and Preparation Plant (CHPP) (Figure 2). The project will not increase the approved peak ROM coal production rate at the Isaac Plains Complex and no upgrades of the existing mine infrastructure are required. New additional infrastructure will be limited to:

- A ROM coal conveyor;
- A ROM coal stockpile;
- A bord and pillar mine industrial area (MIA); and
- Minor ancillary infrastructure including gas drainage, water management, electricity and ventilation infrastructure, and access roads.

1.2 Scope of Assessment

The scope of work for the groundwater assessment included:

- A review of relevant groundwater data and environmental reports from the project mining area, the existing Isaac Plains Complex and surrounding mines / projects to develop an appreciation of the hydrogeological setting of the project;
- A review of relevant geological data including 3D geology models, databases and exploration drilling logs developed by the proponent for the project mining area, the existing Isaac Plains Complex and surrounding areas;
- A review of hydrogeological data held on the Department of Natural Resources, Mines and Energy's (DNRME's) Groundwater Database to identify water supply bores;

- A bore census to confirm the status of potential water supply bores in the vicinity of the project mining area;
- A field investigation to confirm the drainage characteristics of creeks within the project mining area, ground-truth the surface geology within the creeks and the surrounding areas and identify any potential interactions with groundwater;
- The development of a conceptual model of the groundwater regime in the project mining area and its surrounds, based on all available data;
- The development of a numerical groundwater model for the predictive simulation of the scale and extent of mining effects on groundwater levels during mine operations and post closure;
- An assessment of the groundwater impacts and development of feasible mitigation and management strategies, where necessary; and,
- The development of a groundwater monitoring program for the project.

1.3 Report Structure

This report is structured as follows:

- Section 1: Introduction – provides an overview of the project and the assessment scope;
- Section 2: Regulatory Framework – describes the regulatory setting relating to groundwater;
- Section 3: Project Setting – describes the project location, including relevant land uses, local topography and drainage, climate and local stratigraphy and geological structures;
- Section 4: Assessment Methodology – describes the assessment method including the collection of relevant data, the groundwater field investigation and numerical groundwater modelling;
- Section 5: Existing Hydrogeology – describes the existing groundwater regime for the project mining area and its surrounds;
- Section 6: Impact Assessment – provides a detailed description of the proposed mining activities and the predicted effects of mining on the local groundwater regime. This section also presents an assessment of the potential impacts on groundwater users and the sensitive environmental features;
- Section 7: Groundwater Monitoring Program – describes the proposed groundwater monitoring program for the project;
- Section 8: Conclusions; and
- Sections 9 to 11 comprising references, abbreviations and a glossary.

Appendix I provides a compiled list of all groundwater bores within 5 km of the project mining area from which groundwater data has been sourced. This list comprises registered bores from the DNRME Groundwater Database (as discussed in Section 4.1).

A local and regional groundwater dataset was compiled for this assessment. This dataset was sourced from monitoring bores, operational mine monitoring, drilling and testing programs and surveys within the project mining area, its surrounds and the wider regional setting. The collated groundwater quality data is presented in Appendix II.

Appendix III provides a detailed description of the numerical modelling conducted for the project, including details of model construction, calibration, predictive simulation and model sensitivity analysis.

2 QUEENSLAND REGULATORY FRAMEWORK

The Queensland *Mineral Resources Act 1989* (MR Act) entitles the holder of a mining lease to take or interfere with underground water (i.e. groundwater) as part of approved mining operations. This entitlement is termed the mining lease holder's 'underground water rights'. Groundwater that is taken or interfered with while exercising the underground water rights is termed 'associated water'. The holder of the mining lease is entitled to use associated water for any purpose.

Section 227AA of the Queensland *Environmental Protection Act 1994* (EP Act) requires that an EA amendment application that involves a change to the exercise of underground water rights must be supported by the following information:

- A statement describing the proposed exercise of underground water rights and a description of the timing and location of the proposed activities;
- A description of each aquifer and the movement of water within each aquifer affected by the proposed activities;
- An assessment of the extent of depressurisation in each aquifer due to the proposed activities;
- The predicted quantity of associated water taken from each aquifer during the proposed activities.
- A description of the impacts of the proposed activities on environmental values;
- A description of the effects of the proposed activities on groundwater quality; and
- A description of any strategies to manage or mitigate the impacts of the proposed activities.

The supporting information required under the EP Act is provided in this report. The proposed exercise of underground water rights is discussed in Section 6. The conceptual groundwater regime, including relevant aquifers and the movement of groundwater is discussed in Section 5. The predicted effects of the project including groundwater take and changes in groundwater levels and quality are discussed in Sections 6.2 and 6.4. The predicted impacts of the project on groundwater users and sensitive environmental features is also addressed in Sections 6.3 and 6.3. Groundwater monitoring and management is discussed in Section 7.

The proponent will not require a separate approval (e.g. an associated water license under the parallel provisions of the Water Act) in order to exercise its underground water rights.

Other relevant groundwater legislation considered in this assessment includes:

- The Environmental Protection (Water) Policy (EPP Water) provides a framework to protect and/or enhance the suitability of Queensland waters for various beneficial uses. Groundwater resources within the project lie within the Isaac River catchment as listed in Schedule 1 of the EPP Water. The EPP states that the environmental values for groundwaters within the Isaac River catchment may include aquatic ecosystems, irrigation, farm supply, stock water, primary recreation, drinking water and cultural and spiritual values. The EPP provides water quality objectives (WQOs) to support and protect the

various environmental values identified for waters within the Isaac River catchment. The groundwater WQOs for the Isaac River catchment are provided in the *Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin* (DES 2011) according to their chemistry zone and depth category. Groundwater within the vicinity of the project mining area is classified as 'shallow' and 'deep' under chemistry zone 34, a brackish (Na-Cl) type water. Section 5 presents the groundwater quality data relevant to the project setting.

- The water resource planning process under the Water Act provides a framework for the development of catchment specific Water Plans. A Water Plan, along with Water Management Protocols, Resource Operations Licences and associated operations manuals, provides a management framework for water resources in a plan area, and includes outcomes, objectives and strategies for maintaining balanced and sustainable water use in that area. The project mining area is located in the Isaac Connors Groundwater Management Area (GMA) under Schedule 3 of the Water Plan (Fitzroy Basin) 2011 area (Figure 3). The Isaac Connors GMA comprises two groundwater units, namely:
  - the Isaac Connors Groundwater Unit 1, containing the aquifers of the Quaternary alluvium associated with the Isaac River channel; and
  - the Isaac Connors Groundwater Unit 2, containing all sub-artesian aquifers within the Isaac Connors GMA other than the aquifers included in Isaac Connors Groundwater Unit 1.

The potential project impacts on these groundwater resources are addressed in Section 6.

3 PROJECT SETTING

3.1 Land Use

The project mining area has been extensively cleared in the past for cattle grazing. More recently, vegetation has been cleared for seismic surveys and open cut mining as part of the approved Isaac Plains Complex open cut mining operations.

There are a number of coal mines and coal projects in the region of the Isaac Plains Complex and the project mining area as shown in Figure 1, including:

- The existing and future mining areas at the Isaac Plains Complex adjoining and overlying project mining area;
- The Grosvenor Mine adjoining the Isaac Plains Complex;
- The Moranbah North Mine located north-west of the project mining area;
- The Burton, Broadlea and Ironbark No. 1 Mines located north of the project mining area;
- Carborough Downs Mine located east of the project mining area;
- Millennium and Poitrel Mines located south-east of the project mining area; and
- The Moranbah South Project and Caval Ridge Mine located south-west of the project mining area.

The Moranbah Gas Project, which is one of Australia's largest operating CSG projects, also extends over the Grosvenor Mine, Moranbah North Mine and surrounding areas. The Moranbah Gas Project is a joint venture between Arrow Energy and AGL.

The potential for cumulative groundwater impacts due to the project and the surrounding land uses is assessed in Section 6.5.

3.2 Topography and Drainage

The project mining area is traversed by Smoky Creek, its northern tributary and several minor drainage lines (Figure 4). Smoky Creek and its northern tributary converge in the centre of the project mining area. Smoky Creek drains in a south-westerly direction and joins the Isaac River approximately 6 km downstream of the project mining area boundary.

The project mining area comprises undulating terrain (Figure 4). In the northern part of the project mining area, the land slopes towards creek channels. The remainder of the project mining area slopes to the west.

The Isaac River, Smoky Creek and their tributaries are ephemeral and characterised by short-duration surface water flows that are typically restricted to periods during and immediately after rainfall events. Creek flows exhibit naturally elevated suspended sediment loads and the channels show extensive sediment deposition.

3.3 Climate

The climate at the project mining area is sub-tropical continental, characterised by high variability in rainfall, temperature and evaporation, typical of the regional Central Queensland area.

The nearest Climate data has been collected from two Bureau of Meteorology (BoM) weather stations within the vicinity of the project mining area. These weather stations are:

- Moranbah Water Treatment Plant (Station 034038) – now decommissioned, operating from 1972 to March 2012. This monitoring station is located approximately 12 km southwest of the project mining area (Figure 4).
- Moranbah Airport (Station 034035) – operational, operating from March 2012 to present. This monitoring station is located approximately 12.5 km south of the project mining area (Figure 4).

A summary of average temperatures, rainfall and evaporation from the Moranbah Water Treatment Plant station is presented in Table 3-1, while a summary of average temperatures and rainfall from the Moranbah Airport station is presented in Table 3-2.

Table 3-1: Climate Averages – Moranbah Water Treatment Plant (Station 034038)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean max temp (^{0}C)**	33.8	33.1	32.1	29.5	26.5	23.7	23.7	25.5	29.2	32.3	33.1	34.0	29.7
Mean min temp (^{0}C)**	21.9	21.8	20.2	17.6	14.2	11.2	9.9	11.1	14.1	17.6	19.4	21.1	16.7
Mean rainfall (mm)*	103.8	100.7	55.4	36.4	34.5	22.1	18.0	25.0	9.1	35.7	69.3	103.9	614.2
Mean daily evaporation (mm)**	8.0	7.4	6.8	5.7	4.3	3.5	3.7	4.9	6.6	8.0	8.5	8.5	6.3

* Data record from 1972 to 2012
** Data record from 1986 to 2012

Table 3-2: Climate Averages – Moranbah Airport (Station 034035)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean max temp (^{0}C)	35.3	33.3	32.1	30.0	27.1	24.3	24.5	26.8	30.3	32.6	34.5	35.3	30.7
Mean min temp (^{0}C)	21.4	21.0	20.1	16.3	12.7	9.6	8.7	8.5	12.4	15.4	18.7	20.1	15.6
Mean rainfall (mm)	90.6	114.6	90.8	28.8	30.7	16.3	36.6	9.3	9.8	19.0	50.7	69.4	602.8

Data record from 2012 to June 2018

The available climate data identifies distinct cycles of above average and below average rainfall. The Moranbah area has experienced below average rainfall between 2001 and 2006, and 2008 to 2010; with above average rainfall in 2007, and between 2010 and 2012. Rainfall from 2012 to present day has been consistent with the long-term average, except for 2016 where above average rainfall occurred.

Evaporation rates have been recorded at the Moranbah Water Treatment Plant station between 1986 and 2012. Monthly evaporation rates exceed monthly rainfall for all months of the year, highlighting a net evaporative loss over a year.

3.4 Geology

The project mining area is located on the north-western flank of the Bowen Basin, a sedimentary basin comprising Permian to Triassic age geology (Figure 5). A veneer of more recent basalt and weathered sediments typically overlies the Bowen Basin strata (Figure 6).

Field investigations described in Section 4.2 show that there is no Quaternary alluvium within the project mining area and its surrounds. Localised deposits associated with the Isaac River are located approximately 5.5 km south-west of the project mining area.

The ground-truthed geology relevant to the project mining area is shown in Figure 6, and includes:

- A veneer of recent weathered sediments comprising the Suttor Formation and associated colluvium and regolith;
- Localised Tertiary basalt deposits;
- Triassic sediments of the Rewan Formation; and
- Permian sediments of the Rangal Coal Measures (including the target Leichhardt seam) and the deeper Fort Cooper Coal Measures and Moranbah Coal Measures.

The Tertiary sediments comprise a heterogeneous profile of semi-consolidated sandstone, mudstone and other minor sediments associated with the Tertiary Suttor Formation, duricrusted palaeosols at the top of deep weathering profiles, colluvium and regolith (Figure 6). Published geological mapping confirms that the colluvium deposits transition to Suttor Formation sediments, indicating that these materials are frequently indistinguishable due to lithological similarities between these materials. These materials are therefore considered to form a single unit, hereafter referred to as the Tertiary sediments. The Tertiary sediments are widely distributed over the project mining area and its surrounds. The Tertiary sediments are up to approximately 15 m thick in the west and south of the project mining area and are thin or absent elsewhere.

The Tertiary basalt comprises a heterogeneous profile of vesicular and massive basaltic lavas, with minor tuff and ash. The upper basalt profile is highly weathered forming a basaltic clay. The distribution of Tertiary basalt is confined to a paleochannel that is incised into the Permian sediments. The project mining area lies at the western extent of the paleochannel basalt that extends into the north and east of the project mining area. The basalt reaches a maximum thickness of approximately 15 m within the project mining area.

The Triassic Rewan Formation overlies the Permian sediments to the east of the project mining area and consists of fine/medium grained sandstones, siltstones and shale. The upper profile of the Permian sediments have been extensively weathered forming a clay. The Rewan Formation is typically thin or absent in the project mining area and thickens as it dips to the east. The weathered Rewan Formation outcrops at the ground surface to the east of the project mining area or under the Tertiary sediments and basalt, where present.

The Permian sediments include the Rangal Coal Measures and the underlying Fort Cooper Coal Measures and Moranbah Coal Measures. The Permian sediments comprise a sedimentary sequence with interbedded coal seams, including the target Leichardt Seam. The Leichardt Seam is approximately 3.2 to 4.4 m thick in the project mining area. The upper profile of the Permian

sediments have been extensively weathered forming a clay. The weathered Permian sediments outcrop at the ground surface across the majority of the project mining area and much of the surrounding area to the west (Figure 6). In the remainder of the project mining area, the weathered Permian sediments sub-crop under the Tertiary sediments and basalt and dip towards the east (Figure 7). As the Permian sediments dip to the east, the depth of cover above the project underground workings (i.e. the thickness of the strata above the coal seam being mined) increases from approximately 80 m in the western part of the project mining area to approximately 290 m in the north-eastern corner of the project mining area (Figure 8).

The Permian sediments (including the Leichardt Seam) and the Rewan Formation are faulted to the east of the project mining area (Figure 7). The fault dips gently to the east in the northern part of the Isaac Plains Complex. In this area, the downthrust and upthrust Leichardt Seam (located west and east of the fault, respectively) overlap (Figure 7). The project mining activities will target the downthrust coal seam while the open cut mining activities in Pits 1 to 5 target the overlying upthrust coal seam (Figure 7). The fault is sub-vertical in the southern part of the Isaac Plains Complex and there is negligible overlap in the Leichardt Seam in this area.

4 METHODOLOGY

4.1 Desktop Study

4.1.1 Database Searches

A search of relevant Australian and Queensland databases was undertaken. The purpose of this search was to identify the presence of current and historical groundwater bores and collate drilling records and groundwater level, yield and quality data from relevant bores.

The database search area included the project mining area and its surrounds within a 5 km radius. The search radius was considered representative of the geological and hydrogeological setting of the area.

The following databases and mapping were searched:

- The DNRME Groundwater Database of registered water bore data from private water bores and Queensland Government groundwater investigation and monitoring bores (Appendix I). Data includes bore location, groundwater levels, construction details, stratigraphic logs, available hydrogeological testing and available groundwater quality.
- The Queensland Spatial Catalogue (QSpatial), via Queensland Globe. Records of petroleum and coal seam gas (CSG) exploration, production and monitoring wells are contained within this database.

The proponent's Isaac Plains Complex groundwater database was also searched to identify any unregistered groundwater bores.

These searches identified 41 groundwater bores (38 registered and 3 unregistered) within 5 km of the project mining area (Figure 9), including:

- 11 bores (MB1 to MB5, MB8 to MB11, Swamp Bore 2 and Burton Coal Bore 2) that comprise the existing Isaac Plains Complex EA groundwater monitoring network described in Section 4.1.2.
- 6 bores (Smoky Creek Bore, BC095, 240P/AC1, MB4b, MB06 and MB07) that are historical Isaac Plains Complex groundwater monitoring bores;
- 19 water supply and monitoring bores that form part of the Broadlea water supply borefield. The Broadlea water supply borefield is located approximately 4 km north-east of the project mining area and targets the Tertiary basalt aquifer.
- 1 operating landholder water supply bore (Swamp Bore 1).
- 4 groundwater bores (Burton Coal Bore 1, MGC Wotonga 1, MGC Moranbah 1 and 141C) that are predominantly historical and existing monitoring bores associated with local mining and gas operations.

The database information on these bores has been tabulated in Appendix I. It should be noted that a detailed assessment of Swamp Bore 1 and 2 (described in Section 4.2.1) has shown that Swamp Bore 2 is the EA monitoring bore while Swamp Bore 1 is the landholder water supply bore, hence these bore names have been transposed in the public records. The corrected naming convention has been used above and throughout this report.

A total of 83 QSpatial-registered gas production wells were identified within 5 km of the project mining area (Figure 9). The CSG production activities are discussed in Section 3.1. Of the identified 83 CSG wells, 82 are located west of the project mining area, while one is located to the east of the project mining area within the Isaac Plains Complex. All registered CSG wells target the Moranbah Coal Measures.

The relevant reliable data collected from these bores was used to inform the conceptual understanding of the groundwater regime and the numerical groundwater model. The specific use of each bore in the groundwater study was dependent on the type and quality of information available (i.e. bores with reliable water levels were used to establish the groundwater flow regime and calibrate the groundwater model, bores with reliable salinity data were used in the groundwater quality assessment, bores with reliable hydraulic data were used to confirm the groundwater regime and establish suitable model parameters). Stratigraphic information from the remaining bores was used to confirm the geology setting, relevant lithology and construct the model geology.

4.1.2 Isaac Plains Complex Groundwater Monitoring Network

The proponent maintains the Isaac Plains Complex groundwater monitoring network in accordance with the EA. The Isaac Plains Complex EA groundwater monitoring network currently comprises 11 monitoring bores as shown on Figure 9, including:

- 2 bores (Burton Coal Bore 2, Swamp Bore 2) that have been monitored since 2010;
- 5 dedicated groundwater monitoring bores (MB01 to MB05) installed in 2015 as part of the Isaac Plains East Project EAR groundwater assessment; and
- 4 bores (MB8 to MB11) installed in mid-2018 to fulfil the monitoring requirements of the Isaac Plains Complex EA.

The proponent has also historically monitored an additional 6 bores (Smoky Creek Bore, BC095, 240P (also called AC1), MB4b, MB06 and MB07) (Figure 9).

Bore lithology, depth to water strike, bore construction details, screened lithology and hydraulic conductivity testing results have been collected for each bore along with groundwater level and quality data from 2007 to 2018, where available.

4.1.3 Literature Review and Previous Groundwater Studies

A review of available groundwater reports literature and relevant groundwater studies was undertaken to support and refine the conceptual understanding of the local and regional groundwater regime.

The review included the following groundwater studies undertaken within the vicinity of the project mining area and within comparable geological and environmental settings:

- The Isaac Plains East Project Groundwater Report (KCB, 2016). This report includes groundwater levels and quality data from six groundwater monitoring bores (MB01 to MB06) installed as part of the Isaac Plains East Project groundwater field investigation program in 2016. This report also includes pumping test data has been collected from three production wells associated with the Broadlea Mine.

- The Integrated Isaac Plains Project EIS groundwater study (Matrix Plus, 2007). This report includes information on 13 groundwater monitoring bores installed at six locations (i.e. multiple clustered bores targeting various hydrogeological units at each location). A total of 55 water level measurements and 30 water quality samples were collected. Hydraulic testing was also undertaken in the alluvium and the Rangal Coal Measures (including the Leichardt and Vermont seams and the Permian interbeds).
- The Grosvenor Project EIS (JBT, 2010). This report includes extensive field investigation data from the Grosvenor Mine ML, including data collected from Anglo's regional network of 220 exploration and monitoring bores located on the Grosvenor Mine ML, the Moranbah North Mine ML and the surrounding area. Groundwater level and quality data spanning an 11 year period was reviewed.
- The Moranbah South Project EIS (AGE, 2013). This report includes field investigation data that was collected from the installation of 14 monitoring bores (two in the alluvium, six in the Tertiary basalt / sediments, three in the Fort Cooper Coal Measures, three in the Moranbah Coal Measures), the installation of 16 vibrating wire piezometers across four locations targeting the coal seams and falling-head testing on 13 monitoring bores (three in the Fort Cooper Coal Measures, three in the Moranbah Coal Measures, five in the Tertiary basalt, two in the alluvium) to obtain hydraulic conductivity values of the target hydrogeological units.
- The Moranbah Gas Project Underground Water Impact Report (Arrow Energy, 2016). This report includes monitoring data collected from the coal seams and overlying strata to the west of the project mining area and provides information on the response of groundwater levels to dewatering of the coal seams during CSG production.

4.2 Field Investigations

4.2.1 Bore Census

A bore census carried out in 2015 as part of the Isaac Plains East Project groundwater assessment identified Smoky Creek Bore, Burton Coal Bore 1 and Swamp Bore 2 as inactive water supply bores surrounding the Isaac Plains Complex.

The bore census confirmed that Smoky Creek Bore is located on the Broadlea property and the leaseholder of this property has access to an alternative water supply and therefore this bore has not been used as a water supply. This bore is part of the historical Isaac Plains Complex groundwater monitoring network.

In mid-2018 a detailed bore assessment was undertaken to confirm the status of Burton Coal Bore 1 and Swamp Bore 2. In addition, the bore assessment investigated Burton Coal Bore 2 and Swamp Bore 1. The bore assessment concluded that:

- Burton Coal Bore 1 is damaged and inaccessible. No pumping equipment is installed in this bore.
- Burton Coal Bore 2 and Swamp Bore 2 are EA groundwater monitoring bores. These bores are not installed with pumping equipment and are not used for water supply.
- Swamp Bore 1 is an operating water supply bore located approximately 4 km south-east of the project mining area. This bore is screened in the Rewan Formation.

The potential impacts of the project on Swamp Bore 1 are discussed in Section 6.3.2.

4.2.2 Field Investigation of Creeks and Surface Geology

Published geology mapping (1:250,000 scale Mount Coolon geology map sheet) indicates the presence of alluvium associated with Smoky Creek within the Isaac Plains Complex to its confluence with the Isaac River. In June 2018, targeted drilling was undertaken at the Isaac Plains Complex to install a monitoring bore in the mapped alluvium adjacent to Smoky Creek. Drilling observations confirmed that alluvium was not present at that location.

An additional field investigation program was undertaken by KCB on 13 July 2018. The purpose of the field investigation was to confirm the drainage characteristics of creeks within the project mining area, ground-truth the surface geology within the creeks and the surrounding areas and identify any potential interactions with groundwater.

The field investigation included a detailed inspection of the landform and geological characteristics of Smoky Creek and its tributaries within the project mining area and its surrounds. Hand excavations were undertaken to confirm the visual observations. The field investigation was undertaken by qualified and experienced geologists and a hydrogeologist.

The field investigation results are summarised as follows:

- Alluvium is not present in the overbank areas around the creeks traversing the project mining area.
- The landscape around the creeks is an undulating sandy plain characterised by thin sandy to gravelly soils and deeply weathered bedrock.
- Clearing for cattle grazing and mining activities appears to have resulted in extensive sheet erosion of the in-situ sands and gravels, exposing the underlying deeply weathered Tertiary and Permian age bedrock.
- A thin blanket of unconsolidated sediments (washed sands) has been deposited on the bed of Smoky Creek and its northern tributary. Observations indicated that the bed sands are typically 0.5 m thick (and locally up to 1.5 m thick).
- Groundwater was not encountered within the bed sands and no evidence of groundwater interactions was observed in the Smoky Creek or its northern tributary.
- The creeks are typically incised into the landscape the creek banks comprise exposed weathered rock across the full profile.

The ground-truthed surface geology of the project mining area and its surrounds is shown in Figure 6.

4.3 Data Analysis and Conceptualisation

The data collected from the desktop study and project field investigation was collated and screened. The relevant local data was analysed in detail to develop a conceptual understanding of the groundwater regime in the project mining area and its immediate surrounds (Section 5).

The collated local groundwater dataset includes the following relevant measurements:

- Geological data collected from the proponent's geology database of in excess of exploration 200 drill holes within the project mining area and its surrounds, lithological logs from 41 DNRME-registered and unregistered bores.
- Groundwater level data collected from 33 bores within the main stratigraphic units within the project area and its surrounds. This includes manual and automated logger groundwater level data from the Isaac Plains Complex groundwater monitoring bores and adjacent landholder bores.
- Hydraulic data collected from 14 rising/falling head tests at the Isaac Plains Complex groundwater monitoring bores and adjacent landholder bores. This includes hydraulic data for each of the main stratigraphic units within the project mining area and its surrounds (Figure 10).
- Groundwater quality data collected from 8 bores, including detailed field measurements and laboratory results for each of the main stratigraphic units within and surrounding the project area.

4.3.1 Groundwater Flow

Spatially distributed groundwater level data were used to characterise groundwater flow directions, gradients and velocities. In addition, time variant variations in groundwater level were used to interpret the rate and distribution of recharge/discharge, depressurisation influence from surrounding mining activities and pre-development/seasonal variability in groundwater levels.

4.3.2 Groundwater Quality

Groundwater quality data provides useful information on the hydrogeological regime, as it is influenced by interaction with the aquifer matrix, and groundwater recharge/discharge processes.

Salinity is a key constraint to the usability of groundwater resources for productive applications such as potable supply, irrigation, stock watering and industrial applications. If groundwater with elevated salinity levels are used for incompatible purposes or applications it may result in impacts to agricultural productivity, health and the environment.

A categorisation scheme for salinity proposed by Fao (2013) is presented in Table 4-1. Table 4-1 also categorises the groundwater salinity collected from laboratory analysis at the current and historical Isaac Plains Complex groundwater monitoring bores. The dataset collected from these bores represents the most relevant and comprehensive, long-term record of groundwater quality within the vicinity of the project.

There are no records indicating that 'fresh' groundwater has been encountered near the project mining area.

Table 4-1: Salinity Classification Scale

Salinity	Range (TDS mg/l)	Groundwater salinity in Isaac Plains Complex monitoring bores (Average TDS mg/L)
Fresh	<500	Nil
Brackish	500 – 1,500	Nil
Moderately saline	1,500 – 7,000	Swamp Bore 2 – 6,300 Burton Coal Bore 2 – 2,450 MB1 – 3,375 MB6 – 6,680
Saline	7,000 – 15,000	MB2 – 7,900 MB5 – 14,800 MB7 - 13,450
Highly saline	15,000 – 35,000	MB4 – 24,750
Brine	>35,000	Nil

A detailed piper plot analysis was undertaken to understand the ionic salt composition of the groundwater regime. Piper plots are useful for assessing groundwater mixing and evolution (e.g. through water-rock interaction) and identifying potential zones of groundwater recharge and discharge. Figure 11 provides a piper diagram of groundwater ion composition in the bores listed in Table 4-1. This diagram shows data from 2010 onwards.

Collectively, this data represents all reliable data on groundwater ion composition within 5 km of the project mining area. Figure 11 clearly demonstrates that the ionic composition of groundwater is consistent across all measured bores, and was used to further support the assessment that the groundwater regime is generally consistent at a local and regional scale.

4.4 Numerical Modelling

A 3D numerical groundwater flow model was developed from the collated dataset (described in Sections 4.1 to 4.3) using MODFLOW software to represent the conceptual groundwater regime described in Section 5. A detailed description of the modelling methodology is provided in Appendix III.

The model represented the key geological units using 19 model layers and extends 48 km north-south and 27 km east-west. The project mining area was located in the centre of the model domain.

The physical structure of the groundwater model was based on the detailed geological model developed by the proponent and a numerical groundwater model developed for the Isaac Plains East Project. Model development was supplemented by published geological maps, digital geology surfaces and information from mining operations near the project mining area and data from the DNRME groundwater database.

The Australian Groundwater Modelling Guidelines (Barnett et al., 2012) were used to frame the calibration process. A detailed description of the calibration method is provided in Appendix III. The groundwater model was initially calibrated to 609 reliable groundwater level records from 34 monitoring bores screened across a variety of aquifers and aquitards; this included the monitoring

bores installed during the project mining area investigation. Groundwater dewatering and level data from existing mining and coal seam gas operations was also used as a target for model calibration.

The groundwater regime near the project mining area has varied over time due to the influence of historic and current mining activities. For this assessment, it was necessary to perform a transient (time-variant) calibration which considered the change in groundwater levels and flow from pre-mining conditions up to and including current conditions.

The transient calibration achieved a 3.6% scaled RMS error which is an acceptable calibration metric as recommended by the Australian Groundwater Modelling Guidelines (Barnett et al. 2012). Furthermore, the calibrated groundwater levels, vertical gradients, flow patterns and groundwater take replicate measured data and groundwater trends. The model calibration is therefore considered robust.

The numerical model was used to predict the effects of the project mining activities on the groundwater regime during and post mining. The modelling results were used to inform assessments of the project impacts on groundwater users and the surrounding environment, and the cumulative groundwater impacts of the project and other nearby mining projects. Section 6 describes the predictions of the groundwater model.

The sensitivity of the model predictions to the input parameters was tested, and involved varying key model parameters in isolation and assessing the influence the change made on predictions of drawdown and groundwater take. Key model parameters were selected based on their potential to most influence model predictions. Sensitivity analysis included testing of the following parameters, which covers the range of likely uncertainty in key parameters:

- Horizontal hydraulic conductivity, vertical hydraulic conductivity, specific yield and specific storage of all geological units and the fault; and
- The rainfall recharge rate across the model domain.

The changes used to test the model sensitivity include extremes in the potential parameter ranges and encompass the full range of relevant measured values for these parameters.

The analysis found that predicted groundwater take was most sensitive to an increase in hydraulic conductivity and storage. Groundwater take was relatively insensitive to changes in recharge. The magnitude and extent of depressurisation was relatively insensitive to sensitivity changes.

Changing the bulk hydraulic conductivity and storage parameters within the model was associated with an increase in the model error. This indicates that the magnitude of these changes reduced the ability of the model to reliably predict measured groundwater levels, and indicates that the changes made during the sensitivity analyses are likely to represent conservative extremes for these parameters.

Overall, the results of the sensitivity analysis confirmed that the sensitivity of the model calibration and predictions to changes in model input parameters is in all instances acceptable and the model is fit for purpose.

Appendix III provides a detailed discussion of the sensitivity analyses.

5 EXISTING HYDROGEOLOGY

The relevant hydrogeological units of the project mining area and its surrounds broadly comprise:

- A shallow, highly weathered veneer of low permeability Tertiary sediments;
- Tertiary basalt comprising highly weathered, low permeability basaltic clay and a relatively permeably basalt aquifer;
- Low permeability Rewan Formation sediments;
- Permian sediments comprising low permeability sediments and relatively permeable coal seams.

The main groundwater-bearing formations are the fresh Tertiary basalt and the coal seams of the Permian sediments. These formations have been significantly depressurised and impacted by mining and gas production activities at nearby operations. The Rewan Formation is a low permeability formation that is a regionally recognised aquitard. The Tertiary sediments do not form a permanent, saturated aquifer, and persistent groundwater occurs only where these sediments extend below the regional water table.

Recharge predominantly occurs via direct and diffuse rainfall to the weathered surface sediments (i.e. Tertiary sediments and basalt) and outcropping weathered Permian and Rewan Formation sediments. A portion of the rainfall moves downwards to the groundwater table then moves through the system following the hydraulic gradient. Recharge to the Permian sediments and Rewan Formation will occur where these units sub-crop below the Tertiary sediments and basalt.

The regional groundwater flow is generally from elevated areas in the north-east to lower lying areas in the south-west (i.e. the Isaac River). However, groundwater flow has been significantly altered by mining operations in the vicinity of the project mining area. A zone of depressurisation exists above and around the surrounding mines and gas production bores. This zone locally influences groundwater flow directions and results in groundwater flowing towards these mines and gas production activities.

The Tertiary sediments and upper weathered profile of the Tertiary basalt, Rewan Formation and Permian sediments are predominantly unsaturated in the vicinity of the project mining area, therefore, interpolated groundwater surfaces for these units are unable to be produced.

The current depth to groundwater and the elevation of the water table based upon the available data are presented in Figure 12.

All formations within the project mining area and its surrounds have a relatively low hydraulic conductivity (Figure 10).

Figure 7 shows a conceptual cross-section of the geology and groundwater regime within the project mining area and its surrounds.

Groundwater quality within the project mining area and its surrounds ranges from moderately saline to brine. Local groundwater is therefore generally unsuitable for potable, irrigation or stock watering uses. There are no current groundwater users in the project mining area.

5.1 Tertiary Sediments

5.1.1 Groundwater Distribution

The Tertiary sediments comprise a heterogeneous profile of semi-consolidated sandstone, mudstone and other minor sediments. The Tertiary sediments are widely distributed over the project mining area and its surrounds (Figure 6) where they form undulating sandy plains. The Tertiary sediments have been extensively weathered resulting in the formation of a heterogeneous layer of residual soils and weathered clays.

The Tertiary sediments are up to 10 m thick within the project mining area and its surrounds. The limited thickness and low primary porosity of these sediments results in limited capacity for groundwater storage and movement.

The Tertiary sediments are typically located above the regional groundwater table and are therefore generally dry and unsaturated in the vicinity of the project mining area. Where saturated, the groundwater within the Tertiary sediments is in direct hydraulic connection with the underlying Triassic Rewan Formation or Permian sediments. The saturated extent and thickness of the Tertiary sediments is shown in Figure 13.

The Tertiary sediments are not a significant aquifer.

5.1.2 Hydraulic Parameters

Hydraulic testing data indicates the Tertiary sediments have a low to moderately low hydraulic conductivity, ranging from approximately 0.0007 to 0.04 m/d. The hydraulic conductivity of this unit is within the range exhibited by the Triassic Rewan Formation and Permian sediments. This supports the assessment that these sediments are not a significant aquifer.

5.1.3 Potentiometric Surface, Recharge, Flow and Discharge

The Tertiary sediments are recharged by direct infiltration from rainfall where these sediments are present at the surface. The Tertiary sediments are also recharged by the underlying groundwater regime where they are hydraulically connected.

Groundwater flows in the Tertiary sediments are towards the south-west and are locally influenced by dewatering of the Tertiary basalt at the Broadlea water supply borefield and mining operations.

Discharge predominantly occurs as seepage to the underlying Permo-Triassic groundwater regime.

Due to the depth of groundwater in the Tertiary sediments, there is no significant interaction with surface waters within the vicinity of the project area.

5.1.4 Groundwater Quality

Groundwater quality in the Tertiary sediments at the Isaac Plains Complex (MB4) is highly saline (TDS of 24,750 mg/L). The elevated salinity reflects the degree of connectivity with the underlying low permeability Permian sediments and the long groundwater residency times of groundwater in this formation.

5.1.5 Yield and Use

Groundwater yields are expected to be low (less than 1 L/s). No groundwater supply bores are located in the Tertiary sediments within 5 km of the project area due to the general lack of saturation or reliable water supply in these sediments.

5.2 Tertiary Basalt

5.2.1 Distribution

The Tertiary basalt underlies the Tertiary sediments and overlies weathered Permo-Triassic strata at the project mining area and typically occurs as a single composite unit comprising massive and vesicular lava, tuff and ash flows.

Regionally, the Tertiary basalt occurs within paleo-channels incised into the underlying Permo-Triassic bedrock. Paleo-channels with associated basalt flows are located to the north, east and south of the project mining area. The regional basalt flows have a saturated to a thickness of up to approximately 50 m in the centre of the paleo-channels (Figure 14).

The basalt extends into the northern and eastern parts of the project mining area from the main paleo-channel to the east. The local distribution of the Tertiary basalt is shown in Figure 6. Basalt within the project mining area is typically dry or has a limited saturated profile of less than 10 m (Figure 14). The saturated profile thickens to the east of the project mining area (i.e. towards the regional paleo-channel).

5.2.2 Hydraulic Parameters

The basalt exhibits highly variable hydraulic properties due to its complex lithology. Groundwater storage and flow is dominated by localised vesicular and fractured zones.

Fractured and vesicular basalt zones are compartmentalised by zones of massive basalt that is not significantly fractured or vesicular. In addition, the shallow highly weathered basalt also forms a very low hydraulic conductivity clay. Therefore, massive basalt and shallow highly-weathered basalt do not generally contain significant groundwater and can act as barriers to flow.

The hydraulic conductivity of the Tertiary basalt in the project mining area and its surrounds ranges from 0.004 to 6.5 m/d), reflecting the variability in the basalt characteristics. Higher hydraulic conductivity values are generally associated with the fractured / vesicular basalt within the centre of the basalt paleo-channel approximately 5 km east of the project mining area. Lower hydraulic conductivity values are typically associated with massive basalt along the lateral extents of the paleo-channel, and as minor limbs of the paleo-channel. The limbs of the paleo-channel within the project mining area are characterised by low permeability massive basalt.

5.2.3 Potentiometric Surface, Recharge, Flow and Discharge

Recharge to the Tertiary basalt occurs via direct rainfall infiltration in areas where the Tertiary basalt outcrops and via seepage from the overlying Tertiary sediments where present.

Regional groundwater flow in the Tertiary basalt is typically parallel with the orientation of the paleo-channels. Within the project mining area and its local surrounds the paleo-channel and

groundwater flow are towards the south-east (i.e. towards the centre of the paleo-channel). Flows are locally influenced by mining and water abstraction from the Broadlea water supply borefield.

Discharge occurs as seepage to underlying Permo-Triassic geology and licensed dewatering from the Broadlea water supply borefield.

5.2.4 Groundwater Quality

Groundwater in the Tertiary basalt at the project mining area and its surrounds is of variable quality. Groundwater is typically moderately saline with an average TDS of 6,680 mg/L (MB6).

The salinity of groundwater in the Tertiary basalt is due to solute dissolution into the groundwater as a result of weathering of the rock structure and lengthy residence times. Weathering profiles in the Tertiary basalt may contribute to the salinity at various depths within the basalt. This is further confirmed by stratification of groundwater quality within the Tertiary basalt, supporting the concept that groundwater in the basalt occurs within discrete zone of fractured / vesicular basalt.

5.2.5 Yield and Use

Groundwater yield from the Tertiary basalt in the project mining area and its surrounds is very low (0.009 L/s). This is due to the basalt within the project mining area being dominated by low permeability, low yielding massive basalt (i.e. competent rock with negligible structure or defects that containing groundwater).

The Broadlea water supply borefield targets vesicular/fractured basalts approximately 4 km east of the project mining area. The impact of the project on the Broadlea water supply borefield is addressed in Section 6.3.2.

5.3 Triassic Rewan Group

5.3.1 Distribution

The Rewan Group is a thinly interbedded sequence of siltstone, claystone and minor fine grained sandstone. This unit sub-crops and outcrops in the east of the project mining area where it overlies the Rangal Coal Measures (Figure 6 and Figure 7). The Rewan Group is faulted in the east of the project mining area.

The Rewan Group is uniformly saturated at depth, and may become unsaturated where it outcrops or subcrops above the regional groundwater table east of the project mining area.

5.3.2 Hydraulic Parameters

The measured hydraulic conductivity of the Rewan Group ranges from 0.001 to 1 m/d.

The Rewan Group is recognised as a regional aquitard and acts as a confining unit overlying the Permian sediments. This unit is characterised by low primary porosity and as a result, groundwater movement is controlled by local fracture sets. Where fractures are intersected, this unit shows slightly higher permeability, and conversely, where limited fractures are intersected this unit shows lower permeability associated with the primary porosity. Bulk permeability of this unit is therefore constrained by the degree of connection between any localised fractures. This

means that at the regional scale the representative average hydraulic conductivity is expected to be towards the lower end of the values measured by field testing.

5.3.3 Potentiometric Surface, Recharge, Flow and Discharge

The Rewan Group is recharged via direct rainfall infiltration in outcropping areas and via seepage from overlying units (including the Tertiary sediments and Tertiary basalt).

Groundwater flow is towards the south-west and is a subdued reflection of the topography and surface water catchments. Discharge into the underlying Permian sediments is the main discharge mechanism. However, discharge volumes are very low due to the very low rates of groundwater recharge.

5.3.4 Groundwater Quality

Groundwater quality within the Rewan Group at the project mining area and its surrounds is moderately saline (bordering on saline) with an average TDS ranging from 2,450 to 6,300 mg/L (Burton Coal Bore 2 and Swamp Bore 2, respectively). The salinity of groundwater from the Rewan Group reflects the low hydraulic conductivity of this unit, which results in solute contribution from the rock mass to the groundwater due to the longer residence time of groundwater.

5.3.5 Yield and Use

Groundwater yields from the Rewan Group are typically very low. Slightly higher yields can occur where localised fractures are intersected by drilling. Water supply bores tend to have targeted these localised fractures.

The bore census confirmed the presence of a single active water supply bore (Swamp Bore 1) screened in the Rewan Formation within 5 km of the project mining area. The highest recorded yield from this bore is 1.13 L/s (i.e. low yield). The impact of the project on this bore is addressed in Section 6.3.2.

5.4 Permian Sediments

5.4.1 Distribution

The Permian sediments include the Rangal Coal Measures, the Fort Cooper Coal Measures and the Moranbah Coal Measures (Figure 5 and Figure 7). They comprise alternating layers of fine to medium grained sandstone, siltstone and coal, including the target Leichardt seam. The upper profile of the sub-cropping coal measures have been extensively weathered forming a clay cap.

Individual coal seams form the principal water-bearing strata within the coal measures and are therefore typically saturated throughout their full thickness, but may become unsaturated where they outcrop or subcrop above the regional groundwater table. Groundwater storage and movement occurs within the coal seam cleats and fissures and within open fractures that intersect the seams.

The overburden and interburden sediments of the coal measures (above and between the coal seams) comprise hydraulically “tight” and hence very low yielding sediments. These sediments form thick confining aquitards within the coal measures.

The Permian coal measures at the project mining area are fault bound by the Isaac Thrust Fault and the associated fault splay. Faulted strata can exhibit a range of hydraulic characteristics, and in extreme circumstances can act as either a barrier or a conduit to groundwater flow. In this setting, the faults are likely to restrict groundwater flow in the horizontal direction, compared to un-faulted areas for the following reasons:

- Fractures associated with the faults in the vicinity of the project are typically sealed by mineralisation and precipitation.
- The high clay content of the Permian coal measures means that there is a significant likelihood of clay smearing across the fault plane that is likely to reduce the fault permeability by several orders of magnitude compared to the un-faulted areas.
- The coal seams are thin (up to 4.4 m) and represent an extremely small proportion of the overall thickness of the Permo-Triassic sediments (i.e. less than 1%). There is therefore a greater than 99% probability that fault displacement has resulted in a coal seam being juxtaposed with less permeable Permian interburden or Rewan Group sediments on the other side of the fault.
- Previous mining experience in the Bowen Basin indicates that coal seams are typically highly compartmentalised by faulting.

The low permeability of the fault zones is therefore likely to restrict groundwater flow, compared to un-faulted areas (OGIA, 2016).

The Rangal Coal Measures is underlain by the FCCM. The FCCM is a sequence of sandstone, carbonanceous mudstone, coal and tuffaceous material and is recognised as a regional aquitard.

The FCCM separates the Rangal Coal Measures from the MCM. The FCCM therefore acts to limit the hydraulic interaction between the overlying Rangal Coal Measures and the underlying MCM (and associated coal seams).

5.4.2 Hydrogeological Parameters

Hydraulic conductivity within the Permian sediments is typically associated with secondary porosity through fractures and cleats within the coal seams. The spacing and nature of cleating are the primary controls on hydraulic conductivity within the coal seams. The thick sequences of siltstone and sandstone interburden form confining aquitards within the coal measures.

The hydraulic conductivity of the Leichardt seam ranges from 0.07 to 2.3 m/d, while the other seams in the Permian sediments range from 0.00001 to 2 m/d.

The hydraulic conductivity of the Permian sediments overburden/interburden range from 0.00002 to 2 m/d. The hydraulic conductivity range in the interburden reflects the high degree of variability in the interburden strata, and includes measurements collected from very tight mudstones and extensively fractured horizons.

Hydraulic conductivity of the Permian sediments also reduces with increasing depth, as a result of increasing lithostatic pressure causing compression of the strata. Regionally, the measured ranges of hydraulic conductivity therefore reflect the depth at which measurements were collected. The regional and local dataset contains a high proportion of relatively shallow measurements due to the practical limitations of collecting deeper measurements.

5.4.3 Recharge, Flow and Discharge

Recharge occurs via rainfall infiltration on localised outcrops of Permian sediments within and to the west of the project mining area, and slow downward seepage from overlying strata. As a result, the groundwater recharge to the Permian sediments is typically very low. Locally, seepage is enhanced by the storage of water within open cut pit voids west of the project mining area. The rate of recharge may also be enhanced where the Permian sediments subcrop against the overlying strata, although the clayey nature of this weathered material will also limit recharge. Overall, the rate of recharge remains very low.

Conceptually, the undisturbed groundwater flow direction in the Permian sediments is towards the southwest.

However, coal mining at surrounding mining operations and CSG production at the Moranbah Gas Project have reduced groundwater pressures in the surrounding coal measures, creating a zone of depressurisation that gradually diminishes with distance from these operations. The project mining area lies within the zone of depressurisation associated with the existing and approved Isaac Plains Complex mining activities. Depressurisation of the coal measures has reduced the potentiometric groundwater surface creating a hydraulic gradient towards the open cut pits. Groundwater movement in vicinity of the project mining area is therefore a reflection of the depressurisation within the coal measures (i.e. towards these pits).

Groundwater discharge within the vicinity of the project mining area is therefore dominated by groundwater drainage associated with the Isaac Plains Complex open cut mine pits. Groundwater discharge into overlying formations is negligible in the vicinity of the project mining area.

5.4.4 Groundwater Quality

Groundwater within the Permian sediments at the project area and its surrounds is moderately saline to (more typically) saline, with an average TDS ranging from 3,375 to 14,800 mg/L reflecting the long groundwater residency times and low permeability of this formation.

5.4.5 Groundwater Yields and Use

Groundwater yields from the Permian sediments are typically low, with a median yield of less than 0.5 L/s.

At the project mining area, yields from the target Leichardt seam and fractured overburden are very low (<0.5 L/s).

There are no water supply bores targeting the Permian coal measures within 5 km of the project mining area due to the typically low yields and therefore lack of reliable water supply in these sediments.

6 IMPACT ASSESSMENT

6.1 Introduction

The project involves the development of an underground bord and pillar mine. The project mining area is located to the east of the existing Isaac Plains open cuts pits and west of the existing and approved Isaac Plains East open cut pits (Figure 2).

The bord and pillar mine layout has been specifically designed with sufficient roadway and pillar strength to ensure that there will be no caving and the underground workings will be stable and safe. Consequently, the bord and pillar mining will not result in any significant subsidence above the underground bord and pillar workings.

Bord and pillar mining will involve dewatering the underground workings which will result in depressurisation of the overlying and surrounding strata. Due to the easterly dip of the coal measures (and target coal seam), the underground workings within the project mining area will be located at a depth of up to 290 m. The project mining operations will be undertaken at a lower elevation than the approved Isaac Plains Complex open cut pits. The underground workings will therefore be dewatered to a lower elevation than the approved Isaac Plains Complex open cut pits.

The project involves the following activities that have the potential to impact the groundwater regime:

- The extraction of coal through bord and pillar mining, with associated depressurisation of the surrounding strata; and
- Use of hydrocarbons and chemicals which may result in groundwater contamination.

Appendix III describes how project bord and pillar mining was represented in the numerical groundwater model.

The following sections provides a detailed assessment of these potential impacts and is structured as follows:

- Section 6.2 presents the predictions of the groundwater modelling, including changes in groundwater levels during mining operations, groundwater take from the surrounding formations and recovery of groundwater levels following mine closure.
- Section 6.3 and Section 6.4 describes potential impacts to groundwater users and the environment.
- Section 6.5 outlines potential cumulative impacts with the adjacent mines and CSG production activities.

6.2 Groundwater Modelling Predictions

6.2.1 Drawdown and Depressurisation During Mining Operations

Figure 15 shows the predicted maximum depressurisation within the target Leichardt seam. The project will locally depressurise the Leichardt seam within the project mining area and its surrounds by up to approximately 260 m (Figure 15). Depressurisation is greatest in the

north-eastern part of the project mining area, where the depth of mining is greatest (approximately 290 m below ground level), and therefore the groundwater pressure is greatest.

Depressurisation of the Leichardt seam is generally constrained to the project mining area in the south. The maximum zone of depressurisation in the Leichardt seam is predicted to extend up to 3.5 km north and 1.5 km east of the project mining area. In the north, the project is predicted to result in up to approximately 200 m of depressurisation within the Leichardt seam at the project mining area boundary, decreasing to 50 m of depressurisation within approximately 700 m from the project mining area. In the east, the project is predicted to result in up to approximately 50 m of depressurisation within the Leichardt seam at the project mining area boundary, decreasing to 10 m of depressurisation within approximately 700 m from the project mining area.

Depressurisation is generally constrained to the coal seam but is predicted to extend to the upper weathered profile of the Permian and Triassic sediments to the north and east of the project mining area. The weathered profile is predicted to experience approximately 1 to 2 m of depressurisation to the east of the project mining area and up to 17 m of depressurisation to the north (Figure 16).

Minor localised depressurisation (up to 4.5 m) of the Tertiary basalt is predicted to the east of the project mining area (Figure 17).

No depressurisation is predicted to occur in the Tertiary sediments or the distant Isaac River alluvium as a result of mining in the project mining area.

6.2.2 Groundwater Take

Modelled groundwater take from the proposed mining operation are presented in Figure 18.

The modelled rate of groundwater take is controlled by factors such as mining depth and extent, the thickness and hydraulic conductivity of mined and overlying strata, the hydraulic gradients induced by depressurisation and drawdown from nearby mines.

The modelled groundwater take from the project mining area gradually increase as mining progresses east, the underground workings increase in size and the Leichardt seam becomes deeper. The modelled groundwater take peaks at approximately 1,200 ML/yr during mining operations.

The modelled groundwater take represents the theoretical volume of groundwater that could be removed from the groundwater regime. The actual volume of groundwater pumped from the underground mining area will be less that that predicted by the numerical model, as a component of the groundwater will be lost to wetting of surfaces, ventilation and retained moisture within the coal. The groundwater take presented in Figure 18 does not account for the above mentioned losses that will occur when converting groundwater take to mine dewatering rates.

6.2.3 Post-Closure Groundwater Recovery

The recovery of groundwater levels after the cessation of mining was also predicted by the model. Appendix III outlines the development of the post mining groundwater modelling.

The modelling results indicate that mined areas will gradually fill, reducing the hydraulic gradient and magnitude of depressurisation immediately surrounding the project. The predicted time for the depressurisation effects attributable to the project to recover is approximately 50 years.

6.3 Project Impacts

This section describes the operational and post closure impacts of the project on:

- Groundwater resources;
- Groundwater users; and
- Surface water features.

Prediction and assessment of cumulative impacts is included in Section 6.5.

The groundwater assessment also investigated potential impacts on groundwater quality due to the use of hydrocarbons and chemicals. These potential impacts are discussed in Section 6.4.

6.3.1 Impacts on Groundwater Resources

As discussed in Section 2, groundwater resources within the project mining area and its surrounds are located within the Isaac Connors GMA. The Isaac Connors GMA is managed under the Water Plan (Fitzroy Basin) and comprises two groundwater units. Groundwater Unit 1 includes alluvial aquifers and Groundwater Unit 2 comprises all other sub-artesian aquifers.

As discussed in Sections 3.4 and 4.2.2, there is no alluvium in the vicinity of the project mining area and the closest alluvium is in the Isaac River, approximately 5.5 km to the south-west. There is no drawdown within alluvium as a result of the project. There will be no groundwater take from alluvium (i.e. Groundwater Unit 1) and therefore, the project will not impact on this groundwater resource.

Groundwater depressurisation is limited to the Permian sediments (and to a lesser extent the Rewan Formation aquitard and Tertiary basalt) which form part of Groundwater Unit 2. Figure 18 shows the predicted groundwater take associated with the project, and hence, Groundwater Unit 2. The project is predicted to result in a total groundwater take of up to approximately 6,330 ML from Groundwater Unit 2 over the life of the project.

Post mining, the underground workings will be allowed to flood, and the groundwater level will recover. As there is no final void there will be no evaporative losses from the system and hence no water take post-mining.

6.3.2 Impacts on Groundwater Users

A bore census was carried out to identify water supply bores surrounding the project mining area that could potentially be impacted by the project. The bore census drew upon information gathered through consultation with surrounding landholders as part of the Isaac Plains East

Project groundwater assessment, advice from the proponent, a search of the DNRME groundwater database and a recent detailed bore assessment.

The bore census was targeted towards bores and properties that could potentially be impacted by the project due to their proximity to proposed mining activities. The local hydrogeology was also taken into account in planning the bore census. The bore census included a conservative search radius of 5 km beyond the boundary of the project mining area.

The bore census indicated that groundwater use is typically opportunistic and dispersed over a wide area due to the generally low yields and access to alternative supplies (i.e. water supply pipelines). Water quality is variable, but can be suitable for stock watering.

The bore census confirmed the presence of a single active water supply bore (Swamp Bore 1) on the Wotonga property (Figure 9). As discussed in Section 4.2.1, the owner of this property has access to an alternative water supply and therefore this bore is not used as a sole water supply to the property.

This bore is screened in the Rewan Formation. As discussed in Section 6.2.1, the project is not predicted to result in any depressurisation of the Rewan Formation in the vicinity of Swamp Bore 1. As a result, this bore is unlikely to be affected by the project.

The proponent has entered into a make good agreement with the landholder of this property as part of the approval of the existing mining tenure. The potential impacts to the water supply bore is managed under this agreement.

The Broadlea water supply borefield is located to the north-east of the project mining area and targets the Tertiary basalt aquifer. As shown in Figure 17, the project is not predicted to result in any depressurisation of the Tertiary basalt in the vicinity of these bores and therefore the Broadlea water supply borefield is unlikely to be affected by the project.

6.3.3 Impacts on Surface Drainage

Figure 4 shows the drainage setting of the project.

The project mining area is traversed by Smoky Creek and its northern tributary. These creeks are ephemeral and are characterised by short duration, surface water flows that are typically restricted to periods during and immediately after rainfall events. This is consistent with observations made during the field investigation described in Section 4.2.2. This is also supported by surface water flow data collected from DNRME's surface water gauging stations sited downstream of the project mining area and groundwater modelling predictions, which both indicate no perennial flows in the vicinity of the project mining area.

The groundwater table is currently located approximately 10 m below the bed of Smoky Creek and its northern tributary within the north-east of the project mining area (Figure 12). The depth of groundwater increases to approximately 50 m below the bed of Smoky Creek in the west of the project mining area, adjacent to the existing Isaac Plains Complex open cut pits. The existing open cut pits have therefore reduced the elevation of the groundwater table by approximately 30 m in this area. The groundwater table depth is currently slightly shallower (approximately 5 m depth) to the east of the project mining area. However, the approved open cut mining operations at Pits 1 to 5 are predicted to decrease the water table depth in these areas by up to approximately 8 m.

The separating depth between the bed of these creeks and the groundwater table means that there is no direct interconnection between the groundwater table and surface water flows in this area. Groundwater does not provide baseflow to surface waters in the vicinity of the project mining area.

Drawdown on the groundwater table will therefore not impact the overlying surface drainage features.

6.3.4 Impacts on Groundwater Dependent Ecosystems

There are no significant aquifers or surface alluvium in the vicinity of the project mining area. The coal seams are the only water bearing strata in the vicinity of the project mining area. The coal seams have been extensively dewatered in the project mining area and its surrounds by the adjacent existing Isaac Plains open cut mining activities. These will be further dewatered by the approved Isaac Plains East open cut mining operations, increasing the depth of groundwater in the vicinity of the project.

In addition, groundwater within the project mining area and its surrounds is saline. The EAR *Terrestrial Ecology Report* concludes that saline groundwater does not represent a suitable water supply for vegetation that occurs within the project mining area or its surrounds. Consequently, groundwater dependent ecosystems are not considered to be present in the project mining area or its surrounds.

6.4 Impacts on Groundwater Quality

The project is an extension of the existing Isaac Plains Complex mining area that will be operated as part of the approved Isaac Plains Complex.

The project will utilise existing infrastructure at the Isaac Plains Complex for processing coal and the storage of rejects associated with coal processing. Therefore, there is no potential for contamination from new surface infrastructure areas.

The storage of hydrocarbon and chemicals will continue to be managed in accordance with the existing Isaac Plains Complex management practices, including the use of bunding and immediate clean-up of spills which are standard practice and a legislated requirement at mine sites that will prevent the contamination of the groundwater regime.

Given the limited activities proposed, and the controls that will be adopted, the project has a very limited potential to give rise to groundwater contamination as a result of hydrocarbon and chemical contamination.

6.5 Cumulative Impacts

The existing and approved future mines and CSG operations in the vicinity of the project mining area are shown on Figure 1 and include:

- The existing and approved future open cut mining areas at the Isaac Plains Complex adjoining and overlying the project mining area;
- The Grosvenor Mine adjoining the Isaac Plains Complex;

- The Moranbah North Mine located north-west of the project mining area;
- The Burton, Broadlea and Ironbark No. 1 Mines located north of the project mining area;
- Carborough Downs Mine located east of the project mining area;
- Millennium and Poitrel Mines located south-east of the project mining area; and
- The Moranbah South Project and Caval Ridge Mine located south-west of the project mining area; and
- The Moranbah Gas Project.

The potential impacts of these operations on the groundwater environment in the region has been considered in relation to potential cumulative impacts they may have with the project.

The numerical groundwater model considered all approved future mining activities at the Isaac Plains Complex, Grosvenor Mine, Moranbah North Mine, Moranbah South Project, Burton Mine, Broadlea Mine, Carborough Mine, Poitrel Mine and Millenium Mine, as well as Arrow Energy's CSG production activities. These are the nearest significant operations or projects to the project mining area and include all operations which could potentially have cumulative drawdown impacts with the project.

Ironbark No.1 Mine and Caval Ridge Mine are located at significant distances from the project mining area and well beyond limit of predicted depressurisation from the project. These distant and hydraulically disconnected operations are unlikely to add any significant depressurisation to the extensively depressurised groundwater regime at the project mining area. Ironbark No.1 Mine and Caval Ridge Mine are therefore unlikely to give rise to cumulative impacts with the project.

The numerical groundwater model was used to assess the cumulative groundwater impacts associated with the project during mining and post closure. The maximum predicted extents of depressurisation for the project and the relevant operations were compared in order to determine whether any areas could potentially be cumulatively impacted. The extent of cumulative impacts will be less than this extent at all other times during and post-mining and this approach therefore provides a conservative assessment of the potential worst-case cumulative groundwater impacts.

The project will not result in drawdown in the Isaac River alluvium or Tertiary sediments and therefore will not contribute to cumulative impacts in these formations.

Figure 19 to Figure 21 show the maximum predicted extent of the cumulative groundwater depressurisation (i.e. the area where depressurisation due the project could overlap with depressurisation from other relevant operations) within the Leichardt seam, Tertiary basalt and weathered Permo-Triassic sediments. Figure 19 to Figure 21 also show the percentage of cumulative depressurisation that is attributable to the project.

The extent of cumulative depressurisation is consistent with the extent of the depressurisation of the project in isolation and therefore is effectively limited to the project mining area and its immediate surrounds to the north and east.

In the Leichardt seam, the project contributes up to 100% of the total cumulative depressurisation within the extent of the project mining area and its surrounds to the north, west and south (Figure 19). In these areas, the project mining area is located at greater depth than the surrounding open cut mining operations at the Isaac Plains Complex. To the east of the project mining area, the project is responsible for less than 75% of the total depressurisation in the Leichardt seam. This is due to the depressurisation contribution from the Isaac Plains Complex open cut pits (Pits 1 to 5) and the reduced effects of the project east of the fault.

In the upper weathered profile of the Permo-Triassic sediments, the project contributes to approximately 60% of the total cumulative depressurisation within the extent of the project mining area and its surrounds to the east (Figure 20). As the distance from the approved Isaac Plains Complex open cut mining areas increases to the north, the project contribution generally increases to approximately 80%.

In the Tertiary basalt, the project contributes to approximately 25 to 75% of the total cumulative depressurisation to the east of the project mining area (Figure 21).

The zone of predicted cumulative depressurisation associated with the project does not include any groundwater users.

The cumulative depressurisation within the weathered Permo-Triassic sediments is predicted to extend below Smoky Creek and its northern tributary. However, as discussed in Section 6.3.3, there is no interconnection between the groundwater table and these creeks in this area and therefore, the project is not predicted to contribute to cumulative impacts on these creeks.

7 GROUNDWATER MONITORING AND MANAGEMENT

The Isaac Plains Complex operates an extensive groundwater monitoring network in accordance with the Isaac Plains Complex EA. The EA groundwater monitoring network comprises 11 monitoring bores located on the Isaac Plains Complex ML and its immediate surrounds (Figure 22).

The purpose of the EA groundwater monitoring network is to monitor groundwater levels and quality in the Permian sediments, Rewan Formation, Tertiary basalt, and Tertiary sediments in response to mining.

The existing EA groundwater monitoring network includes 3 bores (MB1, MB5 and MB11) within the project mining area targeting key formations. The existing EA groundwater monitoring network is therefore suitable for monitoring the effects of the project on the groundwater regime and will continue to be utilised throughout the life of the project.

In accordance with the requirements of the Isaac Plains Complex EA, the following monitoring will be undertaken at the EA groundwater monitoring bores:

- Groundwater levels will be recorded on a quarterly basis, which will enable natural groundwater level fluctuations (such as seasonal responses to rainfall) to be distinguished from potential water level impacts due to depressurisation resulting from mining activities.
- Groundwater quality monitoring will be undertaken on a quarterly basis to enhance the existing baseline dataset available prior to commencement of the project. This will be used to detect any changes in groundwater quality during- and post-mining. Water quality samples will be analysed for physico-chemical parameters including pH, electrical conductivity, total dissolved solids, total suspended solids, alkalinity, hardness, major ions (Ca, Mg, Na, K, Cl and SO_4), metals and metalloids (Al, Ag, As, Fe, Hg, Mo, Sb and Se) and total petroleum hydrocarbons.

The groundwater monitoring data will be reviewed annually, and the groundwater monitoring program revised, as necessary.

8 CONCLUSIONS

The key conclusions of the groundwater assessment are as follows:

- Approved mining operations in the region have resulted in extensive regional depressurisation within the Permo-Triassic sediments, Tertiary basalt and Tertiary sediments and the project has negligible potential for additional significant impact on the groundwater regime.
- The project will not impact surface waters or alluvial aquifers because:
  - There is no alluvium present in the vicinity of the project mining area.
  - The significant depth of cover over the project mining area (up to 290 m) and the low permeability interburden of the Permo-Triassic sediments will reduce significant depressurisation of the shallow formations.
  - There is no groundwater contribution to surface water flows in creeks within the project mining area and its surrounds.
- There are no groundwater users or other sensitive receptors predicted to be affected by groundwater depressurisation and therefore no significant impacts on groundwater users are predicted.
- The zone of predicted cumulative depressurisation does not include any groundwater users or other features impacted by the project.
- There is a very low potential for groundwater contamination as a result of the project.

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10 ABBREVIATIONS

BoM: Bureau of Meteorology

DES: Department of Environment and Science

DNRME: Department of Natural Resources, Mines and Energy

EA: Environmental Authority

EAR: Environmental Assessment Report

EC: Electrical Conductivity

EIS: Environmental Impact Statement

EPP Water: Environmental Protection (Water) Policy 2009

GMA: Groundwater Management Area

Kh: lateral hydraulic conductivity

Kv: vertical hydraulic conductivity

mAHD: Metres (above) Australian Height Datum

mbGL: Metres below ground level

Mtpa: Million tonnes per annum

ROM: Run of Mine

RMS: Root Mean Squared

TDS: Total Dissolved solids

The Project: The Isaac Plains Underground Project

VWP: Vibrating Wire Piezometer

Water Act: *Water Act 2000*

11 GLOSSARY

Alluvium: Unconsolidated sediments (gravel/sand/silt/clay) transported by water (i.e. deposits within a stream channel or floodplain).

Aquifer: Permeable earth material such as porous sediments or fractured hard rock, saturated with groundwater. The permeability should be such that it is capable of conducting and yielding usable quantities of groundwater to a borehole(s) and / or springs. An aquifer is 'a geological formation which has structures or textures that hold water or permit appreciable water movement through them'.

Aquitard: A confining bed that retards, but does not completely stop the flow of water to or from an adjacent aquifer. Although it does not readily release water to boreholes or springs, it may function as a storage chamber for groundwater.

Calibration: The process by which independent variables (e.g. hydraulic conductivity) within a model are varied in order to match a dependent variable (e.g. measured groundwater level within a monitoring bore).

Confined aquifer: An aquifer which is overlain by a confining layer of low permeability. The groundwater is confined under pressure greater than atmospheric pressure such that if the aquifer is penetrated the water level may rise above the top of the aquifer.

Confining layer/unit: Geologic material with little permeability or hydraulic conductivity.

Contamination: The introduction into the environment of any substance by the action of man.

Dewatering: The process of removing water from an underground mine or open pit, or from the surrounding rock or non-lithified materials.

Drawdown: Lowering of the water table within an unconfined aquifer, or the potentiometric surface within a confined aquifer caused by an induced stress on the groundwater system (e.g. pumping).

Geology: The study of the earth, its history and the changes that have occurred or are occurring and the rocks and non-lithified materials of which it is composed and their mode of formation and transformation.

Groundwater: The water in the aquifer; saturated zone below the water table.

Hydraulic conductivity: Describes the ease with which water can move through pore spaces or fractures. It depends on the intrinsic permeability of the material and on the degree of saturation. Saturated hydraulic conductivity, Ksat, describes water movement through saturated media.

Hydraulic gradient: The change in hydraulic head or water level over a distance.

Hydraulic head: The height above a datum (such as sea level) of the column of water that can be supported by the hydraulic pressure at a given point in a groundwater system.

Lithology: The systematic description of sediment and rocks, in terms of composition, texture and internal structure.

Model: A formalised expression of a theory, event, object, process or system used for prediction or control; an experimental design based on a casual situation that generates observed data. A model can be viewed as a selective approximation which by the elimination of incidental detail, allows some fundamental, relevant or interesting aspect of the real world to appear in a generalised form.

pH: The negative logarithm to the base 10 of the hydrogen ion activity [H^+] in solution.

Recharge: The addition of water to the saturated zone, either by the downward percolation of precipitation or surface water and/or the lateral migration of groundwater from adjacent aquifers.

Saturated zone: That part of the geological stratum in which all the voids are filled with water under pressure greater than that of the atmosphere.

Specific Storage: Volume of water released form storage from a unit volume of aquifer, per unit decline in hydraulic head.

Specific Yield: The ratio of the volume of water a rock or spoil will yield by gravity drainage to the volume of the rock or soil. The upper bound of a specific yield value for a given material is equal to its porosity.

Storativity: The storage coefficient or storativity is a measure of the volume of water per volume of aquifer released as a result of a change in head. For confined aquifers, the storage coefficient is equal to the product of the specific storage and aquifer thickness.

Transmissivity: Transmissivity is the rate at which water is transmitted through a unit thickness of aquifer under a unit hydraulic gradient (Driscoll, 1986). It is the product of the hydraulic conductivity and the contributing thickness of the aquifer to flow.

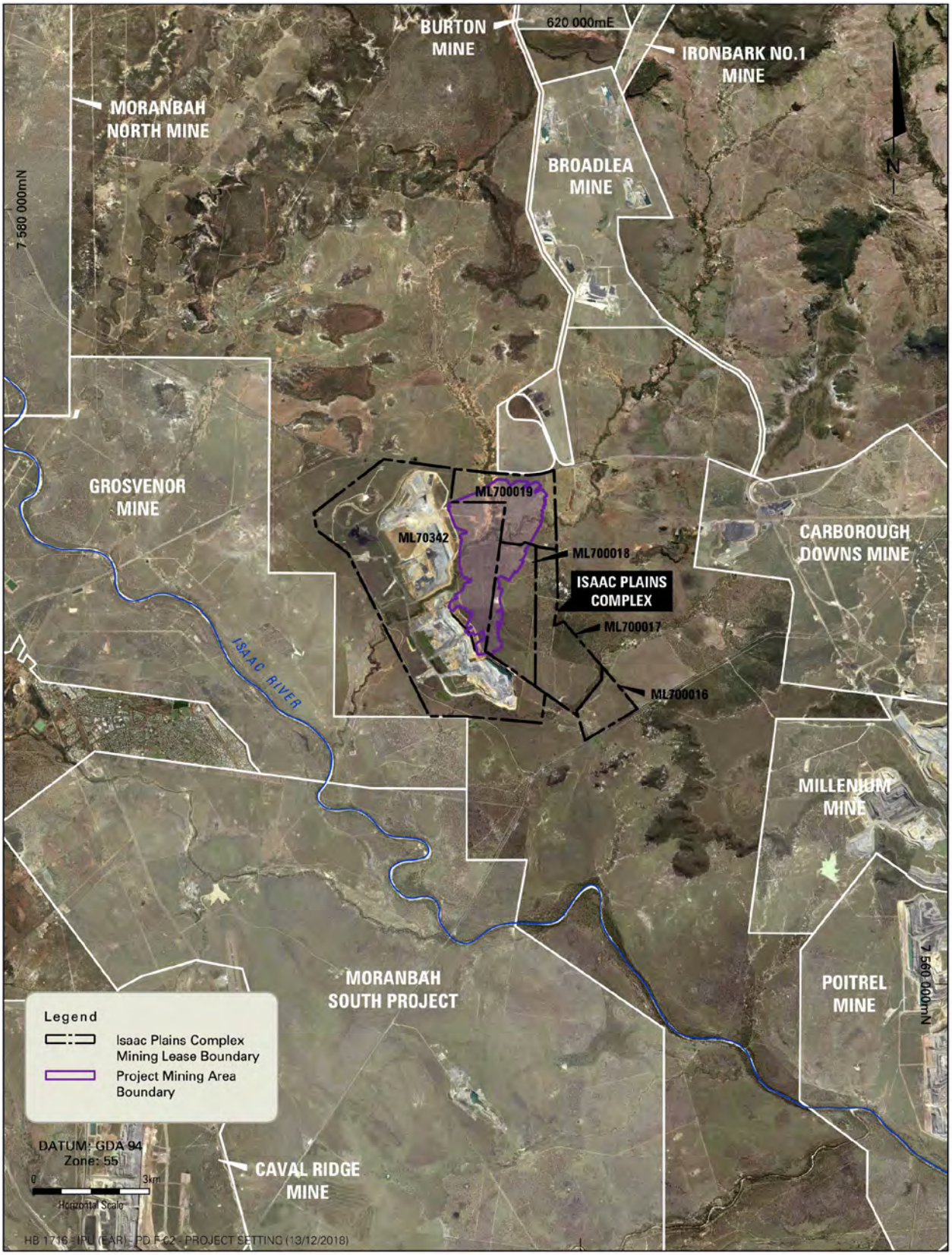
Unconfined aquifer: An aquifer whose upper surface (water table) is free to fluctuate.

Unsaturated zone: That part of the geological stratum above the saturated zone in which the voids contain both air and water.

Water Table: The top of an unconfined aquifer, where the aquifer is fully saturated and the water pressure is equal to atmospheric pressure. Usually measured in metres below ground level or below top of casing.

Weathering: The processes by which *particles, rocks* and *minerals* are altered on exposure to surface temperature and pressure and atmospheric agents such as air, water, and biological activity.

FIGURES



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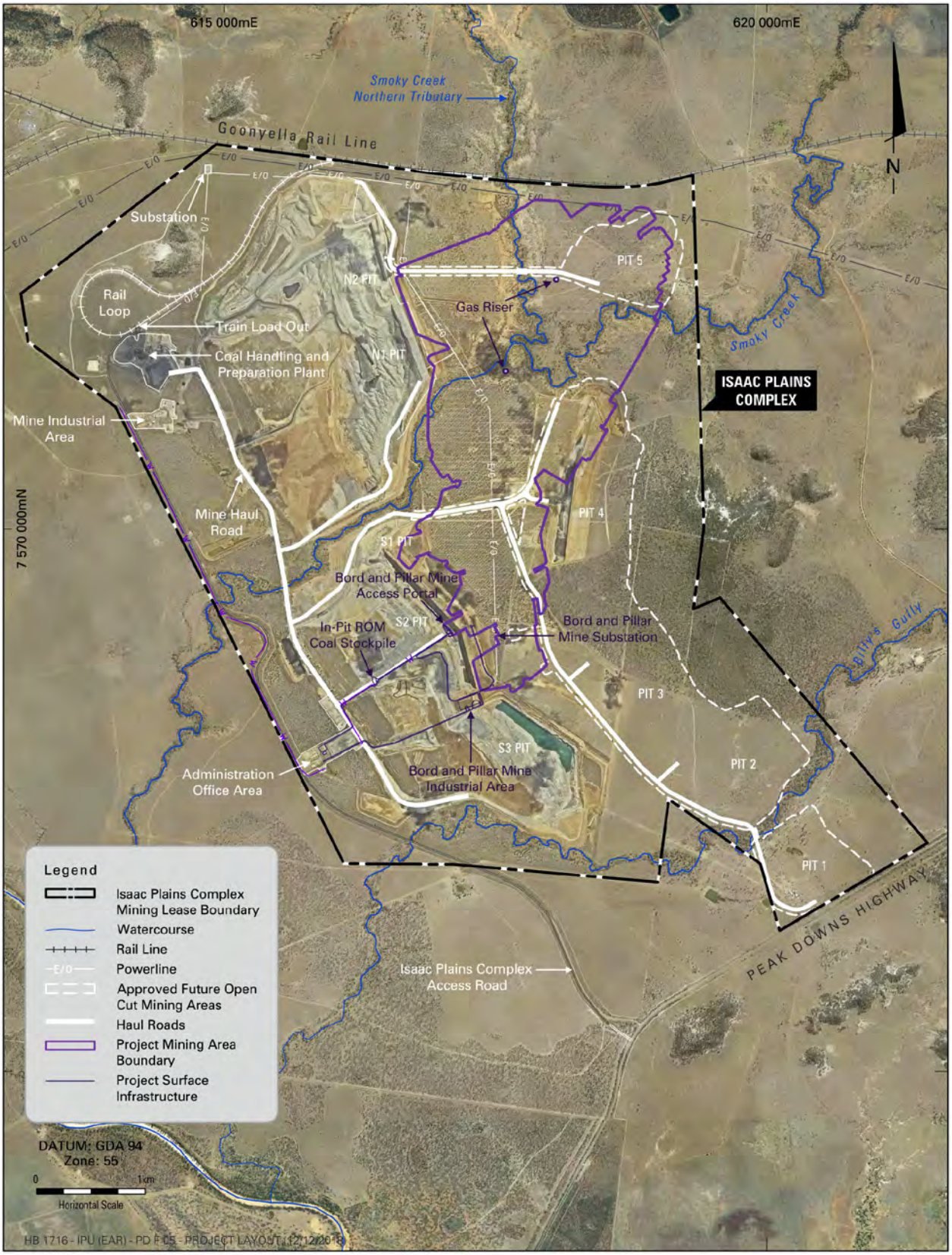
PROJECT	ISAAC PLAINS UNDERGROUND PROJECT GROUNDWATER REPORT
TITLE	PROJECT SETTING
PROJECT No. D10073A03	FIG No. FIGURE 1



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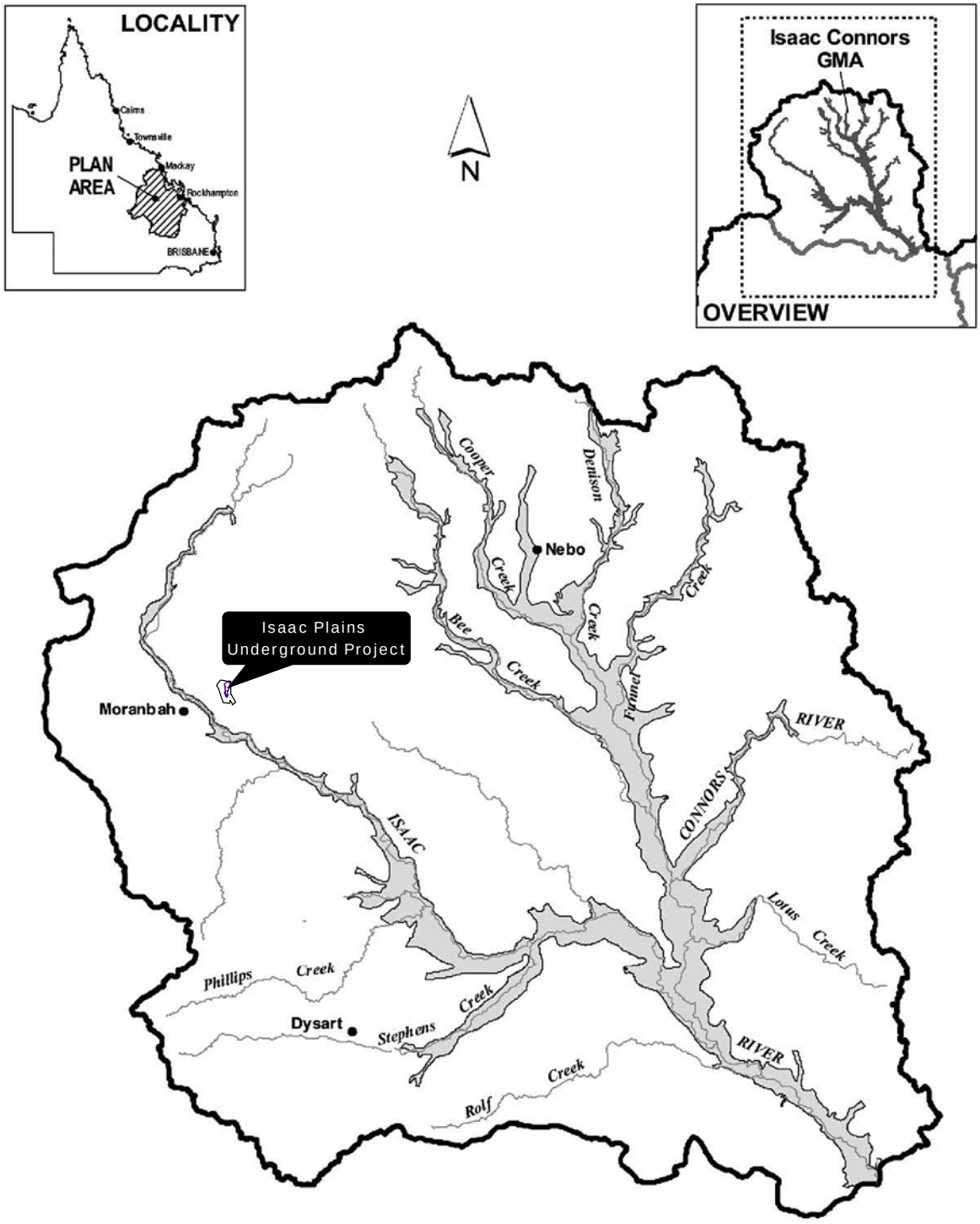
PROJECT	ISAAC PLAINS UNDERGROUND PROJECT GROUNDWATER REPORT
TITLE	PROJECT LAYOUT
PROJECT No. D10073A03	FIG No. FIGURE 2



LEGEND

- Issac Connors groundwater management area (GMA)
- Issac Connors groundwater unit 1

(source: Water Plan (Fitzroy Basin) 2011)

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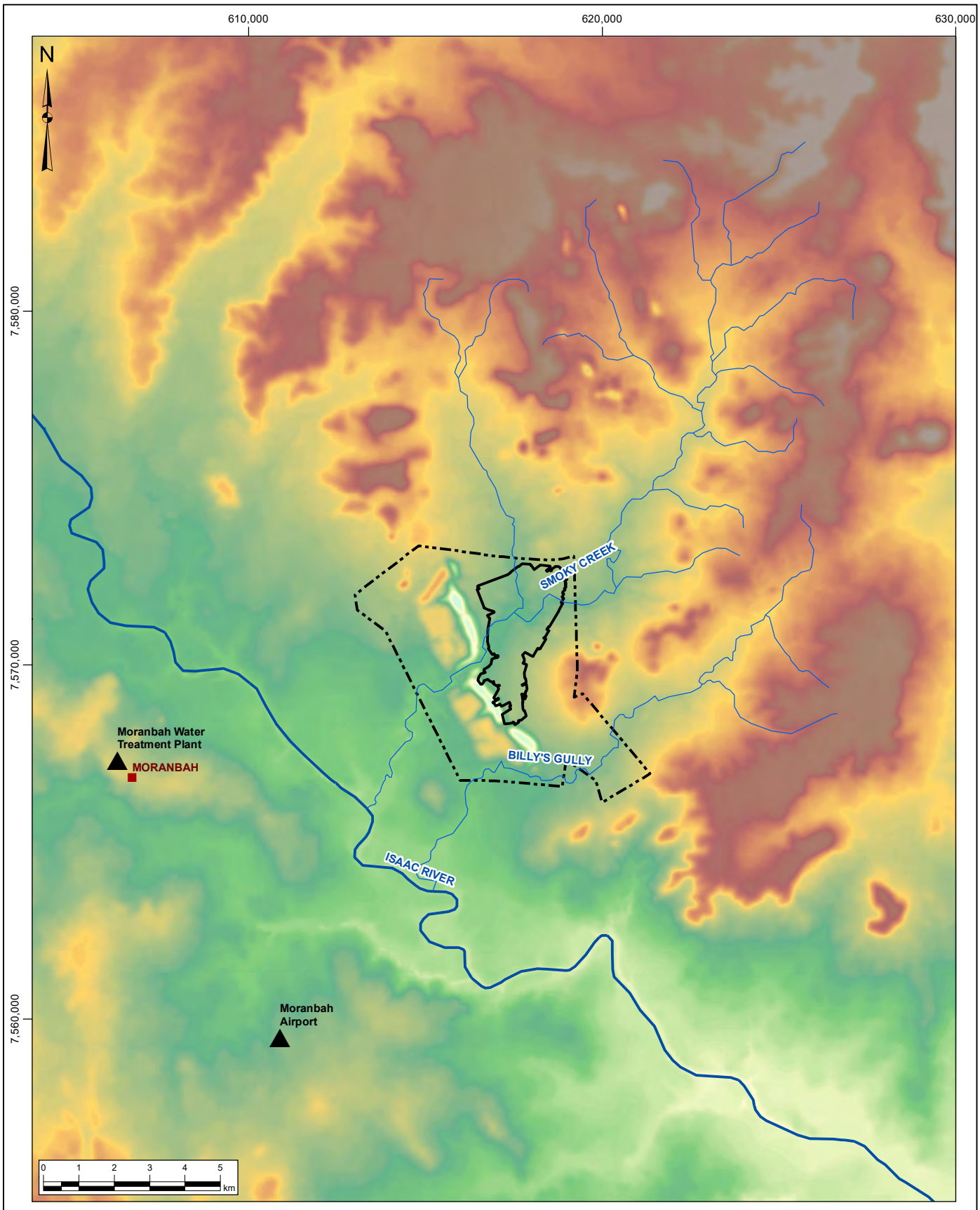
PROJECT
ISAAC PLAINS UNDERGROUND PROJECT
GROUNDWATER REPORT

TITLE
PROJECT GROUNDWATER MANAGEMENT AREA

PROJECT No. D10073A03

FIG No. FIGURE 3



Legend

- Isaac Plains Complex Mining Lease
- Project Mining Area Boundary
- Town
- Weather Station
- Surface Water Drainage
  - River
  - Creek
- Topography Elevation
  - 570 mAHD
  - 150 mAHD

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:150,000

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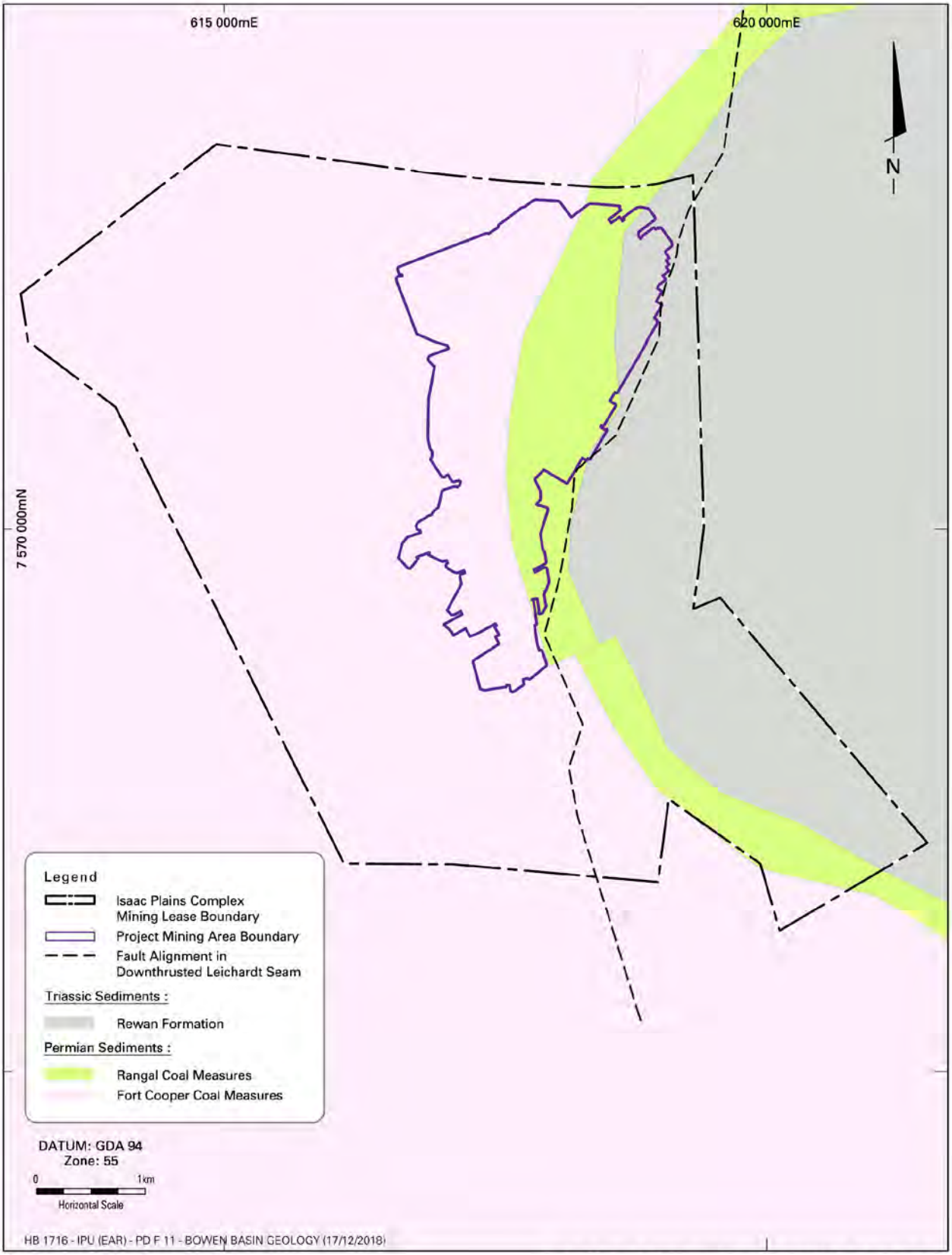
PROJECT
ISAAC PLAINS UNDERGROUND PROJECT
GROUNDWATER REPORT

TITLE
TOPOGRAPHY AND DRAINAGE

PROJECT No. D10073A03

FIG No. FIGURE 4



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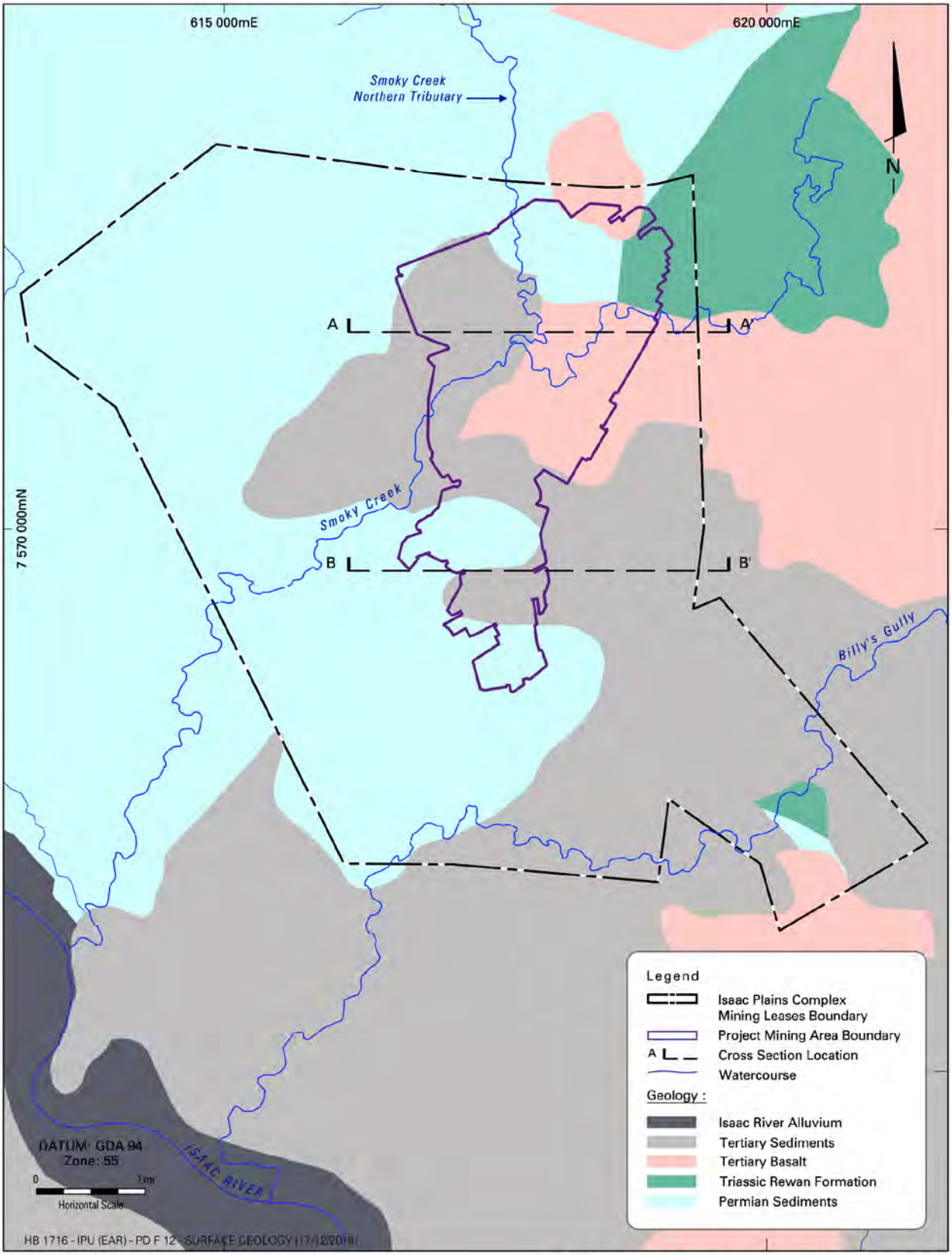
PROJECT	ISAAC PLAINS UNDERGROUND PROJECT GROUNDWATER REPORT
TITLE	BOWEN BASIN GEOLOGY
PROJECT No. D10073A03	FIG No. FIGURE 5



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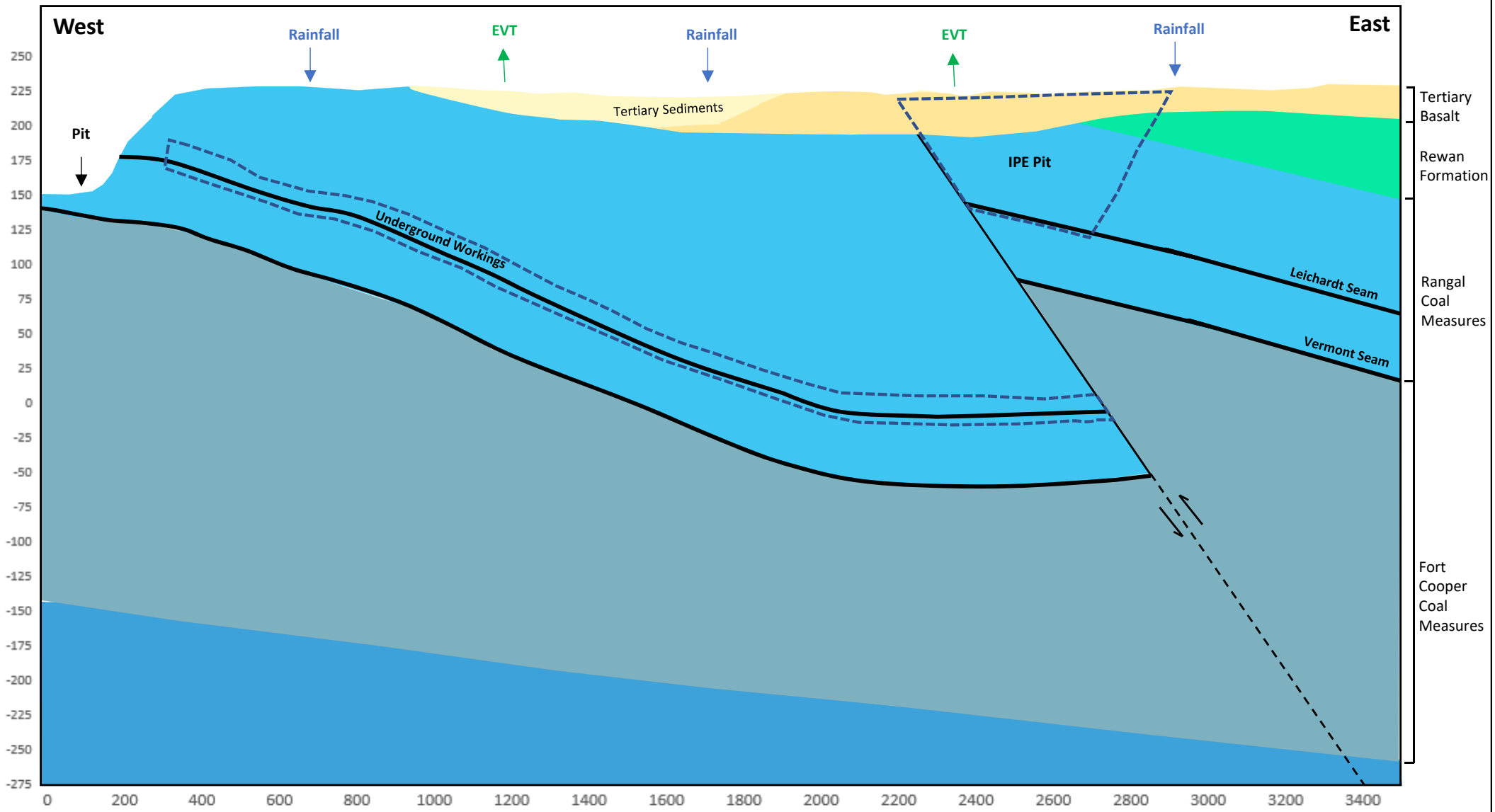
PROJECT	ISAAC PLAINS UNDERGROUND PROJECT GROUNDWATER REPORT
TITLE	SURFACE GEOLOGY
PROJECT No. D10073A03	FIG No. FIGURE 6



Legend

- - - Fault Inferred
— Fault Location
⇄ Fault Slip Sense

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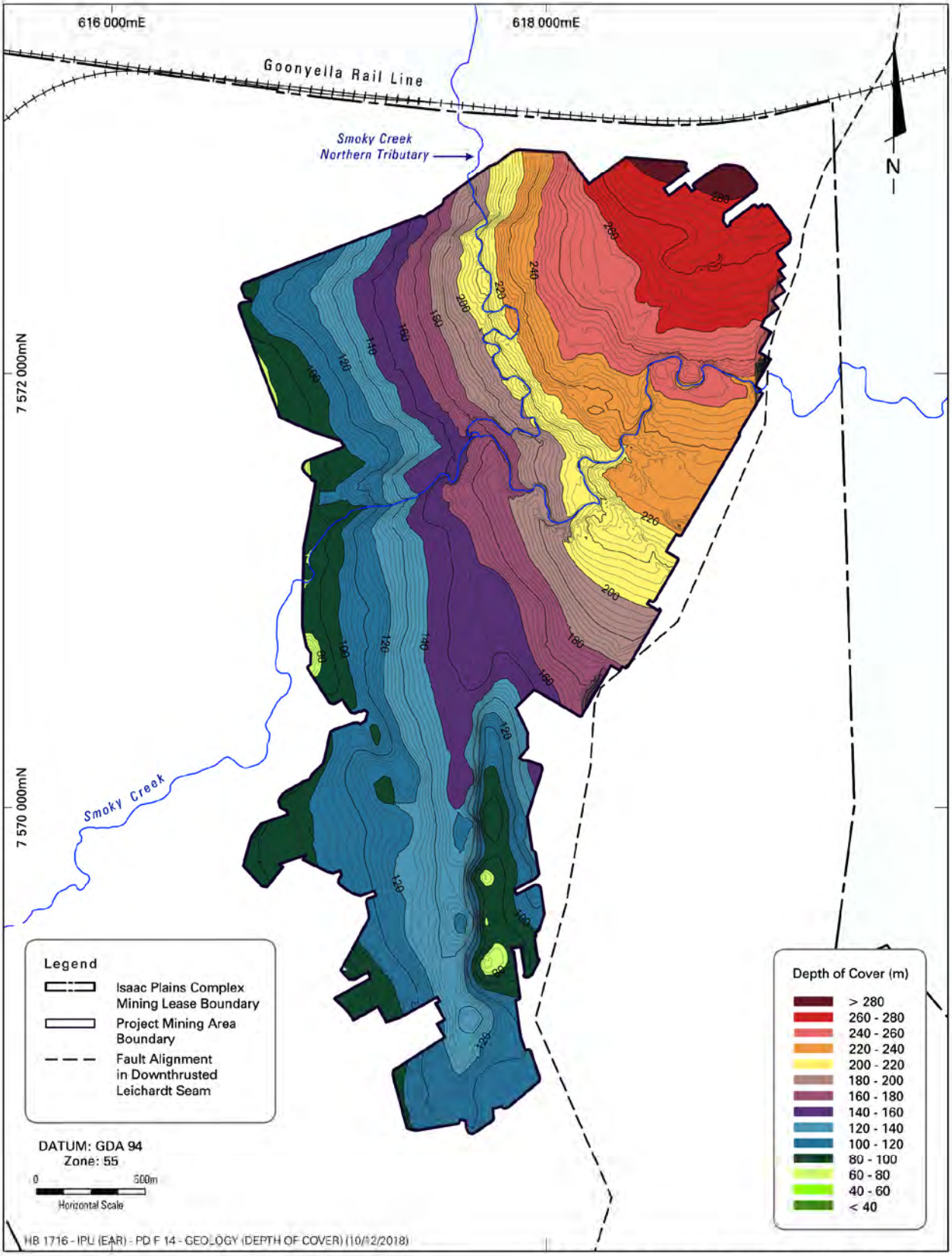
PROJECT
ISAAC PLAINS UNDERGROUND PROJECT
GROUNDWATER REPORT

TITLE
Conceptual Geology Cross-section

PROJECT No.	FIG No.	REV
D10073A03	FIGURE 7	0



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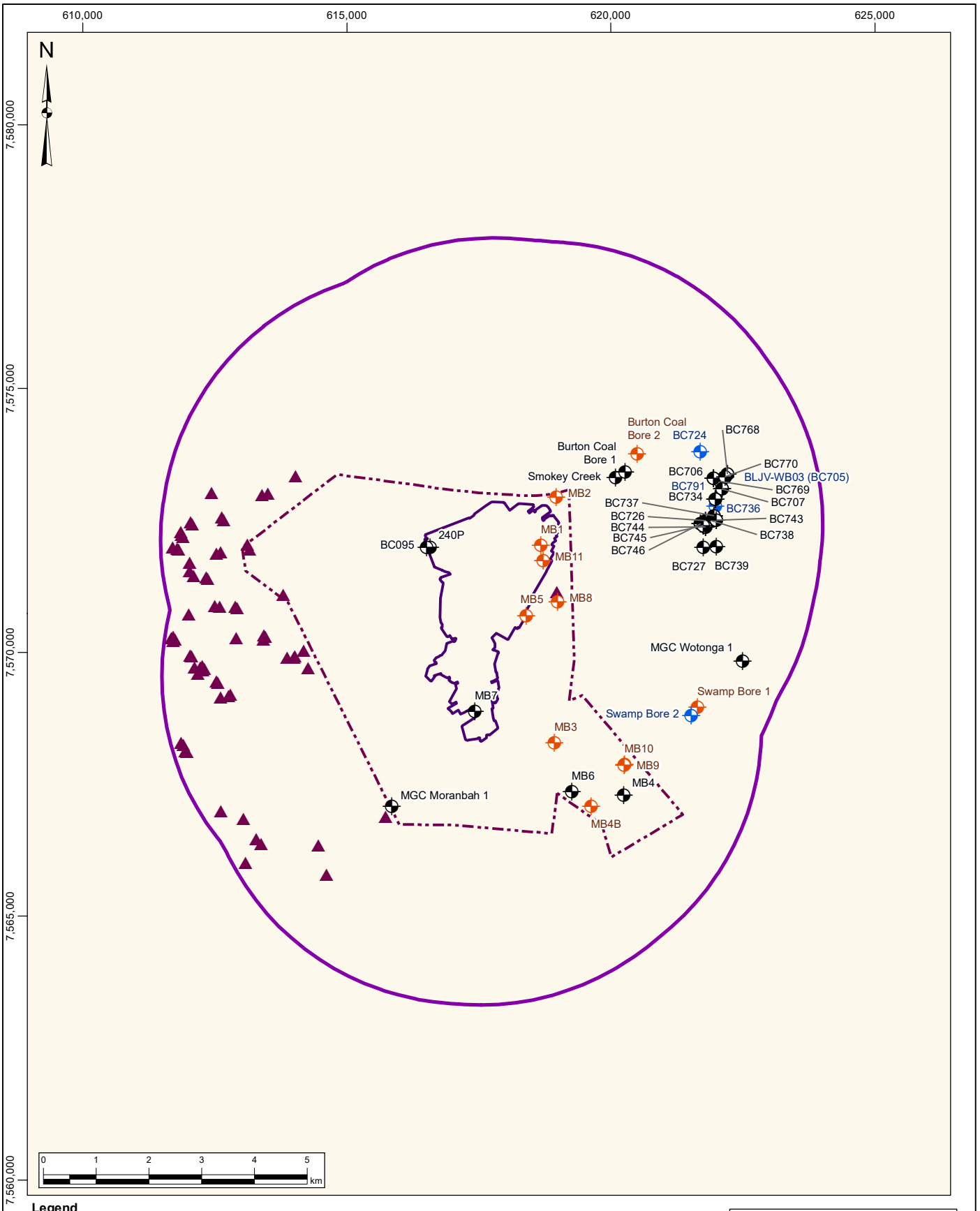
PROJECT
ISAAC PLAINS UNDERGROUND PROJECT
GROUNDWATER REPORT

TITLE
DEPTH OF COVER TO THE LEICHARDT SEAM

PROJECT No. D10073A03

FIG No. FIGURE 8



Legend

- Isaac Plains Complex Mining Lease
- Project Mining Area Boundary
- 5km Buffer
- Registered CSG Production Well
- EA Monitoring Bore
- Monitoring Bore
- Water Supply Bore

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:100,000

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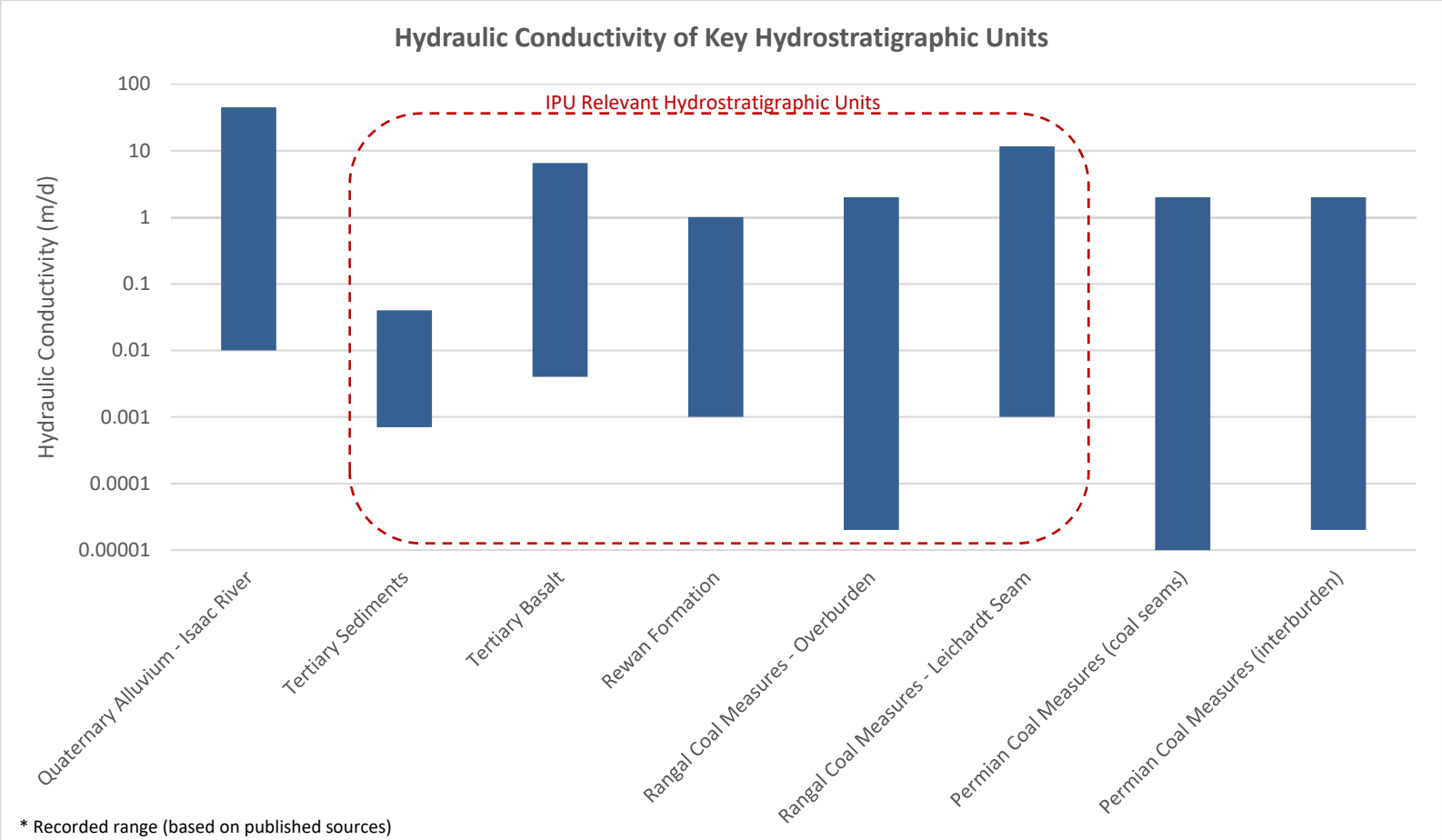
PROJECT
ISAAC PLAINS UNDERGROUND PROJECT
GROUNDWATER REPORT

TITLE
GROUNDWATER BORES

PROJECT No. D10073A03

FIG No. FIGURE 9



* Recorded range (based on published sources)

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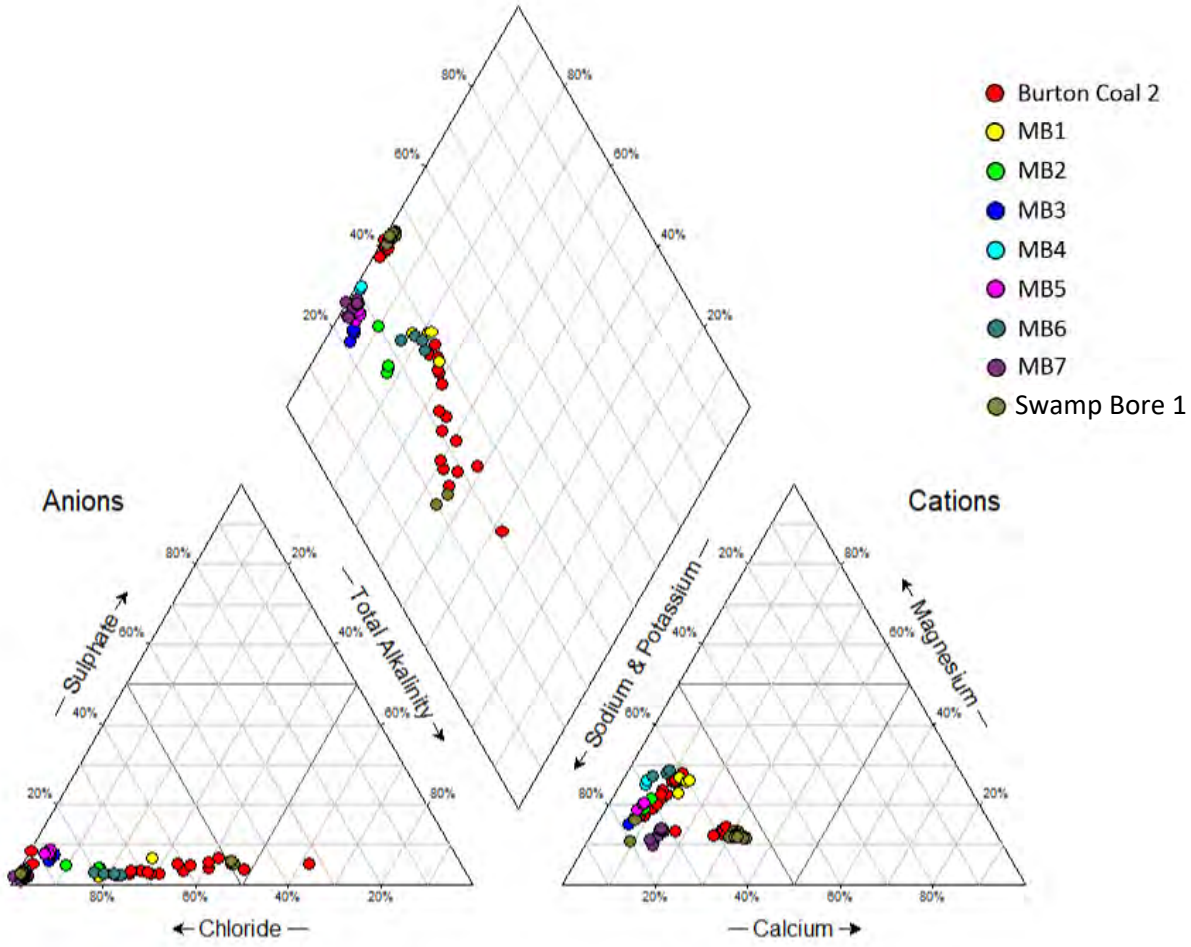
CLIENT:
Hansen Bailey Pty Ltd
Stanmore IP Coal Pty Ltd

Klohn Crippen Berger

PROJECT NAME:
Isaac Plains Underground Project Groundwater Report

TITLE:
Hydraulic Conductivity of Key Hydrostratigraphic Units

PROJECT NO:	FIG NO.:	REV:
D10073A03	FIGURE 10	A



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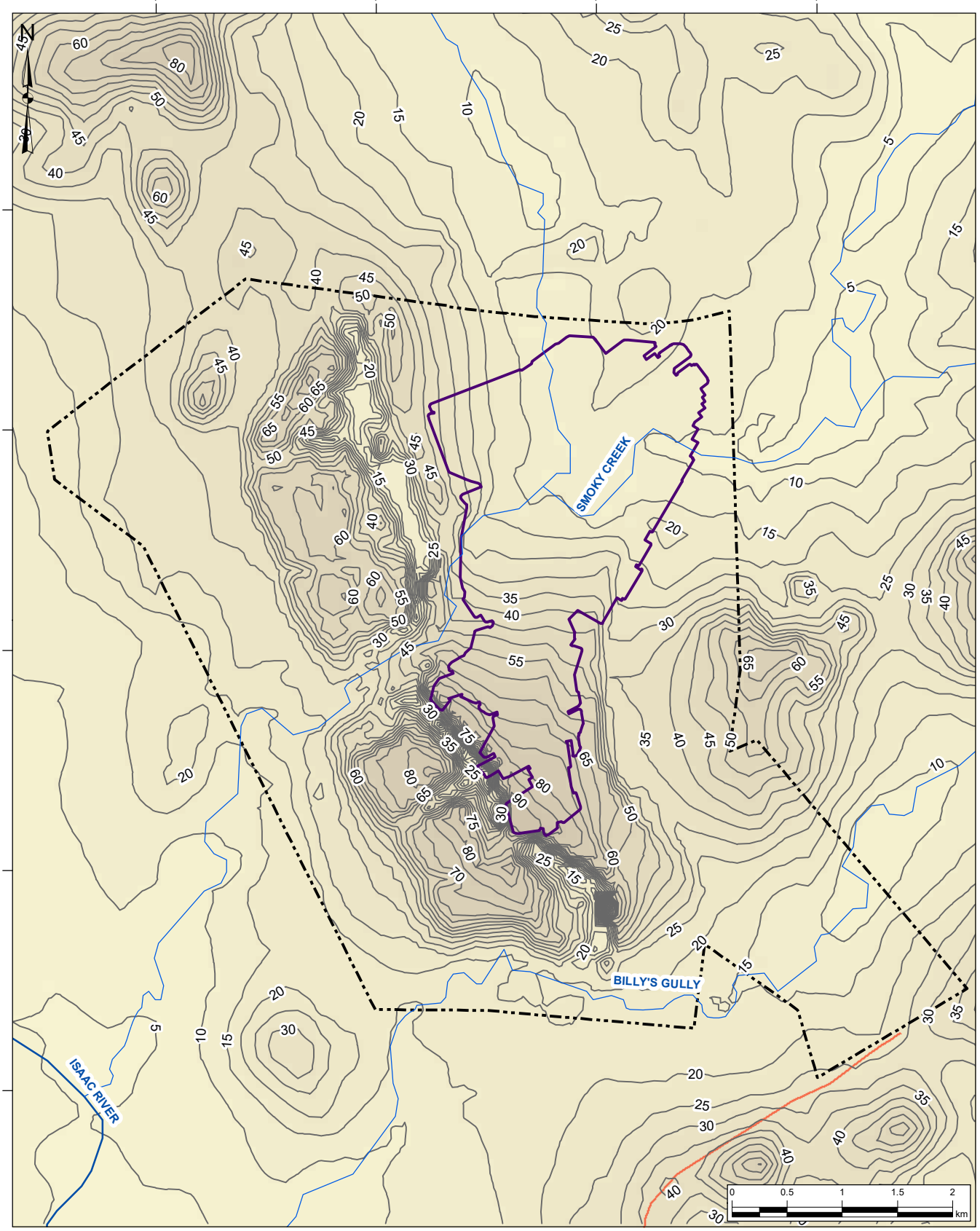
CLIENT:
Hansen Bailey Pty Ltd
Stanmore IP Coal Pty Ltd

Klohn Crippen Berger

PROJECT NAME:
Isaac Plains Underground Project Groundwater Report

TITLE:
Piper Diagram

PROJECT NO:	FIG NO.:	REV:
D10073A03	**FIGURE 11**	**A**



Legend

- Isaac Plains Complex Mining Lease
- Project Mining Area Boundary
- Depth to Groundwater (m)

Surface Water Drainage

- River
- Creek

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:50,000

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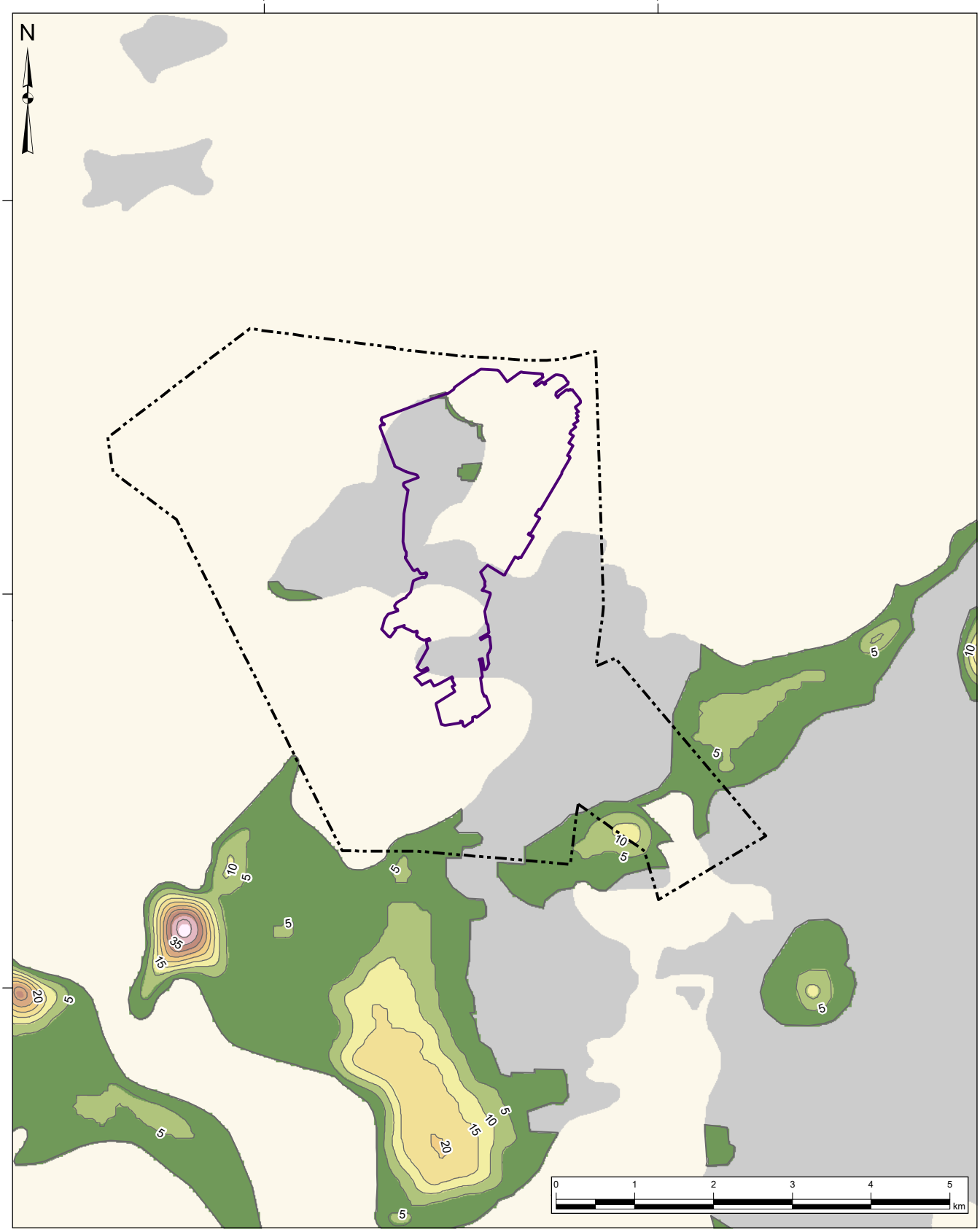
Klohn Crippen Berger

PROJECT
ISAAC PLAINS UNDERGROUND PROJECT
GROUNDWATER REPORT

TITLE
CURRENT DEPTH TO GROUNDWATER

PROJECT No. D10073A03

FIG No. FIGURE 12



Legend

- Isaac Plains Complex Mining Lease
- Project Mining Area Boundary
- Tertiary Sediments Extent
- Saturated Thickness Contour (m)

Tertiary Sediments Saturated Thickness (m)

0 - 5, 5 - 10, 10 - 15, 15 - 20, 20 - 25, 25 - 30, 30 - 35, 35 - 40, 40 - 45, 45 - 50, > 50

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:70,000

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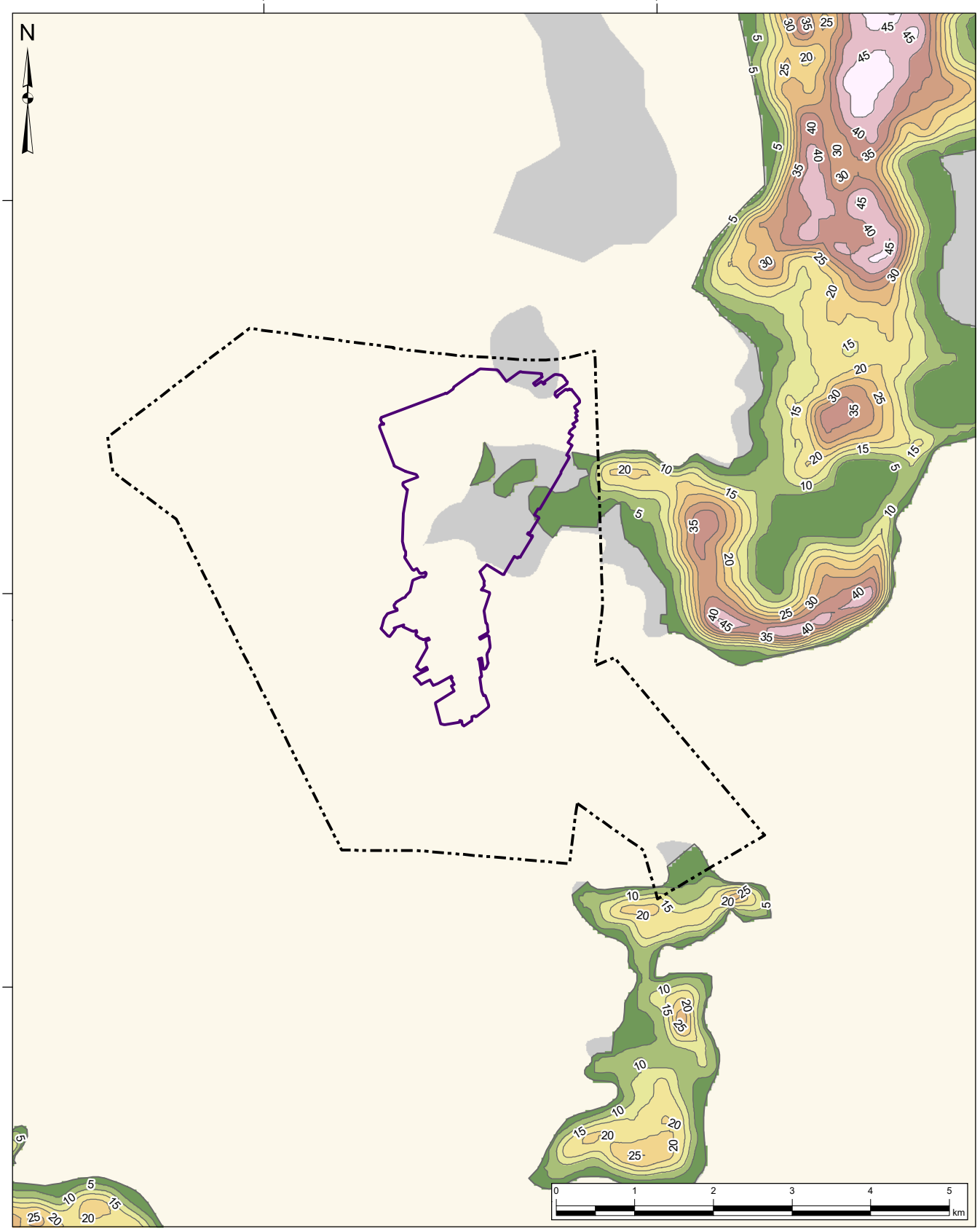
Klohn Crippen Berger

PROJECT
ISAAC PLAINS UNDERGROUND PROJECT
GROUNDWATER REPORT

TITLE
SATURATED TERTIARY SEDIMENTS

PROJECT No. D10073A03

FIG No. FIGURE 13



Legend

- Isaac Plains Complex Mining Lease
- Project Mining Area Boundary
- Tertiary Basalt Extent
- Saturated Thickness Contour (m)

Saturated Tertiary Basalt Saturated Thickness (m)

0 - 5	15 - 20	30 - 35	45 - 50
5 - 10	20 - 25	35 - 40	
10 - 15	25 - 30	40 - 45	

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:70,000

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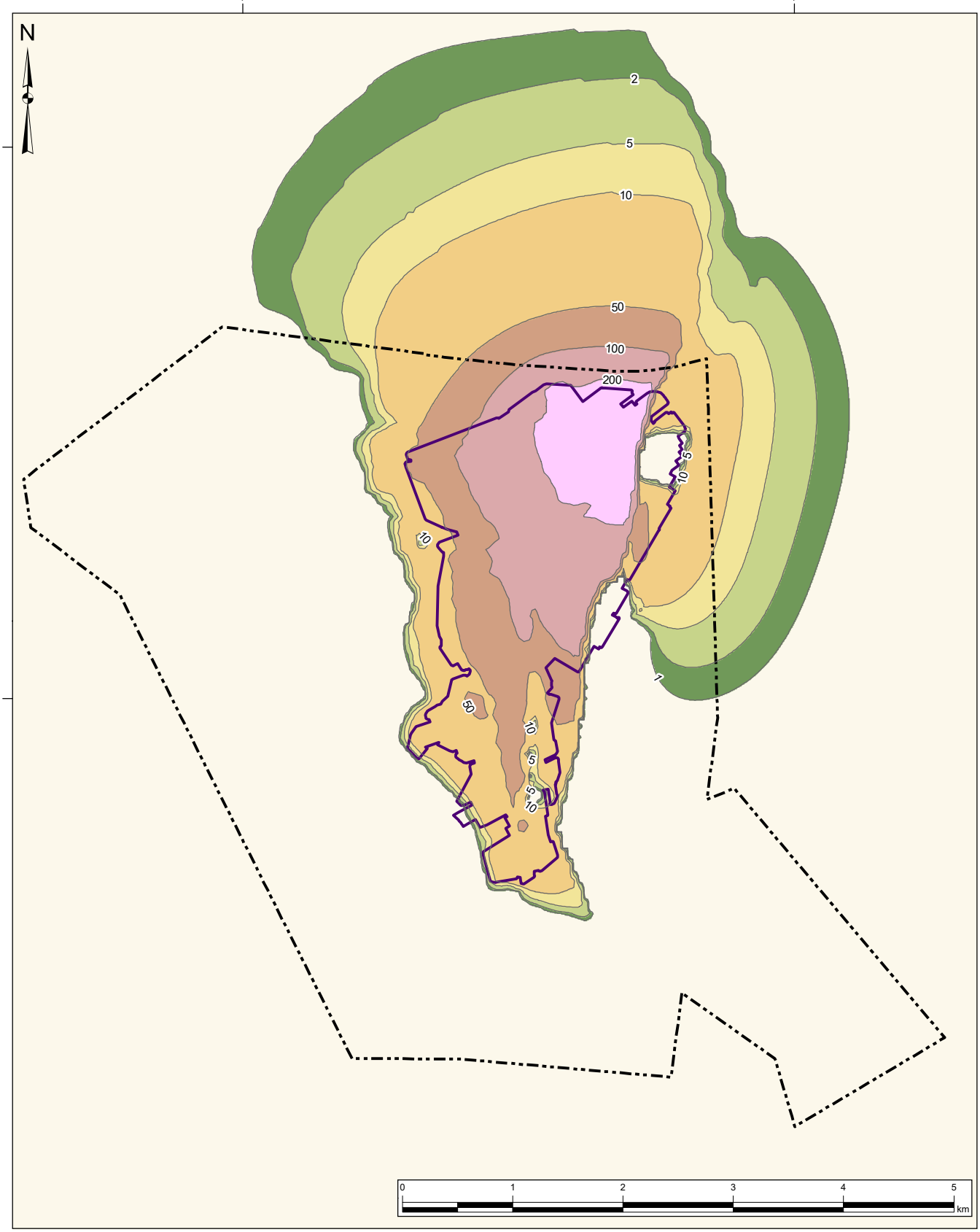
Klohn Crippen Berger

PROJECT
ISAAC PLAINS UNDERGROUND PROJECT
GROUNDWATER REPORT

TITLE
SATURATED TERTIARY BASALT

PROJECT No. D10073A03

FIG No. FIGURE 14



Legend

- Isaac Plains Complex Mining Lease
- Project Mining Area Boundary
- Depressurisation Contour (m)

Leichardt Depressurisation (m)

- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 50
- 50 - 100
- 100 - 200
- 200 - 260

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:50,000

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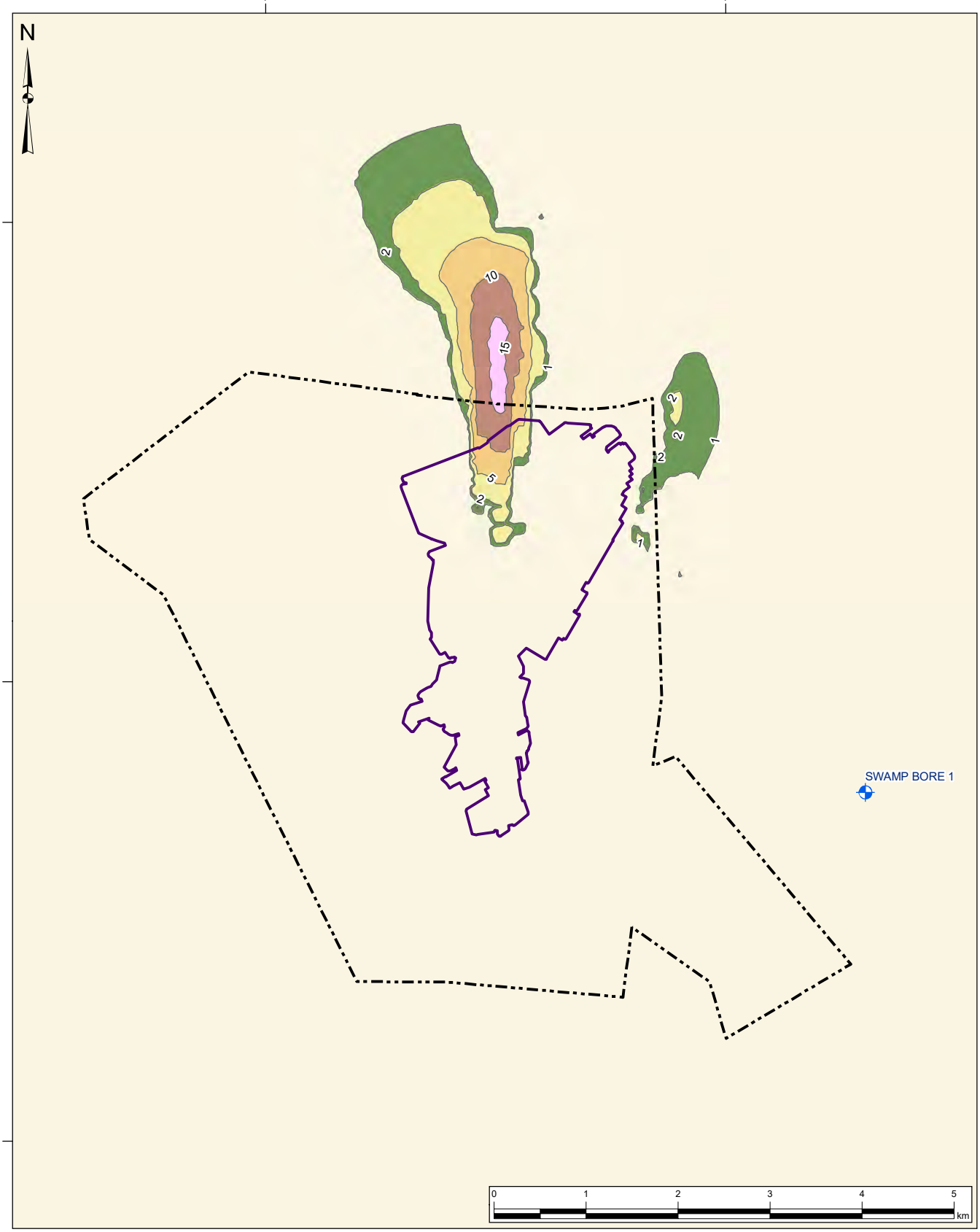
Klohn Crippen Berger

PROJECT
ISAAC PLAINS UNDERGROUND PROJECT
GROUNDWATER REPORT

TITLE
PREDICTED DEPRESSURISATION IN THE LEICHARDT SEAM

PROJECT No. D10073A03

FIG No. FIGURE 15



Legend

- Isaac Plains Complex Mining Lease
- Project Mining Area Boundary
- Depressurisation Contour (m)
- Water Supply Bore

Weathered Sediments Depressurisation (m)

- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 15
- 15 - 17

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:60,000

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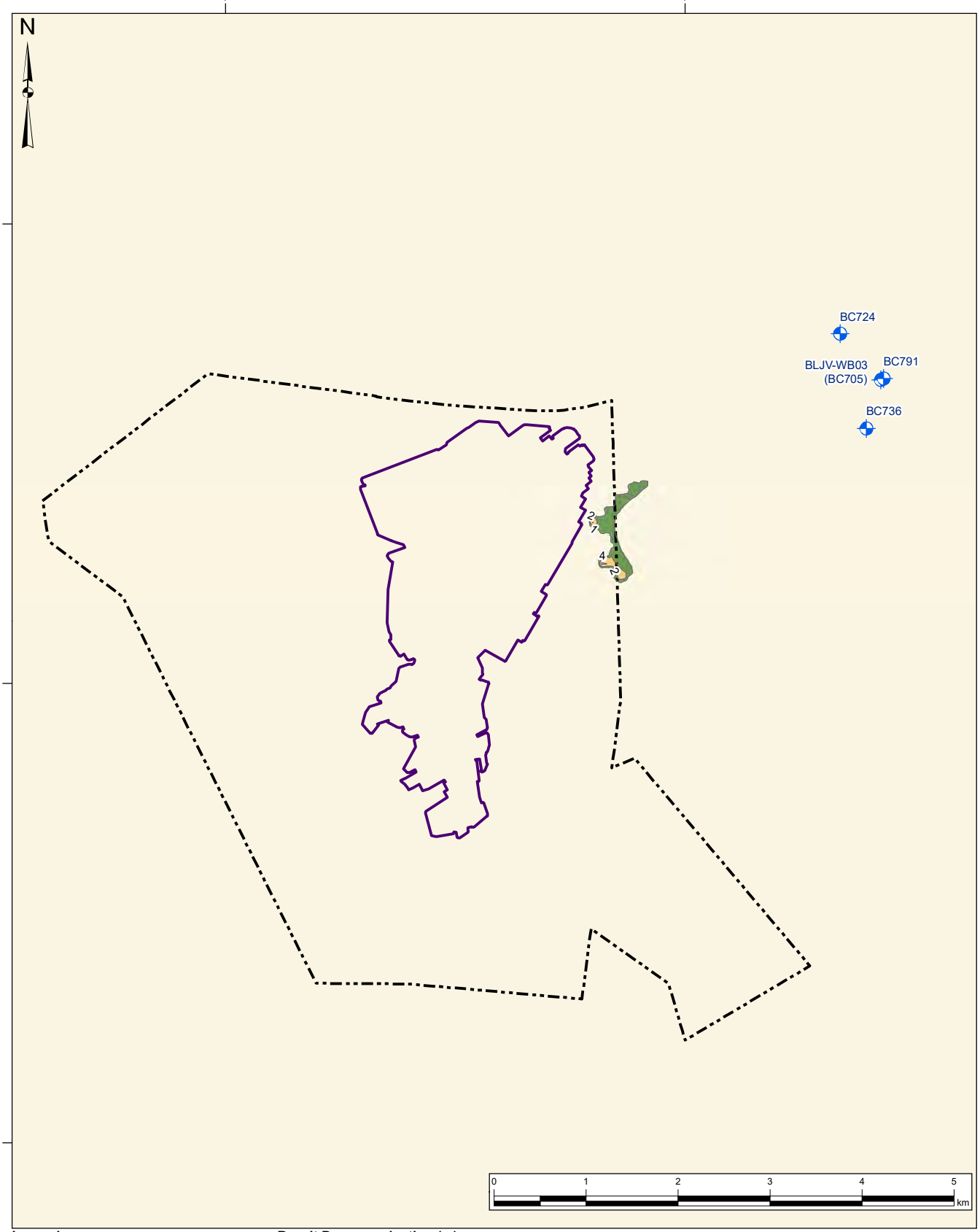
Klohn Crippen Berger

PROJECT
ISAAC PLAINS UNDERGROUND PROJECT
GROUNDWATER REPORT

TITLE
PREDICTED DEPRESSURISATION IN THE WEATHERED SEDIMENTS

PROJECT No. D10073A03

FIG No. FIGURE 16



Legend

- Isaac Plains Complex Mining Lease
- Project Mining Area Boundary
- Depressurisation Contour (m)
- Water Supply Bore

Basalt Depressurisation (m)

- 1 - 2
- 2 - 4
- 4 - 4.5

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:60,000

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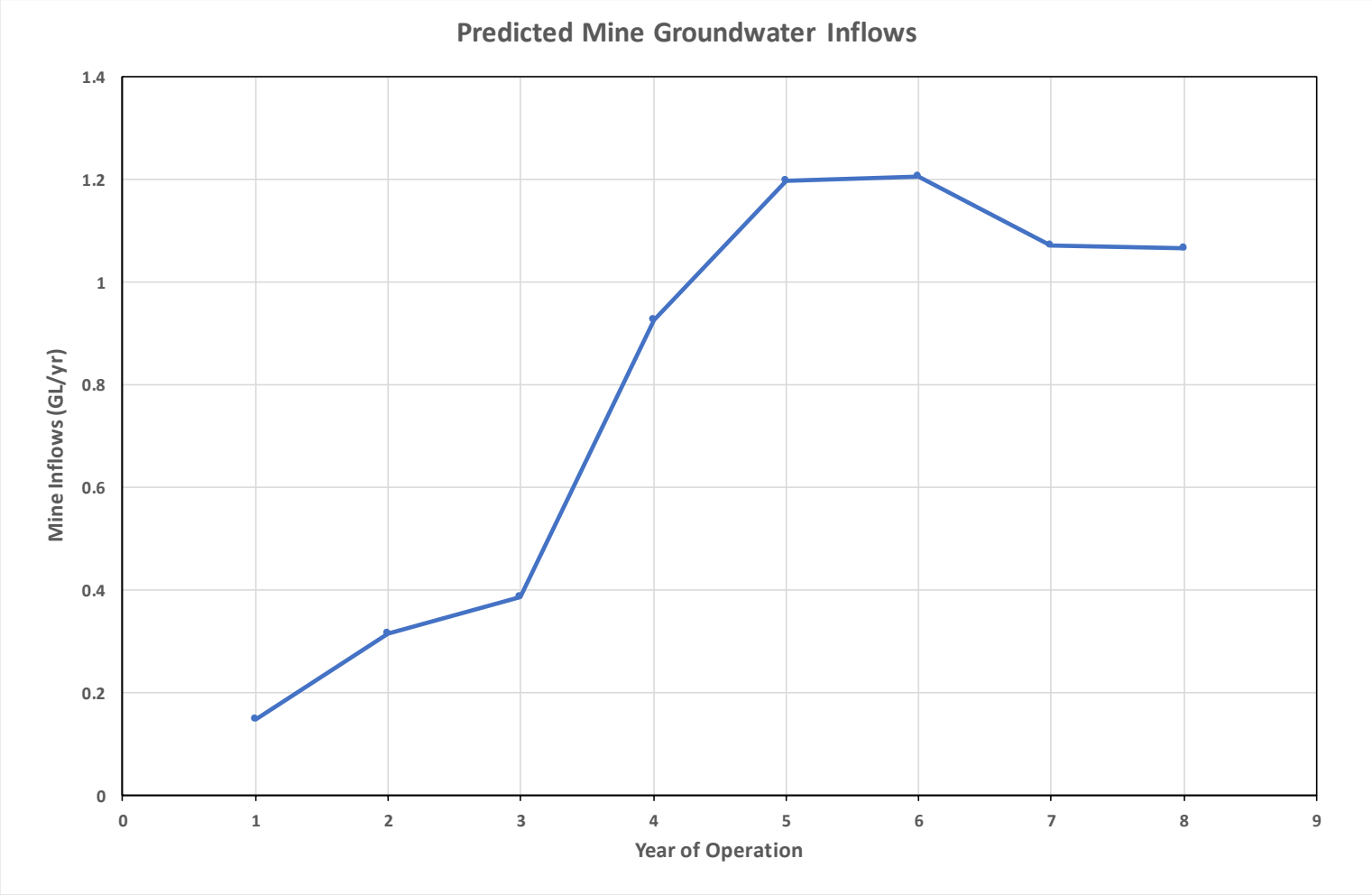
Klohn Crippen Berger

PROJECT
ISAAC PLAINS UNDERGROUND PROJECT
GROUNDWATER REPORT

TITLE
PREDICTED DEPRESSURISATION IN THE
TERTIARY BASALT

PROJECT No. D10073A03

FIG No. FIGURE 17



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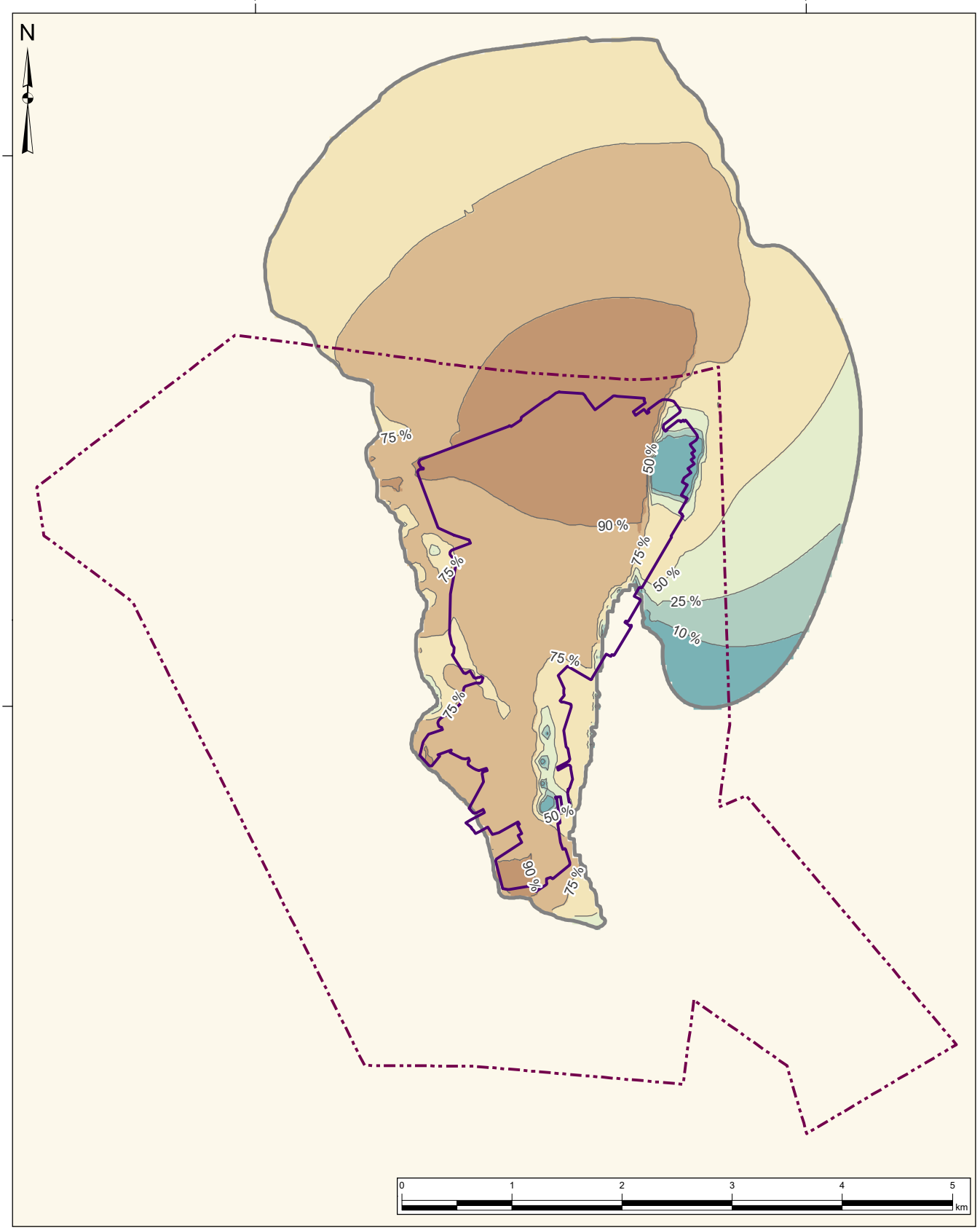
CLIENT:
Hansen Bailey Pty Ltd
Stanmore IP Coal Pty Ltd

Klohn Crippen Berger

PROJECT NAME:
Isaac Plains Underground Project Groundwater Report

TITLE:
Predicted Groundwater Inflow

PROJECT NO:	FIG NO.:	REV:
D10073A03	FIGURE 18	A



Legend

- Isaac Plains Complex Mining Lease
- Project Mining Area Boundary
- Project Contribution (%)

Contribution of Project Depressurisation to Cumulative Depressurisation (%)

0 - 10	50 - 75
10 - 25	75 - 90
25 - 50	90 - 100

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:50,000

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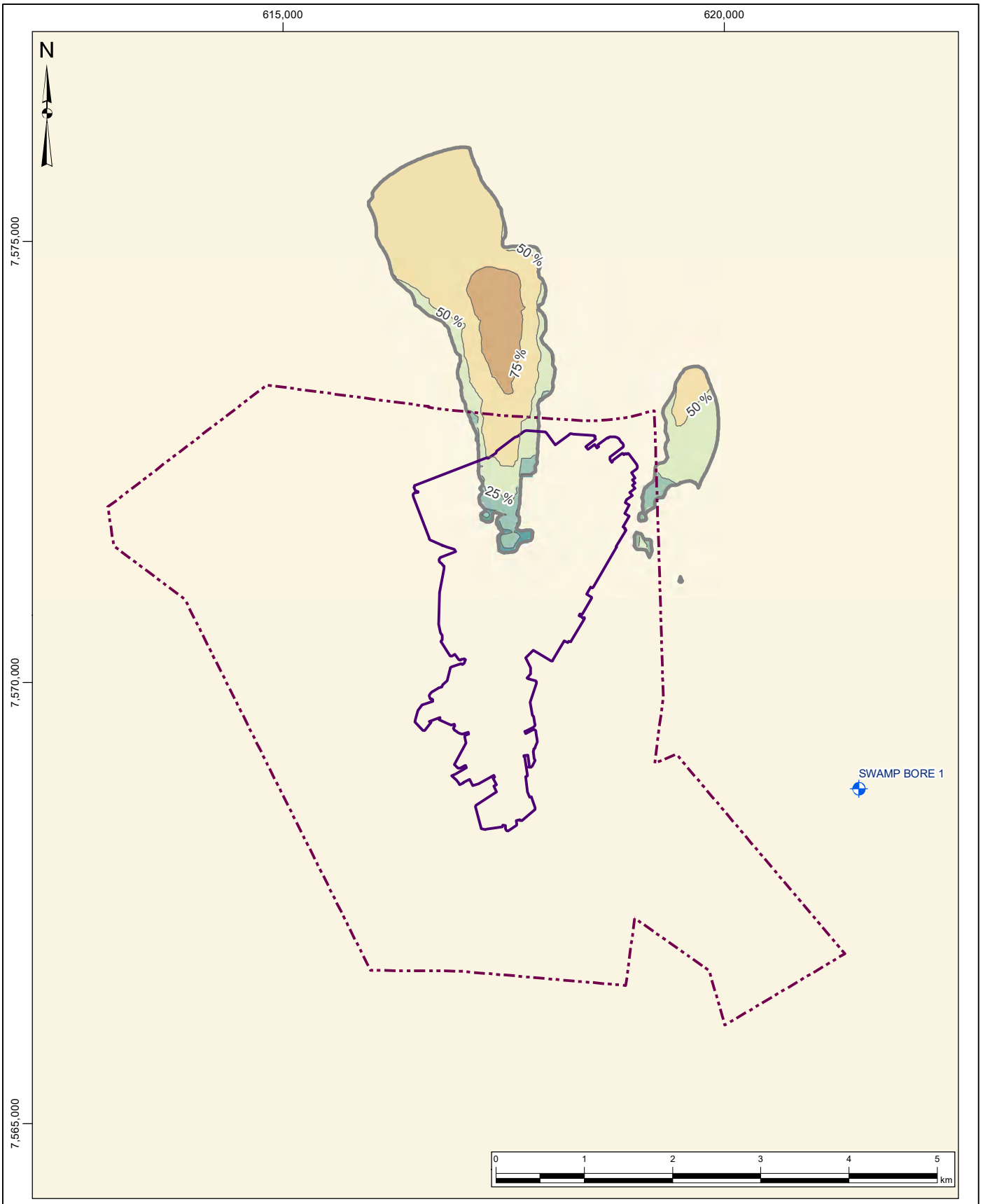
Klohn Crippen Berger

PROJECT
ISAAC PLAINS UNDERGROUND PROJECT
GROUNDWATER REPORT

TITLE
PROJECT CONTRIBUTION TO CUMULATIVE DEPRESSURISATION IN THE LEICHARDT SEAM

PROJECT No. D10073A03

FIG No. FIGURE 19



Legend

- Isaac Plains Complex Mining Lease
- Project Mining Area Boundary
- Project Contribution (%)
- Water Supply Bore

Contribution of Project Depressurisation to Cumulative Depressurisation (%)

0 - 10	50 - 75
10 - 25	75 - 90
25 - 50	90 - 100

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:60,000

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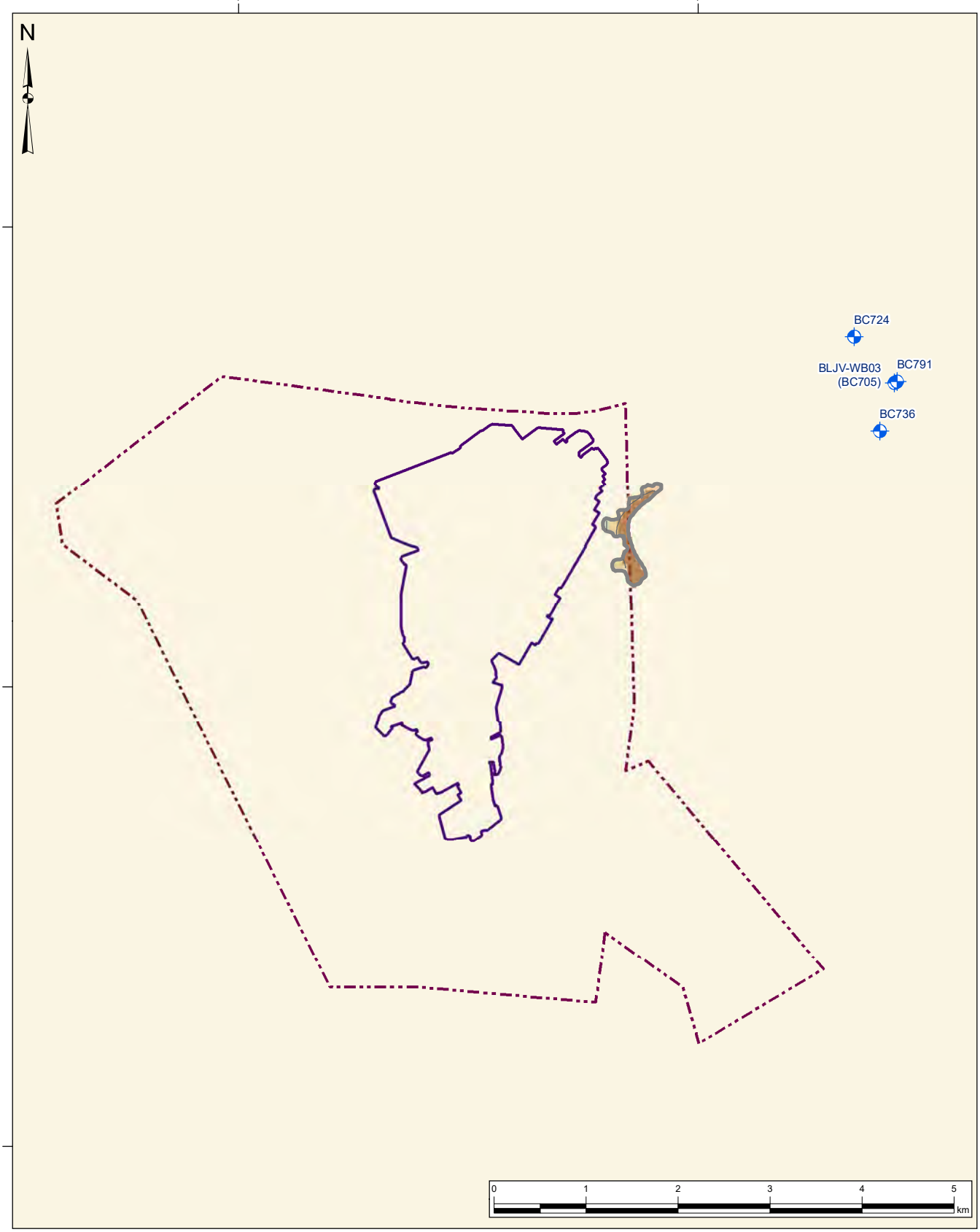
Klohn Crippen Berger

PROJECT
ISAAC PLAINS UNDERGROUND PROJECT
GROUNDWATER REPORT

TITLE
PROJECT CONTRIBUTION TO CUMULATIVE DEPRESSURISATION IN THE WEATHERED SEDIMENTS

PROJECT No. D10073A03

FIG No. FIGURE 20



Legend

- Isaac Plains Complex Mining Lease
- Project Mining Area Boundary
- Project Contribution (%)
- Water Supply Bore

Contribution of Project Depressurisation to Cumulative Depressurisation (%)

- 25 - 50
- 50 - 75
- 75 - 90
- 90 - 100

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:60,000

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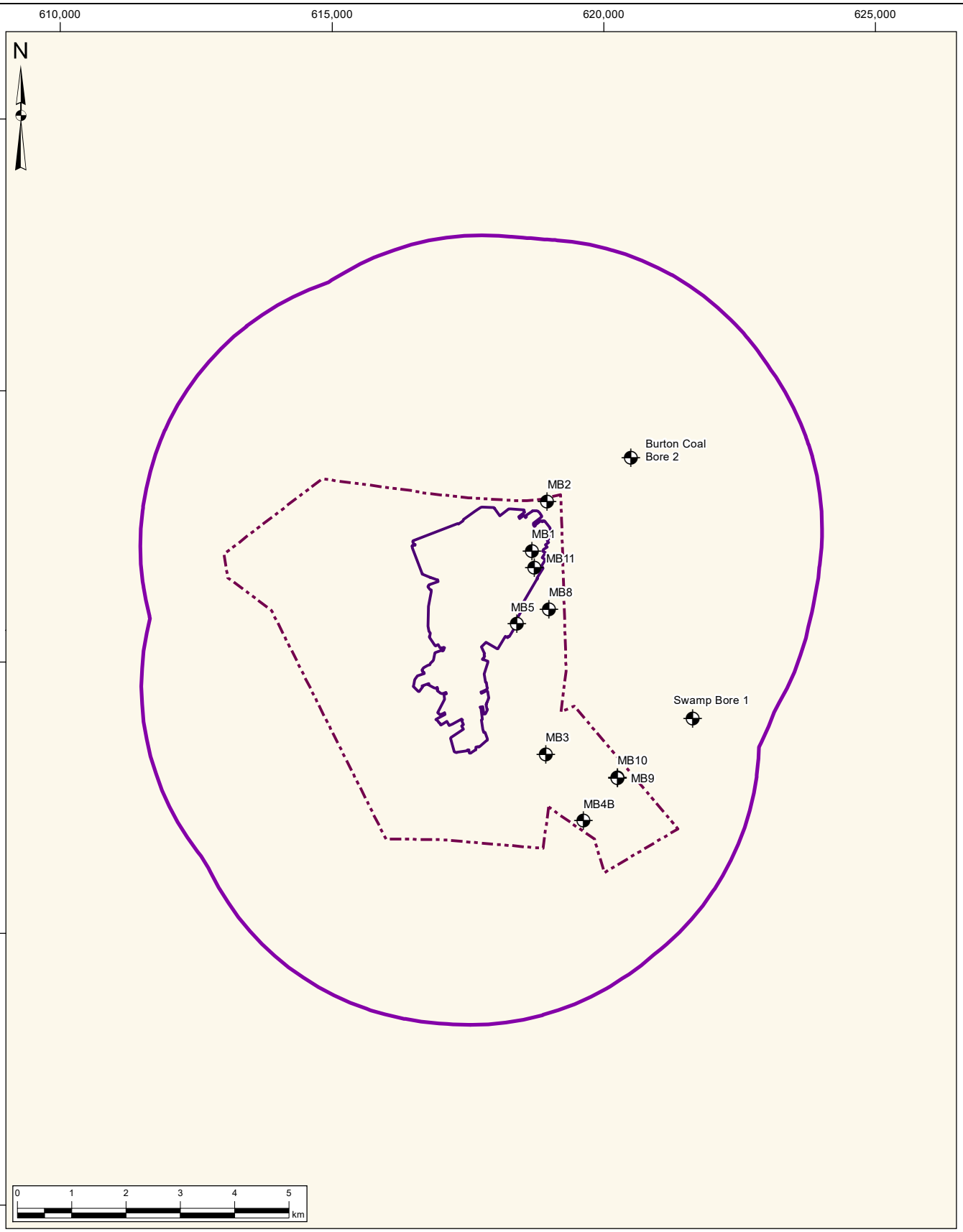
Klohn Crippen Berger

PROJECT
ISAAC PLAINS UNDERGROUND PROJECT
GROUNDWATER REPORT

TITLE
PROJECT CONTRIBUTION TO CUMULATIVE DEPRESSURISATION IN THE TERTIARY BASALT

PROJECT No. D10073A03

FIG No. FIGURE 21



Legend

- Isaac Plains Complex Mining Lease
- Project Mining Area Boundary
- 5km Buffer
- Monitoring Bore

NOTES
1. Horizontal Datum: AGD84
2. Grid Zone: Zone 55
3. Vertical Datum: Mean Sea Level
4. Scale: 1:100,000

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Klohn Crippen Berger

PROJECT
ISAAC PLAINS UNDERGROUND PROJECT
GROUNDWATER REPORT

TITLE
GROUNDWATER MONITORING PROGRAM

PROJECT No. D10073A03

FIG No. FIGURE 22

APPENDIX I

Summary of DNRME-Registered Bores

RN	Original Name	Facility Status	Date Drilled	Easting (AGD84)	Northing (AGD84)	Elevation	Screened Lithology	SWL (mbGL)	EC (µS/cm)	Screen Interval (mbGL)	Gravel Pack Interval (mbGL)
141807	BC724	Existing	3-Jul-05	621693	7573807	261.79	Basalt	-20.15	925	46.80 - 53	7 – 53.00
162020	BC769	Existing	3-Jul-05	622072	7573245	267	Basalt	-24.77	957	54.5 -	7 - 60.50
141865	BC736	Existing	4-Jul-05	621974	7572778	258	Basalt	-16.68	1050	20.50 – 26.50	7 – 32
105677	BLJV-WB03 (BC705)	Existing	13-Jun-05	622135	7573305	-	Basalt	-25.14	1055	62.10 – 67.10	7 – 67.70
141457	BC706	Existing	3-Jul-05	621946	7573298	263	Basalt	-20.14	1167	49.28 – 55.28	7 – 55.28
141458	BC707	Existing	3-Jul-05	622101	7573100	266	Basalt	-29.92	1206	59 - 65	7 - 65.68
162028	BC791	Existing	4-Jul-05	622164	7573318	-	Basalt	-27	1210	61.00 – 67.00	7 – 82.00 & 83.00 – 84.50
141981	BC768	Existing	29-Jun-05	622210	7573375	272	Basalt	-27	1240	48.50 – 54.50	7 – 58
141864	BC734	Abandoned but Still Usable	4-Jul-05	621977	7572901	262.7	Basalt	-20.66	1314	31.50 – 37.50	7 – 41.90
162011	BC737	Existing	4-Jul-05	621951	7572589	264	Basalt	-12.27	2620	22 – 28	7 – 30
162013	BC739	Existing	3-Jul-05	621998	7572002	262.75	Basalt	-17.2	3210	34 – 40	7 – 40
162017	BC746	Existing	4-Jul-05	621699	7572435	259	Basalt	-14.92	3980	24 – 30	7 – 32.96
141808	BC726	Existing	3-Jul-05	621793	7572498	261	Basalt	-14.15	4300	22 – 28	7 – 28.50 & 28.50 – 30
162041	BC770	Existing	4-Jul-05	622161	7573330	267.26	Rewan Group	-	4360	94.70 – 100.70	91 – 101
105435	141C	Existing	12-Jul-04	616877	7570580	-	Blackwater Group	-23	-	Open Hole	Open Hole
141809	BC727	Existing	3-Jul-05	621748	7571997	-	-	-	-	5 – 11	5 – 22
162012	BC738	Existing	4-Jul-05	621900	7572493	265	-	-15.51	-	15 – 21	7 – 21 & 22 – 26.30
162014	BC743	Existing	4-Jul-05	621993	7572501	265	Basalt	-16.22	-	14 – 20	7 – 24.72
162015	BC744	Existing	4-Jul-05	621794	7572380	-	-	-	-	11-Jul	7 – 16.97
162016	BC745	Existing	4-Jul-05	621753	7572407	261	-	-16.73	-	6 – 11	6 – 24.90
162810	Burton Coal Bore 2	Existing	17-Dec-94	620383	7573599	246	Rewan Group	-13.37	2087	-	-
162552	MB1	Existing	22-Feb-16	618679	7572034	236.54	Rangal Coal Measures	-15.54	6000	22.50 – 28.50	19.80 – 29.15
182079	MB10	Existing	30-May-18	620254	7567870	-	Basalt	-	-	21.30 – 27.30	20.30 – 27.30
182081	MB11	Existing	1-Jun-18	618832	7571923	-	Tertiary Sediments	-	-	3 – 4	2.4 – 5
162551	MB2	Existing	21-Feb-16	618960	7572956	242.88	Rangal Coal Measures	-15.98	-	48.70 – 51.70	46.15 – 51.93
162548	MB3	Existing	19-Feb-16	618933	7568291	253	Rangal Coal Measures	-27.95	-	49.64 – 52.64	48.35 – 52.66
182080	MB4B	Existing	30-May-18	619626	7567071	-	Tertiary Sediments	-	-	8.50 – 11.50	7 – 11.50
162550	MB4	Existing	19-Feb-16	620241	7567300	237.56	Tertiary Sediments	-	-	7.80 – 10.80	2.30 – 11.00
162547	MB5	Existing	18-Feb-16	618393	7570697	241.83	Rangal Coal Measures	-22.59	-	36.30 – 39.30	34.00 – 39.40
162549	MB6	Existing	19-Feb-16	619259	7567364	235.72	Basalt	-11.75	-	6.50 – 12.50	3.70 – 13.00
162565	MB7	Existing	21-Apr-16	617422	7568882	-	FCCM	-47	-	126 – 132	6 – 122 & 124 – 137
182077	MB8	Existing	1-Jun-18	619301	7570675	-	Rangal Coal Measures	-24	-	117.30 – 120.30	88 – 100.50 & 114.50 – 126.50
182078	MB9	Existing	30-May-18	620254	7567871	-	Basalt & Rangal Coal Measures	-	1460 & 10300	77.50 – 80.50	76.50 – 80.50
162811	Swamp Bore 1	Existing	1-Jan-01	621518	7568790	249	-	-9.5	-	-	-
162812	Swamp Bore 2	Abandoned but Still Usable	1-Jan-01	621521	7568794	247	-	-12.82	-	-	-
81909	Smokey Creek	Existing	17-Dec-94	620089	7573318	250	Rewan Group	-17.2	2690 – 5670	-	-
100224	MGC Moranbah 1	Existing	5-Nov-93	615843	7567074	-	-	-	-	-	-
100083	MGC Wotonga 1	Existing	25-Sep-92	622492	7569829	-	MCM	-	-	Open Hole	Open Hole
	240P	-		616573	7571997						
	BC095	-		616507	7571995						
	Burton Coal Bore 1	Abandoned		620267	7573421						

APPENDIX II

Summary of Groundwater Quality Data

Parameter	Units	LOR							
Sample ID			Swamp Bore 1	Swamp Bore 1	Swamp Bore 1	Swamp Bore 1	Swamp Bore 1	Swamp Bore 1	Swamp Bore 1
Date Sampled			31/03/10	01/06/10	30/09/10	30/06/11	29/09/11	29/03/12	4/07/12
Formation			Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm
Physical Parameters									
pH	pH Units	0.1	7.75	7.5	7.54	7.54	7.42	7.1	6.9
Electrical Conductivity	µS/cm	1.00	8460	9410	9170	9100	9400	7700	9000
Total Dissolved Solids (grav) @180°C	mg/L	1.00	8110	7010	7090	5820	7990	5300	6300
Carbonate Alkalinity as $CaCO_3$	mg/L	1.00	<1	<1	<1	<1	<1	75	26
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1.00	91	95	111	63	58	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	1.00	91	95	111	63	58	75	26
Major Ions									
Sulfate as SO_4 – Turbidimetric	mg/L	1	105	101	104	143	148	98	380
Chloride	mg/L	1	3060	3120	3240	2980	3160	2700	3100
Calcium	mg/L	1	600	603	601	566	587	520	490
Magnesium	mg/L	1	130	126	127	148	148	140	130
Sodium	mg/L	1	1100	1100	1120	1150	1170	1100	1100
Potassium	mg/L	1	29	28	27	23	25	20	22
Total Anions	meq/L	0.01	90.5	92	95.8	88.3	93.4	----	----
Total Cations	meq/L	0.01	89.3	88.9	90	91	93	----	----
Ionic Balance	%	0.01	0.61	1.7	3.1	1.54	0.18	4.1	-5.5
Dissolved Metals									
Aluminium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<10	<10
Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<1	<1
Arsenic	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.002	5	<1
Iron	mg/L	0.05	<0.05	0.1	0.27	0.29	0.39	46	40
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.05	<0.05
Molybdenum	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<1	<1
Selenium	mg/L	0.005	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<1
Silver	mg/L	0.001	<0.001	0.001	<0.001	<0.001	<0.001	<1	<1

Parameter	Units	LOR							
Sample ID			Swamp Bore 1	Swamp Bore 1	Swamp Bore 1	Swamp Bore 1	Swamp Bore 1	Swamp Bore 1	Swamp Bore 1
Date Sampled			27/09/12	2/01/13	1/07/13	25/09/13	30/12/13	26/03/14	23/06/14
Formation			Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm
Physical Parameters									
pH	pH Units	0.1	7.2	7.4	7.6	7.6	7.4	7.6	7.1
Electrical Conductivity	µS/cm	1.00	8600	8600	8500	8500	8800	8700	8900
Total Dissolved Solids (grav) @180°C	mg/L	1.00	5300	6400	6800	6800	7100	4600	6800
Carbonate Alkalinity as $CaCO_3$	mg/L	1.00	<5	75	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1.00	62	<5	120	120	70	79	84
Total Alkalinity as $CaCO_3$	mg/L	1.00	62	75	120	120	70	79	84
Major Ions									
Sulfate as SO_4 – Turbidimetric	mg/L	1	130	130	98	98	130	170	130
Chloride	mg/L	1	3100	3200	3600	3600	3000	2200	3600
Calcium	mg/L	1	500	480	550	550	500	510	520
Magnesium	mg/L	1	140	120	150	150	150	150	160
Sodium	mg/L	1	1100	950	1300	1300	1200	1200	1200
Potassium	mg/L	1	21	23	26	26	24	23	23
Total Anions	meq/L	0.01	----	----	----	----	----	----	----
Total Cations	meq/L	0.01	----	----	----	----	----	----	----
Ionic Balance	%	0.01	-2.3	-11	-3.7	-3.7	-0.64	14	-6.7
Aluminium	mg/L	0.01	<10	<10	<10	<10	20	60	50
Antimony	mg/L	0.001	<1	<1	<1	<1	<1	<1	<1
Arsenic	mg/L	0.001	<1	<1	<1	<1	<1	<1	<1
Iron	mg/L	0.05	110	56	40	40	53	170	110
Mercury	mg/L	0.0001	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum	mg/L	0.001	1	<1	<1	<1	<1	<1	<1
Selenium	mg/L	0.005	<1	<1	<1	<1	<1	<1	<1
Silver	mg/L	0.001	<1	<1	<1	<1	<1	<1	<1

Parameter	Units	LOR							
Sample ID			Swamp Bore 1	Swamp Bore 1	Swamp Bore 1	Swamp Bore 1	Swamp Bore 1	Swamp Bore 1	Swamp Bore 1
Date Sampled			24/09/14	15/10/15	19/01/16	19/04/16	27/07/16	17/10/16	26/04/17
Formation			Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm
Physical Parameters									
pH	pH Units	0.1	7.5	7.56	7.36	7.4	7.51	4.59	7.41
Electrical Conductivity	µS/cm	1.00	7800	8780	8320	8990	8910	8350	8870
Total Dissolved Solids (grav) @180°C	mg/L	1.00	6000	5970	5580	6480	6440	4630	5610
Carbonate Alkalinity as $CaCO_3$	mg/L	1.00	<5	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1.00	68	74	92	114	72	<1	74
Total Alkalinity as $CaCO_3$	mg/L	1.00	68	74	92	114	72	<1	74
Major Ions									
Sulfate as SO_4 – Turbidimetric	mg/L	1	120	142	3040	3120	2990	113	114
Chloride	mg/L	1	2800	3200	496	541	513	3040	3070
Calcium	mg/L	1	500	486	20	21	20	481	525
Magnesium	mg/L	1	140	115	----	----	----	128	123
Sodium	mg/L	1	1300	1030	----	----	----	1080	1140
Potassium	mg/L	1	22	18	<0.01	<0.01	<0.01	20	22
Total Anions	meq/L	0.01	----	94.7	----	----	----	88.1	90.4
Total Cations	meq/L	0.01	----	79	95.90	87.8	104	82.0	86.5
Ionic Balance	%	0.01	6.7	9.04	102.00	107	99.9	3.57	2.25
Dissolved Metals									
Aluminium	mg/L	0.01	20	0.02	<0.001	<0.001	<0.001	<0.01	<0.01
Antimony	mg/L	0.001	<1	<0.001	<0.01	<0.01	<0.01	<0.001	<0.001
Arsenic	mg/L	0.001	<1	0.001	0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.05	51	0.41	0.09	0.12	0.09	0.22	0.08
Mercury	mg/L	0.0001	----	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	<1	0.001	0.26	<0.05	0.9	<0.001	<0.001
Selenium	mg/L	0.005	<1	<0.01	----	----	----	<0.01	<0.001
Silver	mg/L	0.001	<1	<0.001	----	----	----	<0.001	<0.001

Parameter	Units	LOR							
Sample ID			Swamp Bore 1	Swamp Bore 1	Swamp Bore 1	Swamp Bore 1			
Date Sampled			06/07/17	25/07/17	24/10/17	22/01/18			
Formation			Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm			
Physical Parameters									
pH	pH Units	0.1	7.23	7.75	7.50	7.65			
Electrical Conductivity	µS/cm	1.00	9240	9330	8680	9010			
Total Dissolved Solids (grav) @180°C	mg/L	1.00	6320	5890	5080	7920			
Carbonate Alkalinity as $CaCO_3$	mg/L	1.00	<1	<1	<1	<1			
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1.00	57	55	64	57			
Total Alkalinity as $CaCO_3$	mg/L	1.00	57	55	64	57			
Major Ions									
Sulfate as SO_4 – Turbidimetric	mg/L	1	121	122	114	119			
Chloride	mg/L	1	3180	2970	3320	3280			
Calcium	mg/L	1	538	546	539	535			
Magnesium	mg/L	1	133	129	124	119			
Sodium	mg/L	1	1100	1100	1100	1060			
Potassium	mg/L	1	21	23	22	20			
Total Anions	meq/L	0.01	93.4	87.4	97.3	96.1			
Total Cations	meq/L	0.01	86.2	86.3	85.5	83.1			
Ionic Balance	%	0.01	4.00	0.64	6.45	7.27			
Dissolved Metals									
Aluminium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01			
Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.001			
Arsenic	mg/L	0.001	<0.001	<0.001	0.002	<0.001			
Iron	mg/L	0.05	<0.05	0.46	0.87	1.16			
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001			
Molybdenum	mg/L	0.001	<0.001	<0.001	<0.001	0.001			
Selenium	mg/L	0.005	<0.001	<0.001	<0.001	0.001			
Silver	mg/L	0.001	<0.001	<0.001	<0.001	<0.001			

Parameter	Units	LOR							
Sample ID			Burton Coal 2	Burton Coal 2	Burton Coal 2	Burton Coal 2	Burton Coal 2	Burton Coal 2	Burton Coal 2
Date Sampled			31/03/10	2/06/10	30/09/10	30/06/11	29/09/11	29/03/12	18/12/14
Formation			Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm
Physical Parameters									
pH	pH Units	0.1	7.87	7.36	7.26	7.69	7.37	7.1	7.8
Electrical Conductivity	µS/cm	1.00	3700	3460	2960	1110	3800	3500	4670
Total Dissolved Solids (grav) @180°C	mg/L	1.00	1990	1850	1640	563	2120	1900	2450
Carbonate Alkalinity as $CaCO_3$	mg/L	1.00	<1	<1	<1	<1	<1	840	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1.00	819	791	775	335	797	<5	818
Total Alkalinity as $CaCO_3$	mg/L	1.00	819	791	775	335	797	840	818
Major Ions									
Sulfate as SO_4 – Turbidimetric	mg/L	1	75	87	57	26	121	92	71
Chloride	mg/L	1	778	613	535	125	696	650	982
Calcium	mg/L	1	79	64	69	35	72	66	94
Magnesium	mg/L	1	97	74	84	16	83	81	134
Sodium	mg/L	1	565	519	464	150	671	670	720
Potassium	mg/L	1	5	6	4	9	6	6.2	4
Total Anions	meq/L	0.01	39.9	34.9	31.8	10.8	38.1	----	45.5
Total Cations	meq/L	0.01	36.7	32	30.6	9.82	39.8	----	47.1
Ionic Balance	%	0.01	4.2	4.29	1.85	4.61	2.14	2.7	1.72
Dissolved Metals									
Aluminium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<10	0.07
Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<1	<0.001
Arsenic	mg/L	0.001	0.002	0.002	0.002	0.01	0.008	7	0.004
Iron	mg/L	0.05	0.6	0.78	0.65	1.64	1.3	950	1.17
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.05	<0.0001
Molybdenum	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<1	<0.001
Selenium	mg/L	0.005	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<0.01
Silver	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<1	<0.001

Parameter	Units	LOR							
Sample ID			Burton Coal 2	Burton Coal 2	Burton Coal 2	Burton Coal 2	Burton Coal 2	Burton Coal 2	Burton Coal 2
Date Sampled			20/01/15	15/10/15	19/01/16	19/04/16	14/07/16	27/07/16	17/10/16
Formation			Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm
Physical Parameters									
pH	pH Units	0.1	7.54	7.58	7.44	7.39	7.35	7.45	4.67
Electrical Conductivity	µS/cm	1.00	5050	5730	5480	5390	5060	5320	4880
Total Dissolved Solids (grav) @180°C	mg/L	1.00	2610	3160	3580	3020	2850	3100	3660
Carbonate Alkalinity as $CaCO_3$	mg/L	1.00	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1.00	761	716	747	602	749	726	<1
Total Alkalinity as $CaCO_3$	mg/L	1.00	761	716	747	602	749	726	<1
Major Ions									
Sulfate as SO_4 – Turbidimetric	mg/L	1	63	77	1560	1320	69	1300	87
Chloride	mg/L	1	1150	1510	136	132	1250	125	1450
Calcium	mg/L	1	110	126	4	5	118	4	102
Magnesium	mg/L	1	157	165	----	----	160	----	167
Sodium	mg/L	1	731	759	----	----	737	----	756
Potassium	mg/L	1	4	4	<0.01	<0.01	4	<0.01	5
Total Anions	meq/L	0.01	49	58.5	----	----	51.7	----	42.7
Total Cations	meq/L	0.01	50.3	53	90.9	86.2	51.2	102	51.8
Ionic Balance	%	0.01	1.34	4.96	100.00	106	0.45	103	9.66
Dissolved Metals									
Aluminium	mg/L	0.01	0.02	0.2	0.003	<0.001	<0.01	<0.001	<0.01
Antimony	mg/L	0.001	<0.001	<0.001	<0.01	<0.01	<0.001	<0.01	<0.001
Arsenic	mg/L	0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.05	0.19	0.54	0.01	0.13	<0.05	0.02	<0.05
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	<0.001	<0.001	<0.05	<0.05	<0.001	<0.05	<0.001
Selenium	mg/L	0.005	<0.01	<0.01	----	----	<0.01	----	<0.01
Silver	mg/L	0.001	<0.001	<0.001	----	----	<0.001	----	<0.001

Parameter	Units	LOR							
Sample ID			Burton Coal 2	Burton Coal 2	Burton Coal 2	Burton Coal 2	Burton Coal 2	Burton Coal 2	MB1
Date Sampled			23/01/17	26/04/17	6/07/17	25/07/17	24/10/17	22/01/18	1/02/2016
Formation			Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Coal Meas.
Physical Parameters									
pH	pH Units	0.1	7.80	7.48	8.21	8.28	7.84	7.89	7.99
Electrical Conductivity	µS/cm	1.00	5340	5300	3810	4420	3760	5470	3140
Total Dissolved Solids (grav) @180°C	mg/L	1.00	2860	2950	2180	2460	2160	2500	1740
Carbonate Alkalinity as $CaCO_3$	mg/L	1.00	<1	<1	20	<1	<1	<1	----
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1.00	724	738	746	704	803	692	----
Total Alkalinity as $CaCO_3$	mg/L	1.00	724	738	766	704	803	692	----
Major Ions									
Sulfate as SO_4 – Turbidimetric	mg/L	1	86	80	103	105	97	89	99
Chloride	mg/L	1	1340	1270	733	903	910	1440	756
Calcium	mg/L	1	125	129	61	96	78	134	69
Magnesium	mg/L	1	171	180	89	126	91	186	94
Sodium	mg/L	1	732	814	655	715	594	760	405
Potassium	mg/L	1	5	5	5	6	5	5	3
Total Anions	meq/L	0.01	54.0	52.2	38.1	41.7	43.7	56.3	----
Total Cations	meq/L	0.01	52.3	56.8	39.0	46.4	37.3	55.2	----
Ionic Balance	%	0.01	1.67	4.17	1.12	5.32	7.88	1.00	----
Dissolved Metals									
Aluminium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.008
Iron	mg/L	0.05	<0.05	<0.05	<0.05	0.16	0.23	<0.05	<0.05
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
Selenium	mg/L	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01
Silver	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Parameter	Units	LOR							
Sample ID			MB1	MB1	MB1	MB1	MB1	MB2	MB2
Date Sampled			23/02/2016	1/02/2017	8/02/2017	24/10/2017	22/01/2018	1/02/2016	21/02/2016
Formation			Coal Meas.	Coal Meas.	Coal Meas.	Coal Meas.	Coal Meas.	Coal Meas.	Coal Meas.
Physical Parameters									
pH	pH Units	0.1	8.14	8.14	7.99	7.76	7.85	8.15	7.88
Electrical Conductivity	µS/cm	1.00	5030	5030	3140	4040	4220	8400	11000
Total Dissolved Solids (grav) @180°C	mg/L	1.00	2720	2720	1740	2350	2540	4660	6880
Carbonate Alkalinity as $CaCO_3$	mg/L	1.00	<1	----	<1	<1	<1	----	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1.00	480	----	444	490	476	----	612
Total Alkalinity as $CaCO_3$	mg/L	1.00	480	----	444	490	476	----	612
Major Ions									
Sulfate as SO_4 – Turbidimetric	mg/L	1	54	54	99	53	48	178	273
Chloride	mg/L	1	1500	1500	756	1210	1150	2450	3710
Calcium	mg/L	1	130	130	69	119	121	121	194
Magnesium	mg/L	1	132	132	94	130	131	175	292
Sodium	mg/L	1	696	696	405	574	561	1280	1810
Potassium	mg/L	1	4	4	3	4	3	7	9
Total Anions	meq/L	0.01	53.0	----	32.2	45.0	42.9	----	122
Total Cations	meq/L	0.01	47.7	----	28.9	41.7	41.3	----	113
Ionic Balance	%	0.01	5.27	----	5.54	3.83	1.96	----	4.22
Dissolved Metals									
Aluminium	mg/L	0.01	----	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	mg/L	0.001	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	<0.001	<0.001	0.008	0.003	0.003	0.026	0.003
Iron	mg/L	0.05	----	<0.05	<0.05	0.20	0.11	<0.05	<0.05
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	----	<0.001	0.002	0.002	0.002	0.003	0.003
Selenium	mg/L	0.005	<0.01	<0.01	<0.01	0.002	0.002	<0.01	<0.01
Silver	mg/L	0.001	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Parameter	Units	LOR							
Sample ID			MB2	MB2	MB2	MB2	MB3	MB3	MB3
Date Sampled			1/02/2017	08/02/2017	24/10/2017	22/01/2018	1/02/2016	22/02/2016	1/02/2017
Formation			Coal Meas.	Coal Meas.	Coal Meas.	Coal Meas.	Coal Meas.	Coal Meas.	Coal Meas.
Physical Parameters									
pH	pH Units	0.1	7.88	8.15	7.41	7.82	7.96	8.14	8.14
Electrical Conductivity	µS/cm	1.00	11000	8400	7680	8060	20300	18400	18400
Total Dissolved Solids (grav) @180°C	mg/L	1.00	6880	4660	4250	4680	13200	10800	10800
Carbonate Alkalinity as $CaCO_3$	mg/L	1.00	----	<1	<1	<1	----	<1	----
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1.00	----	771	788	761	----	592	----
Total Alkalinity as $CaCO_3$	mg/L	1.00	----	771	788	761	----	592	----
Major Ions									
Sulfate as SO_4 – Turbidimetric	mg/L	1	273	178	167	173	774	590	590
Chloride	mg/L	1	3710	2450	2490	2470	6650	6530	6530
Calcium	mg/L	1	194	121	126	133	292	287	287
Magnesium	mg/L	1	292	175	178	185	380	368	368
Sodium	mg/L	1	1810	1280	1360	1340	3710	3210	3210
Potassium	mg/L	1	9	7	8	7	39	41	41
Total Anions	meq/L	0.01	----	88.2	89.5	88.5	----	208	----
Total Cations	meq/L	0.01	----	76.3	80.3	80.3	----	185	----
Ionic Balance	%	0.01	----	7.25	5.40	4.83	----	5.86	----
Dissolved Metals									
Aluminium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	----	0.03
Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	----	<0.001
Arsenic	mg/L	0.001	0.003	0.026	0.013	0.019	0.023	0.001	0.001
Iron	mg/L	0.05	<0.05	<0.05	<0.05	1.19	0.05	----	<0.05
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	0.003	0.002	0.003	0.002	0.005	----	0.01
Selenium	mg/L	0.005	<0.01	<0.01	0.003	0.002	<0.01	<0.01	<0.01
Silver	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	----	<0.001

Parameter	Units	LOR							
Sample ID			MB3	MB3	MB3	MB4	MB4	MB4	MB4
Date Sampled			07/02/2017	25/10/2017	22/01/2018	1/02/2016	1/02/2017	08/02/2017	25/10/2017
Formation			Coal Meas.	Coal Meas.	Coal Meas.	Tert. Seds	Tert. Seds	Tert. Seds	Tert. Seds
Physical Parameters									
pH	pH Units	0.1	7.96	6.92	7.44	6.8	----	6.80	7.79
Electrical Conductivity	µS/cm	1.00	20300	20600	21900	51700	----	51700	49700
Total Dissolved Solids (grav) @180°C	mg/L	1.00	13200	14300	14600	36000	----	36000	34500
Carbonate Alkalinity as $CaCO_3$	mg/L	1.00	<1	<1	<1	----	----	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1.00	650	656	628	----	----	401	428
Total Alkalinity as $CaCO_3$	mg/L	1.00	650	656	628	----	----	401	428
Major Ions									
Sulfate as SO_4 – Turbidimetric	mg/L	1	774	884	916	955	----	955	877
Chloride	mg/L	1	6650	7740	7680	17500	----	17500	21300
Calcium	mg/L	1	292	341	350	603	----	603	734
Magnesium	mg/L	1	380	451	459	1600	----	1600	2070
Sodium	mg/L	1	3710	3970	3940	8460	----	8460	10400
Potassium	mg/L	1	39	42	39	4	----	4	6
Total Anions	meq/L	0.01	217	250	248	----	----	522	628
Total Cations	meq/L	0.01	208	228	228	----	----	530	660
Ionic Balance	%	0.01	1.99	4.60	4.34	----	----	0.79	2.48
Dissolved Metals									
Aluminium	mg/L	0.01	<0.01	<0.01	<0.01	<0.05	----	<0.05	<0.05
Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.005	----	<0.005	<0.005
Arsenic	mg/L	0.001	0.023	0.026	0.022	<0.005	----	<0.005	<0.005
Iron	mg/L	0.05	0.05	3.99	5.44	0.39	----	0.39	<0.05
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	----	<0.0001	<0.0001
Molybdenum	mg/L	0.001	0.004	0.002	0.002	<0.005	----	<0.005	<0.005
Selenium	mg/L	0.005	<0.01	0.002	0.002	<0.05	----	<0.05	<0.005
Silver	mg/L	0.001	<0.001	<0.001	<0.001	<0.005	----	<0.005	<0.005

Parameter	Units	LOR							
Sample ID			MB5	MB5	MB5	MB5	MB5	MB5	MB6
Date Sampled			1/02/2016	22/02/2016	1/02/2017	07/02/2017	25/10/2017	22/01/2018	1/02/2016
Formation			Coal	Coal	Coal	Coal	Coal	Coal	Tertiary
Physical Parameters									
pH	pH Units	0.1	8	8.01	8.01	8.00	7.26	7.50	7.19
Electrical Conductivity	µS/cm	1.00	23800	23700	23700	23800	23300	24200	7050
Total Dissolved Solids (grav) @180°C	mg/L	1.00	16400	16900	16900	16400	16000	16900	4180
Carbonate Alkalinity as $CaCO_3$	mg/L	1.00	----	<1	----	<1	<1	<1	----
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1.00	----	552	----	536	577	544	----
Total Alkalinity as $CaCO_3$	mg/L	1.00	----	552	----	536	577	544	----
Major Ions									
Sulfate as SO_4 – Turbidimetric	mg/L	1	1050	1040	1040	1050	936	1000	73
Chloride	mg/L	1	7670	8520	8520	7670	7930	8700	1730
Calcium	mg/L	1	336	371	371	336	380	387	117
Magnesium	mg/L	1	543	601	601	543	621	628	222
Sodium	mg/L	1	4060	4060	4060	4060	4240	4240	938
Potassium	mg/L	1	29	32	32	29	34	30	6
Total Anions	meq/L	0.01	----	273	----	249	255	277	----
Total Cations	meq/L	0.01	----	245	----	239	255	256	----
Ionic Balance	%	0.01	----	5.34	----	2.08	0.13	3.92	----
Dissolved Metals									
Aluminium	mg/L	0.01	<0.01	----	0.04	<0.01	<0.01	<0.01	<0.01
Antimony	mg/L	0.001	<0.001	----	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	0.007	<0.001	<0.001	0.007	0.010	0.011	0.002
Iron	mg/L	0.05	0.06	----	0.09	0.06	3.12	3.34	<0.05
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	0.005	----	0.001	0.004	0.001	0.002	0.002
Selenium	mg/L	0.005	<0.01	<0.01	<0.01	<0.01	0.001	0.002	<0.01
Silver	mg/L	0.001	<0.001	----	<0.001	<0.001	<0.001	<0.001	<0.001

Parameter	Units	LOR							
Sample ID			MB6	MB6	MB6	MB6	MB6	MB7	MB7
Date Sampled			23/02/2016	1/02/2017	07/02/2017	25/10/2017	22/01/2018	1/02/2016	7/04/2016
Formation			Tertiary	Tertiary	Tertiary	Tertiary	Tertiary		
Physical Parameters									
pH	pH Units	0.1	8.14	8.14	7.19	7.64	7.82	7.54	7.81
Electrical Conductivity	µS/cm	1.00	8700	8700	7050	6760	6920	18300	18600
Total Dissolved Solids (grav) @180°C	mg/L	1.00	4270	4270	4180	3860	4390	12800	13000
Carbonate Alkalinity as $CaCO_3$	mg/L	1.00	<1	----	<1	<1	<1	----	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1.00	790	----	748	768	746	----	135
Total Alkalinity as $CaCO_3$	mg/L	1.00	790	----	748	768	746	----	135
Major Ions									
Sulfate as SO_4 – Turbidimetric	mg/L	1	142	142	73	97	89	74	6530
Chloride	mg/L	1	2710	2710	1730	2210	1910	6320	585
Calcium	mg/L	1	104	104	117	126	117	483	18
Magnesium	mg/L	1	284	284	222	243	226	194	----
Sodium	mg/L	1	1320	1320	938	1040	931	2840	----
Potassium	mg/L	1	9	9	6	6	5	15	<0.01
Total Anions	meq/L	0.01	95.2	----	65.3	79.7	70.6	----	----
Total Cations	meq/L	0.01	86.2	----	65.1	71.7	65.1	----	92.1
Ionic Balance	%	0.01	4.96	----	0.16	5.30	4.11	----	103
Dissolved Metals									
Aluminium	mg/L	0.01	----	<0.01	<0.01	0.01	<0.01	<0.01	<0.001
Antimony	mg/L	0.001	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01
Arsenic	mg/L	0.001	0.005	0.005	0.002	0.004	0.002	<0.001	<0.001
Iron	mg/L	0.05	----	<0.05	<0.05	0.26	<0.05	<0.05	0.18
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	----	0.007	0.001	0.001	0.004	0.008	<0.05
Selenium	mg/L	0.005	<0.01	<0.01	<0.01	0.001	0.004	<0.01	----
Silver	mg/L	0.001	----	<0.001	<0.001	<0.001	<0.001	<0.001	----

Parameter	Units	LOR							
Sample ID			MB7	MB7	MB7	MB7	MB7	MB7	MB7
Date Sampled			31/05/2016	28/06/2016	27/07/2016	17/10/2016	23/01/2017	1/02/2017	08/02/2017
Formation									
Physical Parameters									
pH	pH Units	0.1	7.3	7.35	7.18	5.12	7.92	----	7.54
Electrical Conductivity	µS/cm	1.00	20100	18000	23400	18500	19600	----	18300
Total Dissolved Solids (grav) @180°C	mg/L	1.00	14300	12500	16700	12800	11400	----	12800
Carbonate Alkalinity as $CaCO_3$	mg/L	1.00	<1	<1	<1	<1	<1	----	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1.00	269	151	392	2	229	----	172
Total Alkalinity as $CaCO_3$	mg/L	1.00	269	151	392	2	229	----	172
Major Ions									
Sulfate as SO_4 – Turbidimetric	mg/L	1	7410	6270	8260	189	156	----	74
Chloride	mg/L	1	785	556	793	7010	7010	----	6320
Calcium	mg/L	1	20	17	16	616	551	----	483
Magnesium	mg/L	1	----	----	----	306	275	----	194
Sodium	mg/L	1	----	----	----	3680	3140	----	2840
Potassium	mg/L	1	<0.01	0.01	<0.01	18	15	----	15
Total Anions	meq/L	0.01	----	----	----	202	206	----	183
Total Cations	meq/L	0.01	97.3	104	91.7	216	187	----	164
Ionic Balance	%	0.01	102	99.8	102	3.52	4.70	----	5.55
Dissolved Metals									
Aluminium	mg/L	0.01	0.001	0.049	0.002	0.01	<0.01	----	<0.01
Antimony	mg/L	0.001	<0.01	<0.01	<0.01	<0.001	<0.001	----	<0.001
Arsenic	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	----	<0.001
Iron	mg/L	0.05	0.04	0.27	0.01	2.10	1.30	----	<0.05
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	----	<0.0001
Molybdenum	mg/L	0.001	<0.05	1.78	3.41	0.056	<0.001	----	0.006
Selenium	mg/L	0.005	----	----	----	<0.01	<0.001	----	<0.01
Silver	mg/L	0.001	----	----	----	<0.001	<0.001	----	<0.001

Parameter	Units	LOR							
Sample ID			MB7	MB7	MB7	MB7	MB7		
Date Sampled			26/04/2017	06/07/2017	26/07/2017	24/10/2017	23/01/2018		
Formation									
Physical Parameters									
pH	pH Units	0.1	7.50	7.10	7.66	7.46	7.79		
Electrical Conductivity	µS/cm	1.00	18900	19800	20300	20100	20800		
Total Dissolved Solids (grav) @180°C	mg/L	1.00	11300	12800	13200	14000	16200		
Carbonate Alkalinity as $CaCO_3$	mg/L	1.00	<1	<1	<1	<1	<1		
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1.00	247	291	193	322	303		
Total Alkalinity as $CaCO_3$	mg/L	1.00	247	291	193	322	303		
Major Ions									
Sulfate as SO_4 – Turbidimetric	mg/L	1	146	174	188	263	247		
Chloride	mg/L	1	6630	6430	6600	7640	7700		
Calcium	mg/L	1	546	703	640	602	584		
Magnesium	mg/L	1	268	368	353	343	344		
Sodium	mg/L	1	3460	3730	3490	3430	3340		
Potassium	mg/L	1	17	18	18	18	16		
Total Anions	meq/L	0.01	195	191	194	227	228		
Total Cations	meq/L	0.01	200	228	213	208	203		
Ionic Balance	%	0.01	1.32	8.89	4.74	4.48	5.85		
Dissolved Metals									
Aluminium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01		
Antimony	mg/L	0.001	<0.001	<0.001	0.001	<0.001	<0.001		
Arsenic	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Iron	mg/L	0.05	1.76	0.83	0.44	0.85	0.85		
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		
Molybdenum	mg/L	0.001	0.010	0.001	0.009	0.003	0.003		
Selenium	mg/L	0.005	0.010	0.001	0.009	0.003	0.003		
Silver	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001		

APPENDIX III

Groundwater Modelling Report

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1 INTRODUCTION

Klohn Crippen Berger (KCB) has developed a 3D numerical groundwater flow model for the Isaac Plains Underground Project (the project) to simulate the existing conditions of the groundwater regime and provide predictions of the potential impacts of the proposed mining activities.

The model represents the hydrogeology of the project mining area and its surrounds based on the conceptual groundwater model described in the Groundwater Report and the proposed mine plan and mining schedule of the project. The modelling results presented in this appendix have been used to support the assessment of groundwater impacts presented in the Groundwater Report.

1.1 Model Objectives

A calibrated groundwater flow model was developed for the project and its surrounds to assess the impact of project depressurisation on the local and regional groundwater systems. The groundwater flow model also incorporates cumulative stresses from neighboring mining activities.

The objectives of the model were to quantify:

- Changes to local and regional groundwater flow patterns due to the project;
- Project-specific depressurisation on groundwater resources, users and the environment;
- Groundwater inflow into project underground mining area;
- Groundwater recovery following cessation of the project operations; and
- The project contribution to cumulative depressurisation on groundwater resources, users and the environment.

The sensitivity of the model to key parameter changes was tested.

1.2 Model Domain and Hydrogeological Study Area

Figure A1 and Figure A2 present the spatial extents of the groundwater flow model domain. The model domain was selected to reflect the regional hydrostratigraphic units while also ensuring sufficient lateral extents to include relevant existing and approved future mining and CSG operations in the region. The location of existing and approved future mines near the project mining area is shown in Figure 1 of the Groundwater Report. In setting the model domain, the potential extent of project groundwater impacts were also considered.

The established model domain boundaries and orientation are as follows:

- The western limits of the model reflect the outcrop of the Back Creek Group and thus defines the extent of the overlaying Permian sediments;
- The northern extent of the model is positioned to include the Moranbah North Mine;
- The eastern extent of the model is positioned to incorporate the mining activities of the Carborough Down Mine and Millennium Mine;
- The southern limit of the model was located to include the Poitrel Mine and the Moranbah South Project; and

- The model has been slightly rotated to align the principal axis of the model along the strike and dip of the thrust fault as this geological feature plays a significant role in the groundwater flow regime.

1.3 Application of the Conceptual Model

Development of the groundwater flow model is based on the conceptualisation of the hydrogeological system. This conceptualisation is described in Section 5 of the Groundwater Report. The hydrogeological conceptualisation is a descriptive representation of the groundwater flow system and stresses. The closer the conceptual understanding approximates the field situation, the better the performance of the numerical model in making predictions (Anderson and Woessner, 1991). The conceptual understanding defines the key processes of the groundwater system with consideration to the influence of stresses (Barnett et al., 2012).

The application of the conceptual understanding to the groundwater flow model required synthesis and description of the geology framework and consideration of the groundwater flow systems that are present within the vicinity of the project mining area.

The Isaac thrust fault is a key geological feature in the vicinity of the project mining area. The position of this structure defines the location of appreciable hydrostratigraphic unit displacement and has been represented by model layer elevations and hydraulic property zones. In this setting the fault is likely to restrict groundwater flow in the horizontal direction as discussed in Section 5 of the Groundwater Report.

2 MODEL DESIGN

2.1 Model Code Selection

MODFLOW-SURFACT Version 4.0 was used to undertake the numerical modelling for this assessment. This modelling platform is based on the groundwater flow model MODFLOW, while MODFLOW-SURFACT has the additional ability of implementing the Newton-Raphson technique in solution of model heads. This addition accommodates the drying and re-wetting of model cells in a robust manner, which is a pervasive condition in regional models developed for predictions of mining operations.

In this model variable saturation is implemented using a pseudo-soil function method with upstream weighting for the calculation of relative hydraulic conductivities.

The model also utilises an adaptive-time-stepping approach to assist in the solution of non-linear problems associated with the model simulations.

2.2 Model Processing and Discretisation

A combination of Groundwater Vistas Version 7.19 and PLPROC (Doherty, 2016b) were used for model construction and for model results post-processing.

The model grid was constructed from a base grid comprising 400 m x 400 m cells. Grid refinement is used over an area that encompasses the Isaac Plains Complex. In this area of model grid refinement cell sizes are progressively reduced to 50 m x 50 m. The grid is further refined to 25 m grid cells within the project mining area.

The model grid is rotated by 13 degrees to the west to better align the principal axis of the model with the strike of the thrust fault. Figure A3 shows the rotated model domain and associated grid refinement.

2.3 Units and Datum

The time unit for the model is days and the length unit is meters. In the horizontal direction the model uses the AMG Zone 55 projection, while the vertical datum is the Australian Height Datum (AHD) in meters.

2.4 Model Layers

The hydrostratigraphy of the study area was represented using 17 model layers that are continuous across the model domain. Discontinuity of the units is accommodated by applying hydraulic parameters of the underlaying units where appropriate. The uppermost model surface is defined by a digital elevation model derived from 1 second Arc SRTM data blended with 2017 LiDAR derived elevations over the project mining area and its surrounds. The elevation data was provided by the proponent.

Table 2-1 presents the model layers and the primary geological units that are represented by each. The top two layers are used to represent the unconfined to semi-confined Quaternary and Tertiary units.

Both the Triassic Rewan Formation and the Fort Cooper Coal Measures are distributed over five layers, on opposite sides of the thrust fault, to accommodate the extra layers that arise from offsets in the elevations of the geological units across the fault.

Table 2-1: Summary of Model Layers

Model Layer	Geology West of Isaac Thrust Fault	Geology East of Isaac Thrust Fault
1	Alluvium, Tertiary Sediments, Basalt	Alluvium, Tertiary Sediments, Basalt
2	Tertiary Sediments, Basalt	Tertiary Sediments, Basalt
3	Weathering Profile, Basalt	Weathering Profile
4	Pseudo layer - Rewan Formation	Rewan Formation
5	Pseudo layer - Rewan Formation	Rangal Coal Measures - Overburden
6	Pseudo layer - Rewan Formation	Rangal Coal Measures - Overburden
7	Pseudo layer - Rewan Formation	Rangal Coal Measures: Leichardt Seam
8	Rewan Formation	Rangal Coal Measures - Interburden
9	Rangal Coal Measures - Overburden	Rangal Coal Measures: Vermont Seam
10	Rangal Coal Measures - Overburden	Pseudo layer - Fort Cooper Coal Measures
11	Rangal Coal Measures: Leichardt Seam	Pseudo layer - Fort Cooper Coal Measures
12	Rangal Coal Measures - Interburden	Pseudo layer - Fort Cooper Coal Measures
13	Rangal Coal Measures: Vermont Seam	Pseudo layer - Fort Cooper Coal Measures
14	Fort Cooper Coal Measures	Fort Cooper Coal Measures
15	Moranbah Coal Measures - Overburden	Moranbah Coal Measures - Overburden
16	Moranbah Coal Measures: Goonyella Middle Seam	Moranbah Coal Measures : Goonyella Middle Seam
17	Moranbah Coal Measures - Underburden	Moranbah Coal Measures - Underburden

The surfaces of the above layers are derived from the following:

1. Contours provided by the proponent from the geological block models on both sides of the thrust fault and includes:
   - Depth of cover above the top of the Leichardt Seam;
   - Leichardt seam floor and roof; and,
   - Base of Tertiary units.
2. Borehole logs from Geological Survey of Queensland drilled investigation holes;
3. Publicly available CSG drilling logs accessed from the QDEX database;
4. Surfaces and data from the Bowen Basin Supermodel 2000; and,
5. Outcrop locations of Permian formations from surface geology mapping

2.5 Model Boundary Conditions

Boundary conditions are necessary for solution of the 3D groundwater flow equation that is implemented by MODFLOW-SURFACT. They also provide a means by which auxiliary groundwater fluxes and stresses can be specified within the model. The following boundary conditions have been adopted in the model:

- Rainfall Recharge was applied in zones based on the extents of outcropping geological units, using the RCH package of MODFLOW. Recharge is regarded as the fraction of rainfall that passes through the unsaturated zone and arrives at the groundwater system. Within the model it has been calculated as a percentage of historically recorded monthly rainfall totals. Seven recharge zones are defined, each of which has a unique recharge rate that reflects the porosity of the strata through which it infiltrates. The percentage of rainfall that enters the model as recharge in each zone was adjusted during calibration. The zones are defined by the extents/outcrop of Quaternary alluvium, Tertiary sediments, Tertiary basalt and Permian sediments, and are shown in Figure A4;

- Evapotranspiration is a boundary component of the water budget for the groundwater system. In this model, it has been implemented using the MODFLOW EVT package. A uniform extinction depth has been applied across the domain and set at 1.5 m below the natural surface, below which evaporative losses from the groundwater surface are zero. Where the groundwater elevation is above this level, water is removed from the system at a maximum rate of 1,200 mm/annum. This value is adopted from the average areal potential evapotranspiration map (BOM, 2008), which is based on a standard 30-year climatology from 1961-1990;

- General Head Boundary cells (GHB package) were implemented around the active perimeter of the model domain. They are applied to all layers of the model. Use of this boundary type allows for the regional groundwater flow system to be better replicated in the semi-regional model developed here. Conductance values applied to the GHB cells were calculated to be consistent with hydraulic conductivity values for each hydrostratigraphic unit and the dimensions of the boundary cells. A reference head for these cells was obtained from steady state model heads in a pre-development scenario.

This boundary is sufficiently distant from the study area so as not to materially influence model performance;

- The major water courses in the model domain are represented using the MODFLOW Drains package (DRN). The surface drainage system of the area is ephemeral in nature. When stream flows do happen, they are usually rapid and persist for short periods of time. Under these circumstances use of drains along these reaches is considered appropriate. In these cells the reference head was specified as the model top and a conductance was calculated to be consistent with the hydraulic conductivity and dimensions of the cell in which they are placed;

- Drains cells have also been used to simulate open-cut and underground mining activities. For open-cut mining, drains are placed in all layers above and including the target extraction seam layer. In underground mining, drains are placed in the target seam only. Reference heads were specified as the bottom of the layer in which drain cells were placed, while conductance values for these cells were nominally set higher than 10 m^2/day; and

- The default, no flow boundary condition is used on the base of the model which coincides with the interface between the Moranbah Coal Measures and the Back Creek Group. This boundary is located at significant depth in the vicinity of the project mining area at has no significant bearing on the model results.

2.6 Application of Hydraulic Properties

Hydraulic properties for the model layers 1 to 3, corresponding to the Quaternary and Tertiary age units and the weathered surface of the Permian age sediments, have been applied in a zonal fashion. This was also the approach adopted for the Rewan Formation, Fort Cooper Coal Measures and the Permian overburden/interburden/underburden units. In the case of the Leichardt, Vermont and Goonyella Middle Coal Seams, a depth dependent relationship has been applied to horizontal/vertical hydraulic conductivities.

Conceptually, the horizontal and vertical hydraulic conductivity of the Permian coal seams reduces as a function of the depth of the material. This is the result of increasing pressure on the seams, as depth increases, due to the overlaying material which causes a compressing of cleats and therefore a decrease in conductivity. As the general dipping of the Permian units is laterally west to east at the site, the distribution of hydraulic conductivity is therefore spatially variable within the model domain.

The equation that has been implemented to describe coal seam horizontal hydraulic conductivity variability is:

$$Kh_{coal} = Kh_0 \times depth^{(slope)}$$

Where: Kh_{coal} is depth specific horizontal hydraulic conductivity;

Kh_0 is horizontal hydraulic conductivity of material at depth of 0 meters;

slope is a term representing steepness of the curve;

depth is the depth to the mid-point of the cell at that location.

Figure A5 illustrates these relationships. Note the use of log scale for conductivity in this figure. During the calibration process the terms Kh_0 and $slope$ of the above equation were estimated.

Adjustment of the Kh_0 term has the effect of raising or lowering the curves presented in Figure A5. Adjustment of the $slope$ term alters the gradient of the curves. Figure A5 demonstrates the calibrated settings for the three modelled coal seams.

Vertical hydraulic conductivity in all layers is calculated as a factor of the horizontal hydraulic conductivity. Therefore, in the layers where coal seams are represented, vertical hydraulic conductivity also varies spatially across the model domain in accordance with decreasing horizontal hydraulic conductivity.

2.7 Calibration Process and Metrics

Model calibration was performed based on the adjust of model parameter values to all better replicate of historical observations of the system. The outcome of the calibration process also provides the initial conditions for transient predictive simulations used to assess potential impacts of the project on the groundwater regime.

The transient period used for model calibration consists of monthly stress periods over the duration January 2015 to April 2018. This was preceded by a steady-state stress period to condition the model prior to the transient calibration. For predictive model runs a quarterly stress period sequence was adopted.

2.7.1 Calibration Approach

The location of the project mining area within this area of the Bowen Basin has numerous mining operations that have been in operation for some time. Calibration of this model aimed to focus parameter estimation on the more recent prevailing conditions over the period January 2015 to April 2018. This duration also captures the vast majority of available observation data acquired at the Isaac Plains Complex.

The calibration model run is initiated in steady state with boundary conditions applied to replicate known mining development at the beginning of 2015. Following this initial model conditioning period, the model transitions to transient mode for the aforementioned calibration period in which monthly stress periods are implemented. This stress period length readily accommodates

the inclusion of seasonal, climatic variations in rainfall records. All observations used as calibration targets pertain to the transient component of the simulation.

Automatic parameter estimation was implemented with the use of PEST (Doherty, 2016a). In all, 82 adjustable parameters were used. These include hydraulic conductivities, storage properties and recharge factors.

2.7.2 Calibration Targets

All observations that comprise the calibration dataset are water level measurements. These measurements are compiled from 18 monitoring bores for which reliable water level measurements were available over the transient simulation period. In total, 4,572 individual measurements are used in the calibration process, with the majority of these arising from eleven installed water-level recording data-loggers.

2.7.3 Calibration results

Figure A6 presents a comparison between groundwater level measurements and the calibrated model output equivalents. During calibration, all measurements of the calibration dataset were given equal weight, thereby seeking to extract maximum information from the calibration dataset in inference of parameters.

Table 2-2 presents statistics from the calibration process. As can be seen in this table, the scaled root Mean Square (SRMS) of errors is 3.6% which is within the guidance limits recommended by the Australian Groundwater Modelling Guidelines (Barnett et al., 2012) of 10% SRMS.

Hydrographs demonstrating the fit between modelled and measured observations, achieved through the calibration process, are shown in Figures xx to xx.

Table 2-2: Summary Model Calibration Performance

Statistical Metric	Value
Number of Observations	4,572
RMS error (m)	3.1
Scaled RMS (%)	3.6
Mean Sum of Residuals (m)	-0.38
Scaled Mean Sum of Residuals (%)	2.2
Correlation coefficient	0.98

2.8 Calibrated Hydraulic Parameters

Table 2-3 summaries calibrated hydraulic property values for each geological unit represented in the model. As described in Section 2.6, hydraulic conductivity values of the Permian coal seams vary in accordance with the specified depth dependent relationship. As such the values presented in Table 2-3 for Leichardt, Vermont and Goonyella Middle Seams are average values arising in the vicinity of the proposed project. Similarly, the vertical hydraulic conductivity values presented in this table also represent average values for the aforementioned coal seams.

Table 2-3 : Summary Calibrated Hydraulic Properties

Geological Unit	Calibrated Kxy (m/d)	Calibrated Kz (m/d)	Calibrated Specific Yield (-)	Calibrated Specific Storage (m^{-1})
Isaac River Alluvium	4.2000	0.8650	1.55E-01	1.02E-04
All other Quaternary Deposits	0.5195	0.5195	4.98E-02	2.00E-05
Tertiary Basalt	0.3086	0.1582	5.02E-02	1.90E-04
Suttor Formation	0.0196	0.0020	5.00E-04	1.80E-05
All other Tertiary deposits	0.0102	0.0102	4.01E-04	1.61E-05
Weathering Horizon	0.6859	0.3551	3.98E-04	1.70E-05
Rewan Formation	0.0153	0.0144	4.09E-04	1.59E-05
Rangal Coal Measures - Overburden/Interburden	0.0023	0.0003	4.01E-04	1.65E-05
Rangal Coal Measures: Leichardt Seam	0.2500*	0.0220*	4.00E-04	1.62E-05
Rangal Coal Measures: Vermont Seam	3.80E-04*	3.03E-05*	4.00E-04	1.60E-05
Fort Cooper Coal Measures	1.65E-03	3.11E-04	4.00E-04	1.60E-05
Moranbah Coal Measures - Overburden/Interburden	2.08E-04	2.17E-05	4.00E-04	1.60E-05
Moranbah Coal Measures: Goonyella Middle Seam	2.10E-05*	3.10E-06*	1.07E-02	5.65E-06
Thrust Fault	1.00E-04	1.20E-04	5.00E-02	6.67E-06

Note: Hydraulic Conductivity values for coal seams are depth dependant; "*" indicates that reported values are average values across project mining area.

2.9 Calibrated Recharge Rates

Recharge to the model domain was calculated as a percentage of recorded rainfall within the model domain during each stress period of the calibration model run. During the steady state conditioning period, long-term average annual rainfall was converted to daily rainfall, while during the quarterly, transient periods, recorded quarterly rainfall totals were used to calculate average daily rainfall for that period. The percentage of this average daily rainfall that results as recharge were estimated during calibration and these are provided in Table 2-4.

Table 2-4 : Summary calibrated recharge rates

Modelled Recharge Zone	Percentage of Daily Rainfall
Quaternary Alluvium	0.53
Other Quaternary deposits	0.72
Tertiary Basalt	0.56
Suttor Formation	0.14
Other Tertiary deposits	0.25
Weathering Horizon	0.04

2.10 Calibrated Water Balance

The mass balance error of the transient calibration model represents the difference between model inflows and model outflows calculated by the model. An error of approximately 1% is considered acceptable (Anderson and Woessner, 1991). The model reported water budget for the steady state period of the calibrated model is presented in Table 2-5. The water balance error is less than 1%, indicating that convergence of the numerical solution of the groundwater flow problem has been achieved.

Table 2-5 : Summary Water Balance at the End of Calibration Period

Water Budget Item	Inflow (m^3/day)	Outflow (m^3/day)
Recharge (Rainfall deep drainage)	7,360	0
General Head Boundary Throughflow (Regional flow across model extents)	7,688	6,702
Evapotranspiration (from surface heating/vegetation)	0	6,819
Drains (Groundwater removed from system via mining and surface drainage)	0	876
Wells (Pumping from the Broadlea bore field)	0	610
TOTAL	15,049	15008
Mass Balance error	0.27%	

2.11 Model Classification

Barnett et al. (2012) developed a system to classify the confidence level of groundwater flow models based on the calibration process used and the predictive capability of the model. Three classes of model were developed: Class 1, Class 2 and Class 3. A Class 3 model has the greatest confidence level, and a Class 1 model has the least. Factors that are considered when determining model confidence level are:

- Data availability;
- Calibration procedures;
- Consistency between calibration and predictive analyses; and
- Stresses induced on the model.

The model outlined in this report is considered a Class 2 model because:

- A transient calibration was undertaken and mining-induced groundwater trends have been replicated;
- Independent observations and calculations were used to support the calibration process; and
- The water balance error is less than 1%.

The model meets the criteria for a Class 2 model, and exceeds the criteria for a Class 1 model. The model is therefore assessed as being a suitable tool for assessing groundwater impacts that may arise as a result of the project.

3 MODEL SIMULATIONS

3.1 Modelling Approach

The transient model for the predictive scenarios is an extension of the transient calibration model, and is comprised of annual stress periods for a 43 year period leading into the prediction period to allow development of surrounding mining operations to occur. Following this, the simulation then proceeds in quarterly stress periods for the life of the project. Mine development for the predictive scenarios comprises the progressive assignment of MODFLOW drain cells representing underground mining, and the modification of hydraulic parameters to represent mined underground workings.

For the simulation of mine advancement, drain cells were assigned to the corresponding target coal seam, and had an elevation equivalent to the seam floor. A drain conductance value of 10 m^2/d was applied to each drain.

The outcomes of this analysis are presented as Section 6 of the Groundwater Report.

3.2 Post – Closure Recovery

An analysis of post-closure recovery was performed to assess the response of the system to total cessation of mining operations. The model was run over a 1000 year period in which all drain cells were removed and recharge was applied in accordance with the long-term historical average. A pseudo-observation point was placed in the centre of the project mining area, within the Leichardt Seam, to examine the system response. The Leichardt Seam is the unit that is expected to be most impacted by project and local mining activities. Figure A7 shows the recovery in the Leichardt Seam following cessation of mining. This figure shows that recovery to a stable post-mining groundwater level happens quickly (approximately 50 years). The final recovery groundwater level is controlled by evaporation from the final voids of the Isaac Plains Complex.

3.3 Sensitivity Analysis for Predicted Project Impacts

3.3.1 Overview

A sensitivity analysis was performed to assess the response of the model to varying hydraulic properties and recharge rates. This analysis provides for a comparison of the influence of these properties on the outcomes of predictions made by the model. Impacts to predictions of mine groundwater inflows and maximum drawdown due to changes in hydraulic properties have been examined.

Parameters that were assessed during predictive sensitivities were grouped and varied in the following manner:

- Horizontal (Kh) and vertical (Kv) hydraulic conductivity of all layers was varied by 50 % above and below their calibrated values;
- Specific storage (Ss) and specific yield (Sy) values for all hayers was varied by 50 % above and below their calibrated values;
- Recharge rates (Rch) were varied by 50 % above and below their calibrated values; and

- Horizontal (Kh) and vertical (Kv) hydraulic conductivity of Isaac Thrust Fault was varied by 50 % above and below its' calibrated values.

3.3.2 Mine Inflow Estimates

The effects of the sensitivity scenarios on predicted mine inflows are shown in Figure A8. Table 3-1 presents a summary of the change in predicted mine inflows resulting from scenarios tested in the sensitivity analysis. This table shows that in this model, predictions of mine inflows are most sensitive to changes in hydraulic conductivity. Changes in storage values have a significant effect on inflow rates. The third column of Table 3-1 (i.e. SRMS metric) demonstrates that these changes in hydraulic property values significantly "de-calibrate" the model. Therefore, these scenarios represent extreme cases and not an accurate reflection of real world conditions.

Modelled recharge rates have a negligible impact on predicted mine inflows. Similarly, the hydraulic conductivity applied to the thrust fault, also has negligible effects on mine inflows.

Table 3-1 : Summary results from Sensitivity Analysis

Sensitivity Scenario	Parameter adjustment	Transient SRMS (%)	Maximum mine groundwater inflow (L/s)	Average mine groundwater inflow (L/s)
Calibrated – Baseline	NA	3.63	48.0	17.2
1	Kx and Kz: Minus 50%	46.6	32.4	12.0
2	Kx and Kz: Plus 50%	47.3	59.9	21.5
3	Recharge: Minus 50%	47.1	47.1	16.8
4	Recharge: Plus 50%	46.9	49.1	17.6
5	Ss and Sy: Minus 50%	47.3	38.1	13.1
6	Ss and Sy: Plus 50%	46.8	56.9	20.4
7	Fault Kx and Kz: Minus 50%	47.1	47.4	16.3
8	Fault Kx and Kz: Plus 50%	46.9	48.7	17.9

3.3.3 Drawdown Extents

The maximum extent of project induced drawdown that results from the scenarios outlined in Section 3.3.1 are shown in Figure A10, Figure A9 and Figure A11. These figures present the project drawdown effects in layer 2 (Tertiary basalt), layer 3 (weathered horizon) and layer 7/11 (Leichardt Seam – east and west of the thrust fault). As can be seen from these figures, the extent of drawdown impact (defined by the 1 m drawdown contour) have limited changes under the sensitivity scenarios.

3.3.4 Sensitivity Classification

The Murray Darling Basin Modelling Guidelines (MDBC, 2000) provide a framework for classification of a predictive model parameters in terms of their impacts on the model. These can be summarised as follows:

- Type I: Insignificant changes to calibration and predictions;
- Type II: Significant changes to calibration with insignificant changes to predictions;
- Type III: Significant changes to calibration with significant changes to predictions; and
- Type IV: Insignificant changes to calibration and significant changes to prediction.

Types I to III present no concern where management decisions are to be based on the model, provided the model is calibrated and encapsulates sufficient complexity to replicate the system. However, Type IV classification may be of concern as calibration may have done little to reduce potential for predictive error.

With consideration to the results of the sensitivity analysis, parameters employed in this model can be considered Type I to II classification and are suitable for the purpose of supporting a groundwater assessment for the project.

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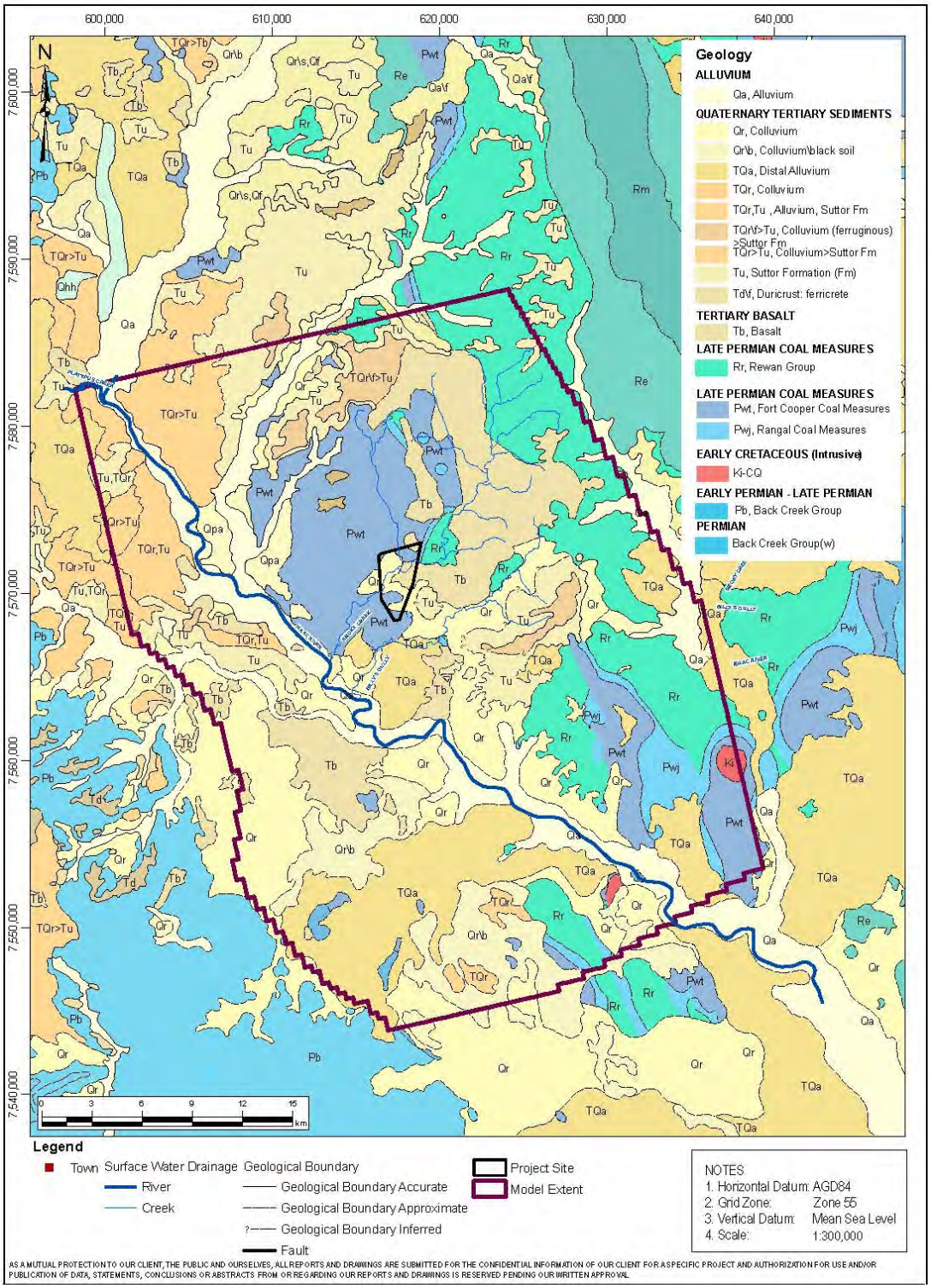

Figure A1: Model extent over surface geological mapping

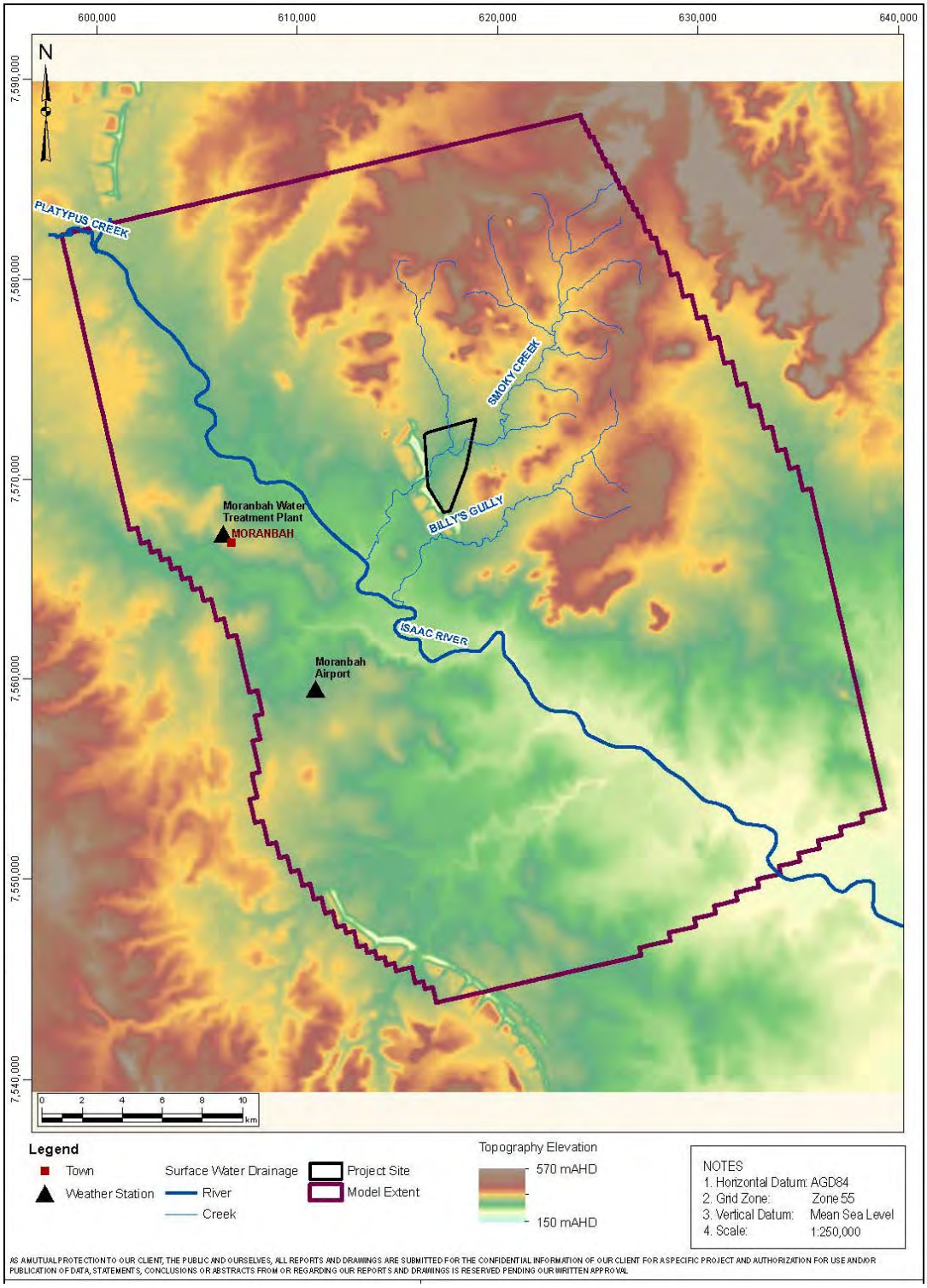

Figure A2: Model extent over topography

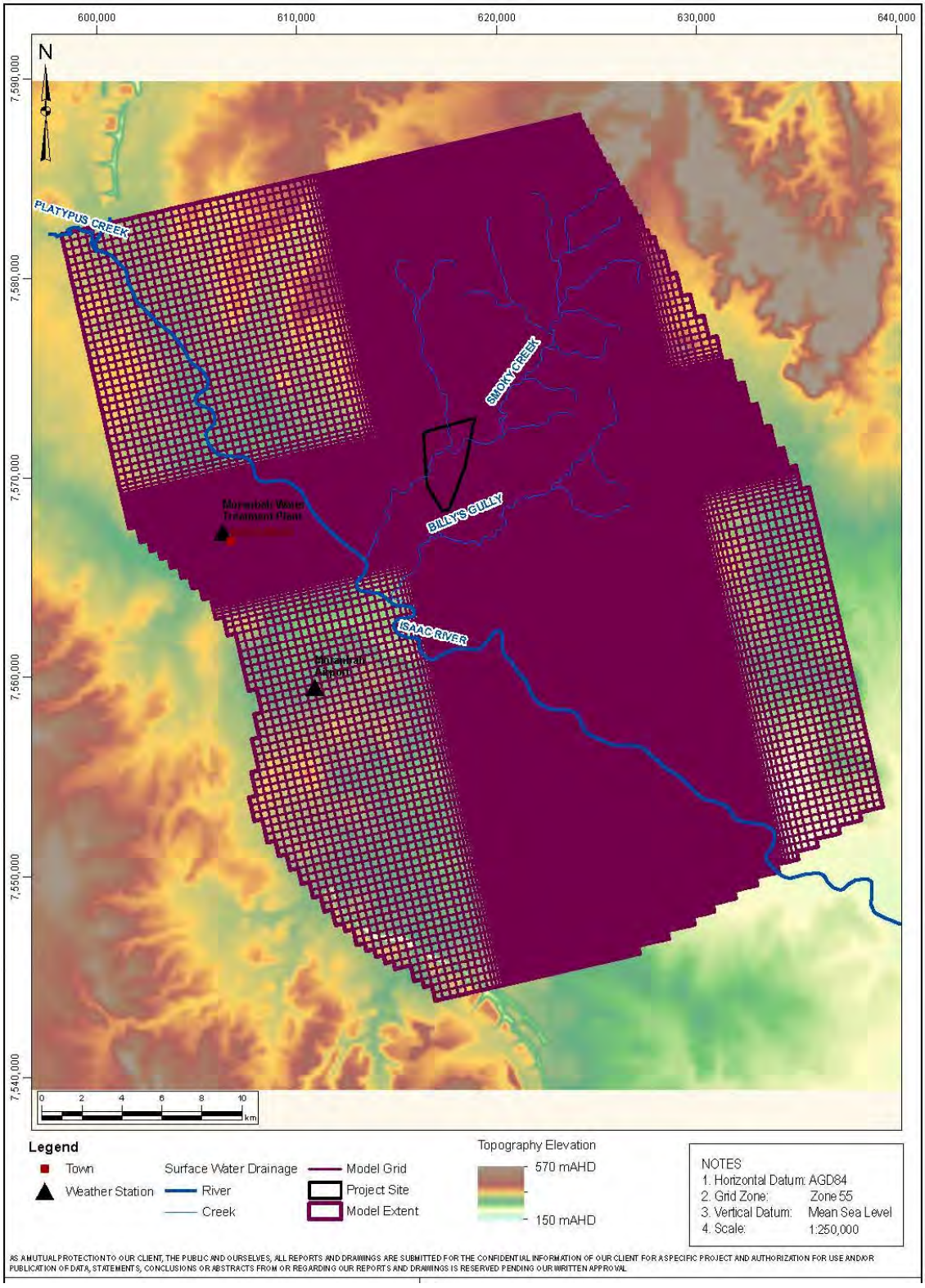

Figure A3: Model grid refinement

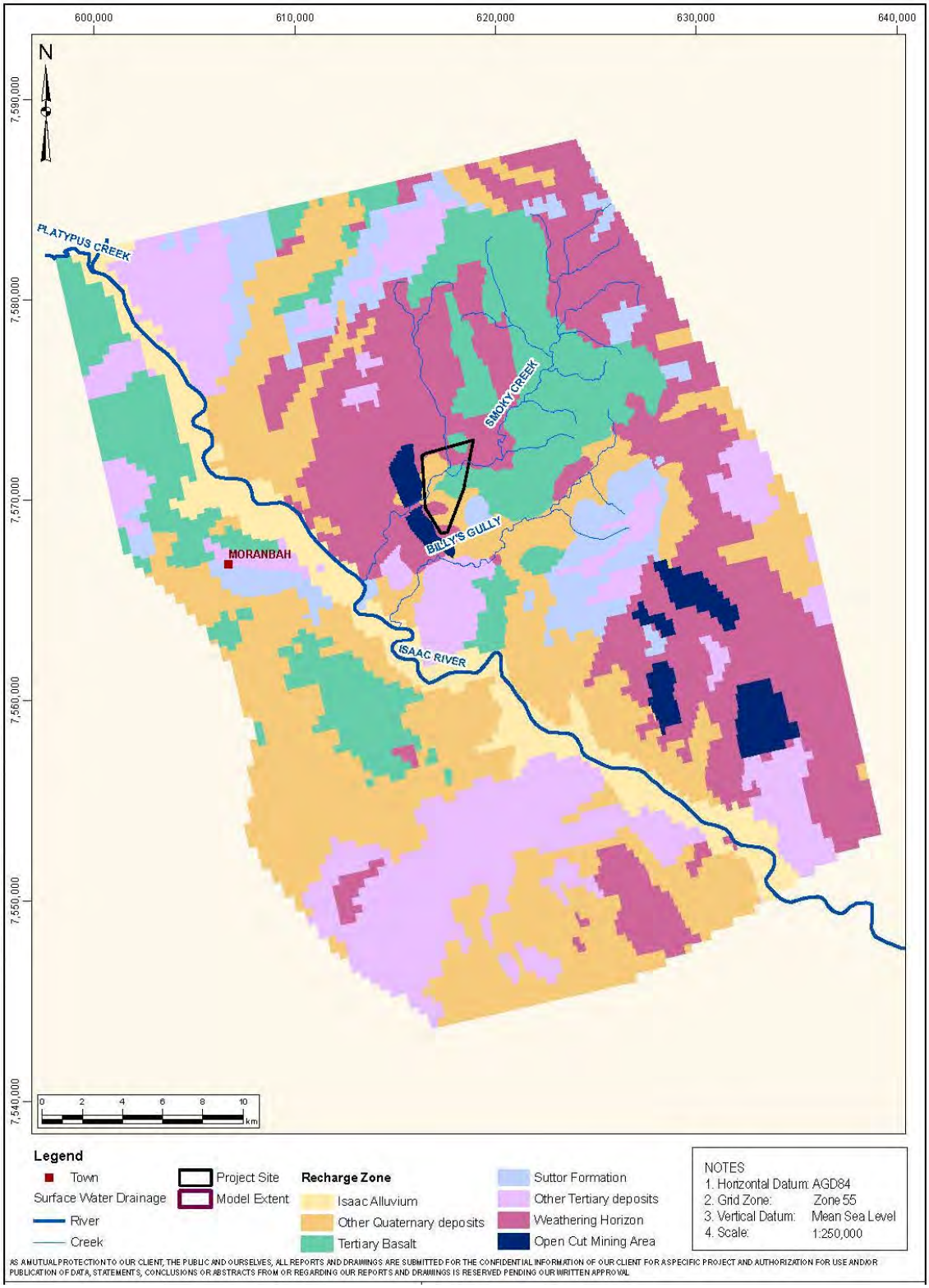

Figure A4: Recharge zones implemented in the model

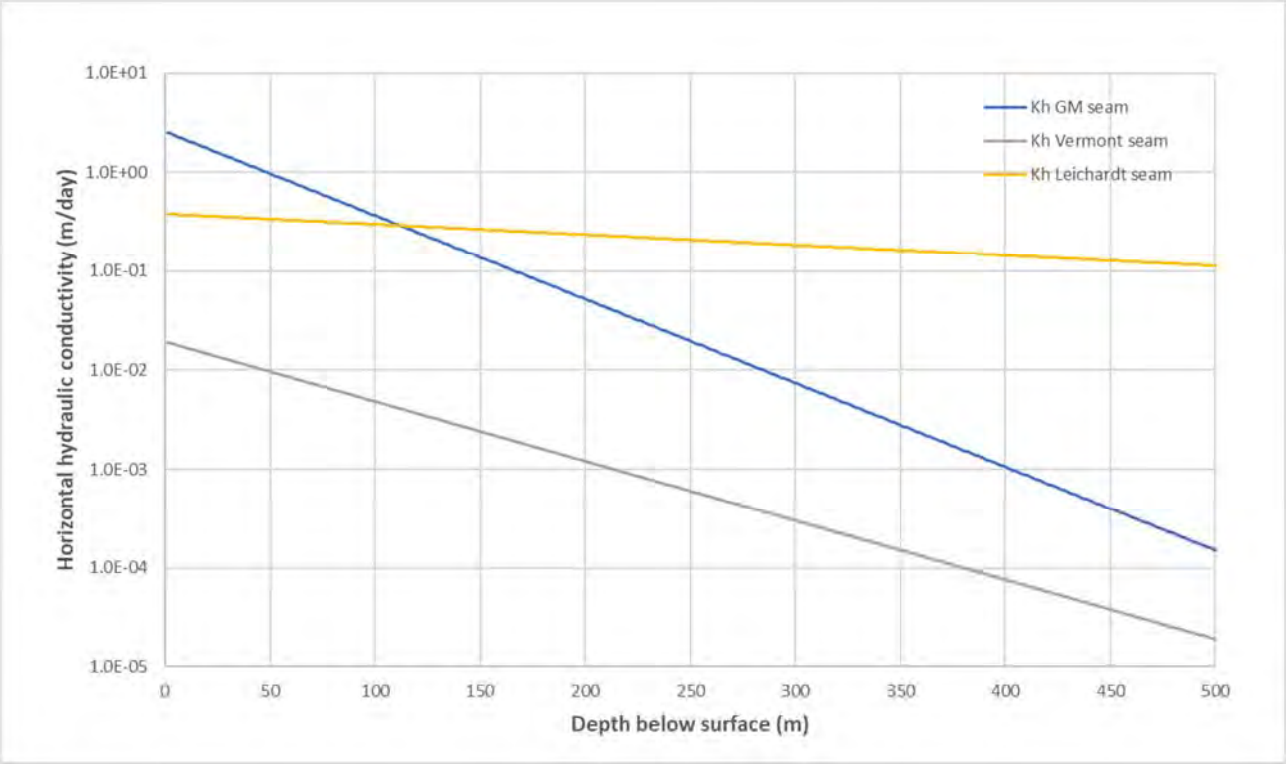

Figure A5: Depth dependent relationship implemented for distribution of hydraulic conductivities of coal seam layers

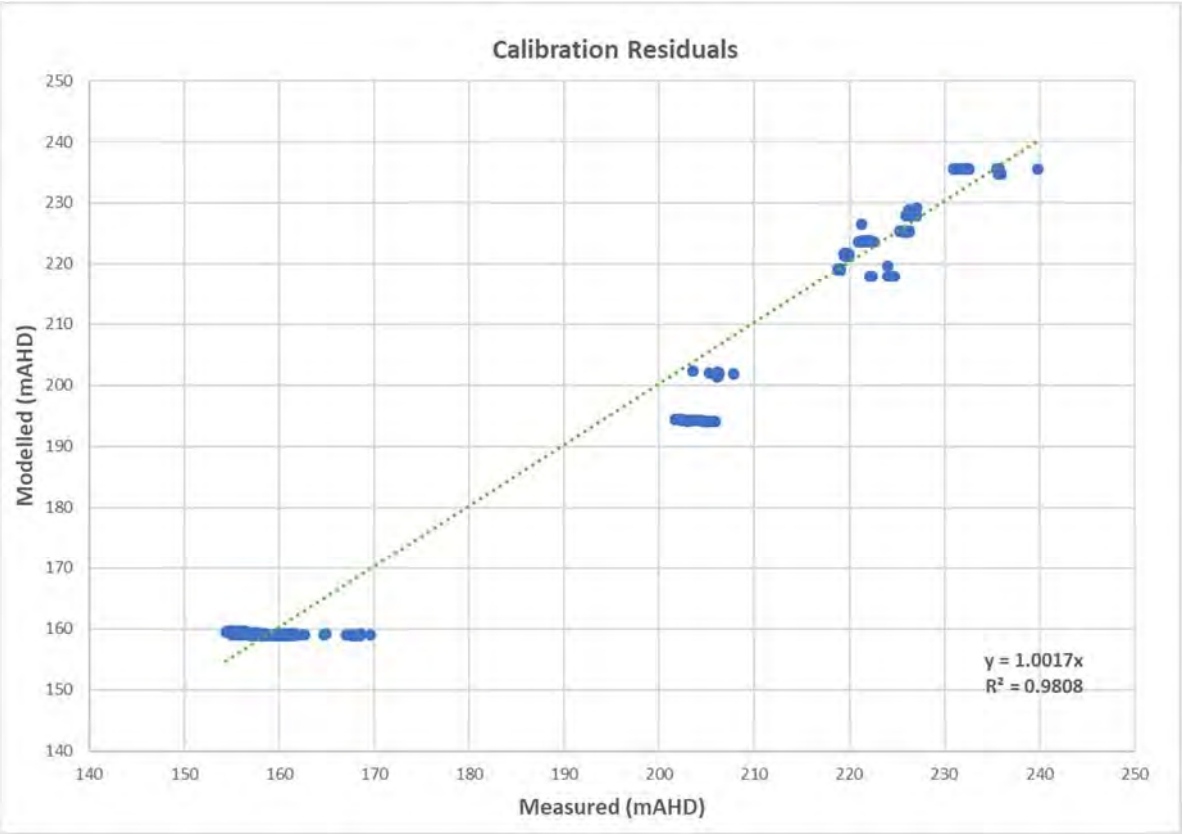

Figure A6: Cross-plot of calibration residuals

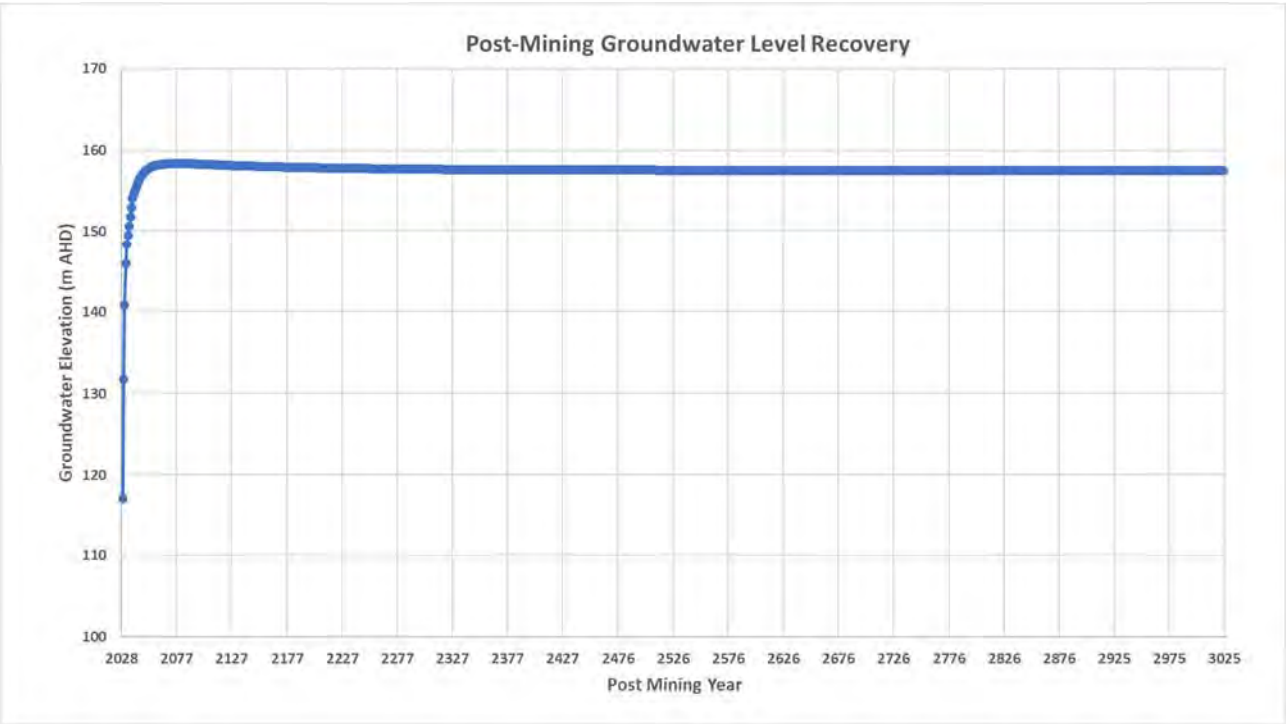

Figure A7: Post-closure recovery of the Leichardt seam

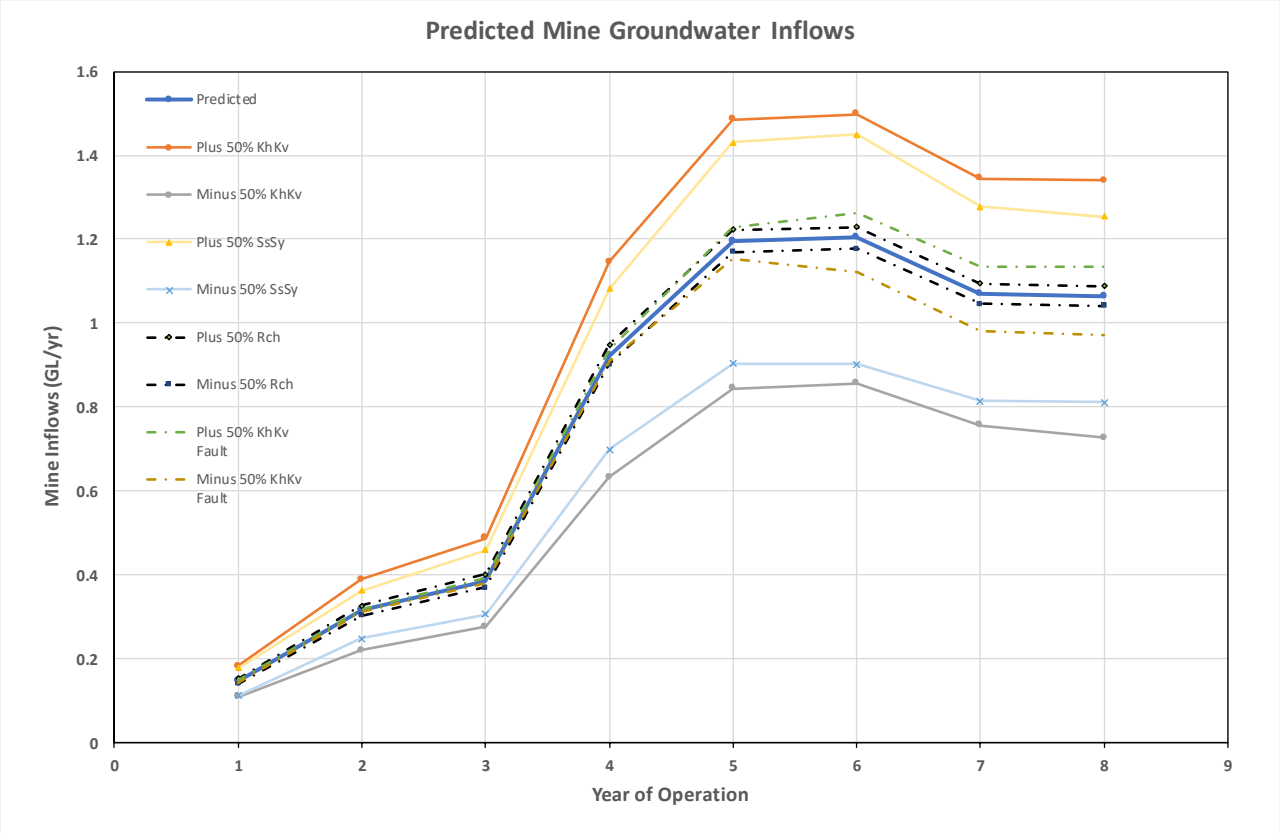

Figure A8: Sensitivity of predicted mine inflows

Figure A9: Sensitivity of zone of depressurisation – Tertiary Basalt

Figure A10: Sensitivity of zone of depressurisation – Weathered Horizon

Figure A11: Sensitivity of zone of depressurisation – Leichardt Seam

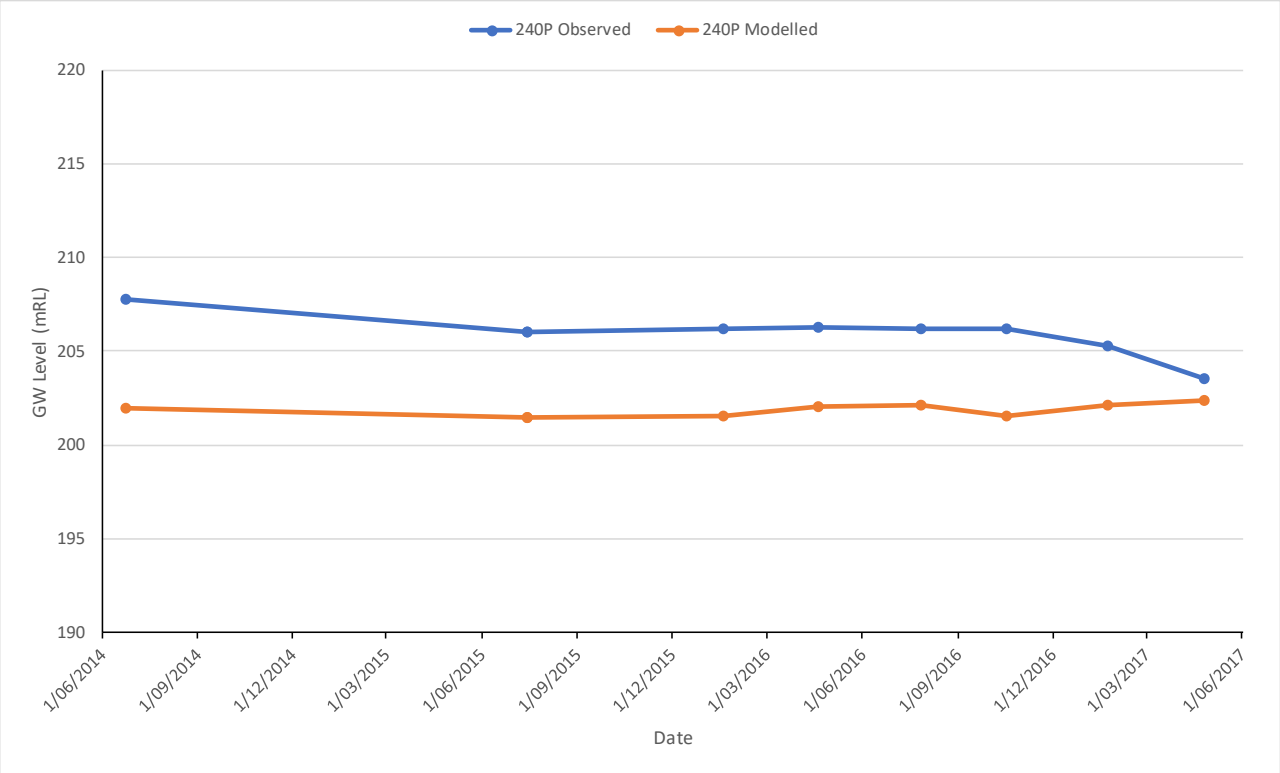

Figure A12: Modelled and observed groundwater levels from bore 240P

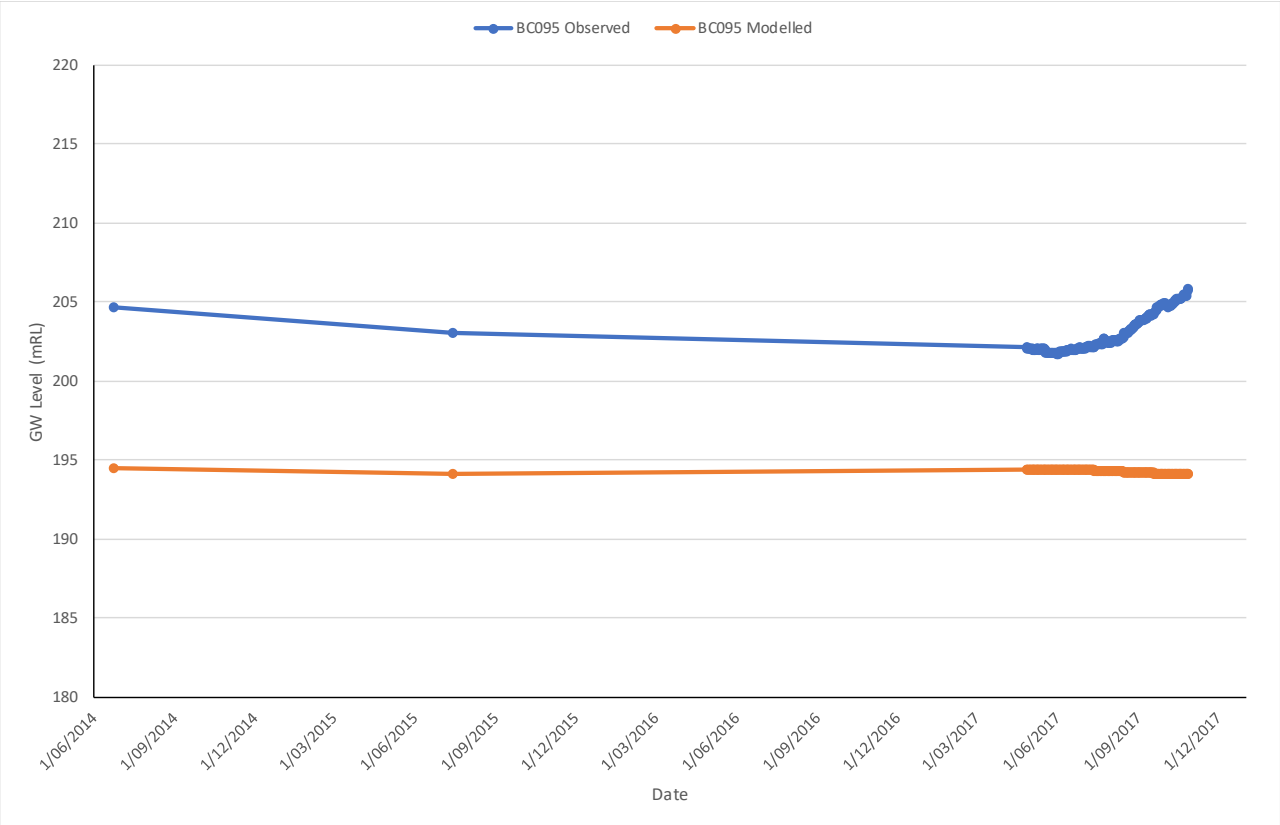

Figure A13: Modelled and observed groundwater levels from bore BC095

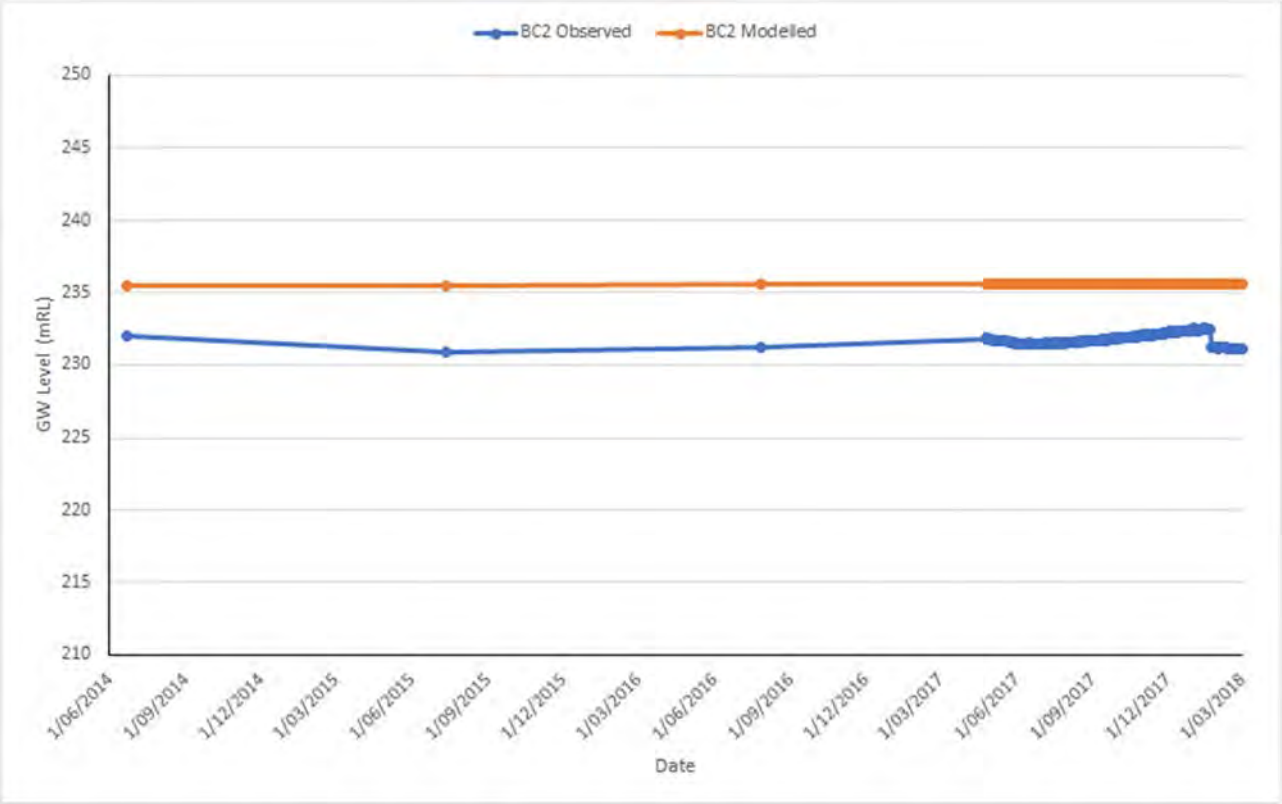

Figure A14: Modelled and observed groundwater levels from bore BC2

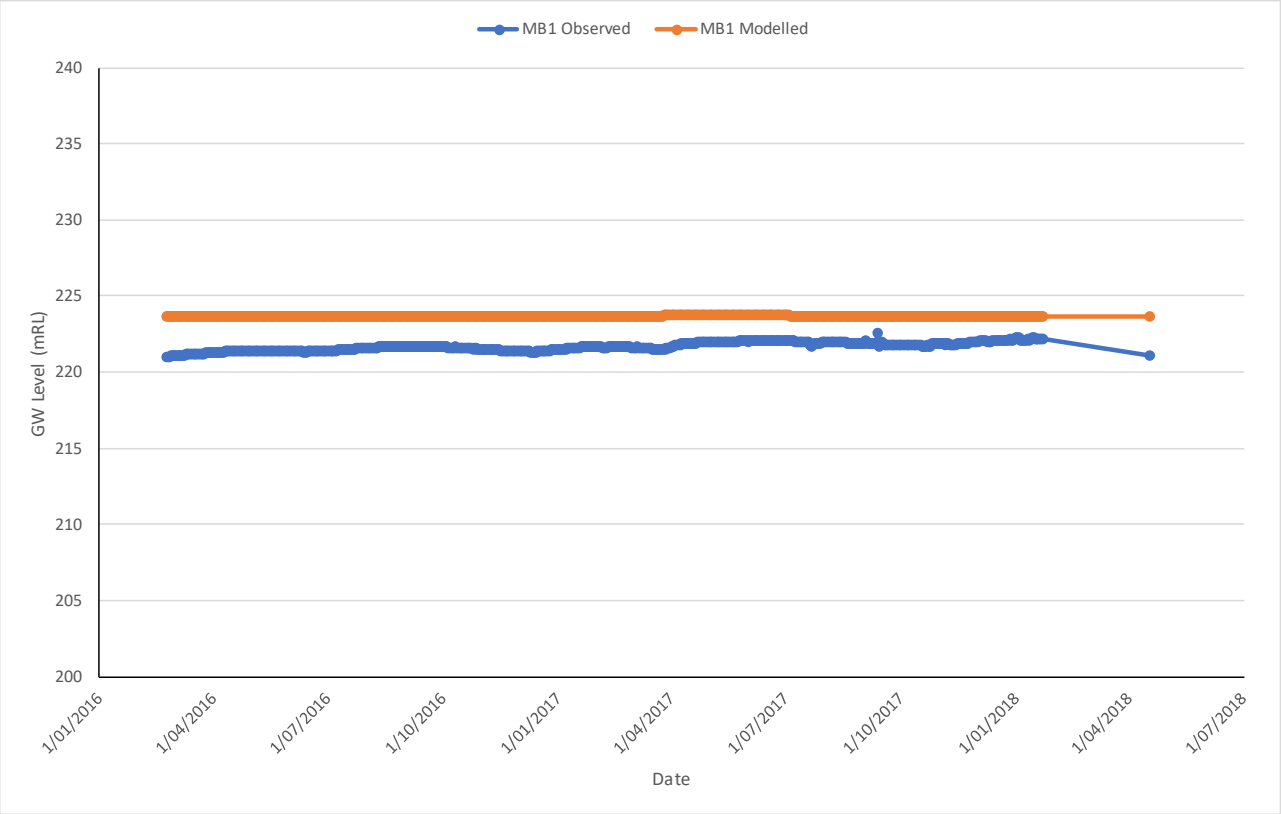

Figure A15: Modelled and observed groundwater levels from bore MB1

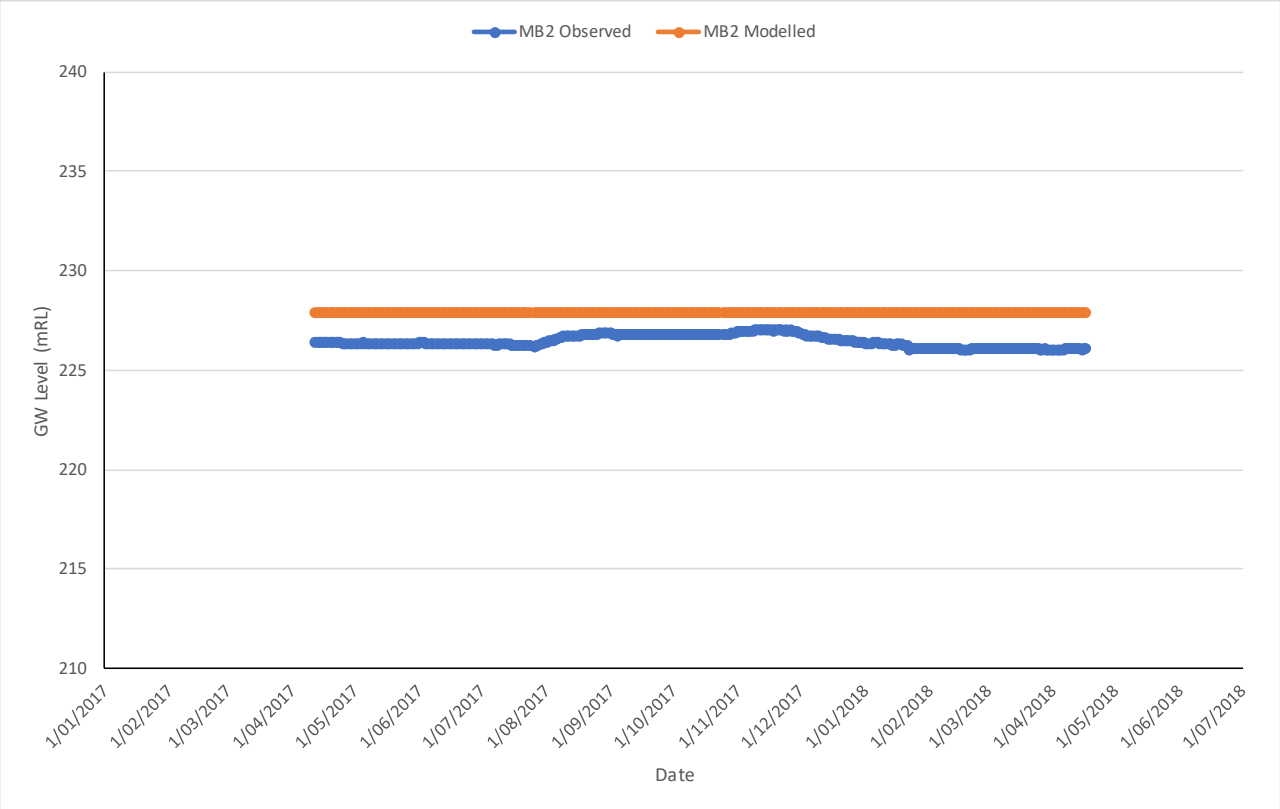

Figure A16: Modelled and observed groundwater levels from bore MB2

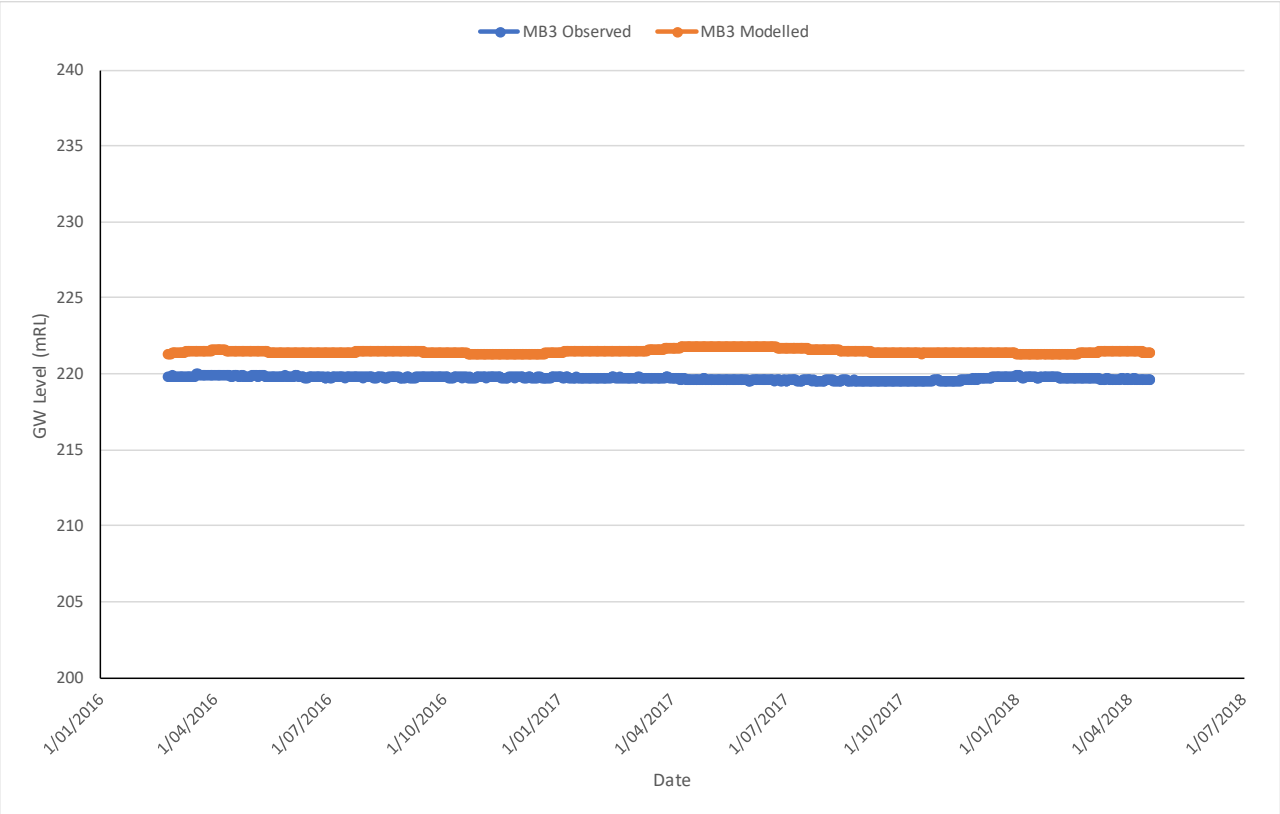

Figure A17: Modelled and observed groundwater levels from bore MB3

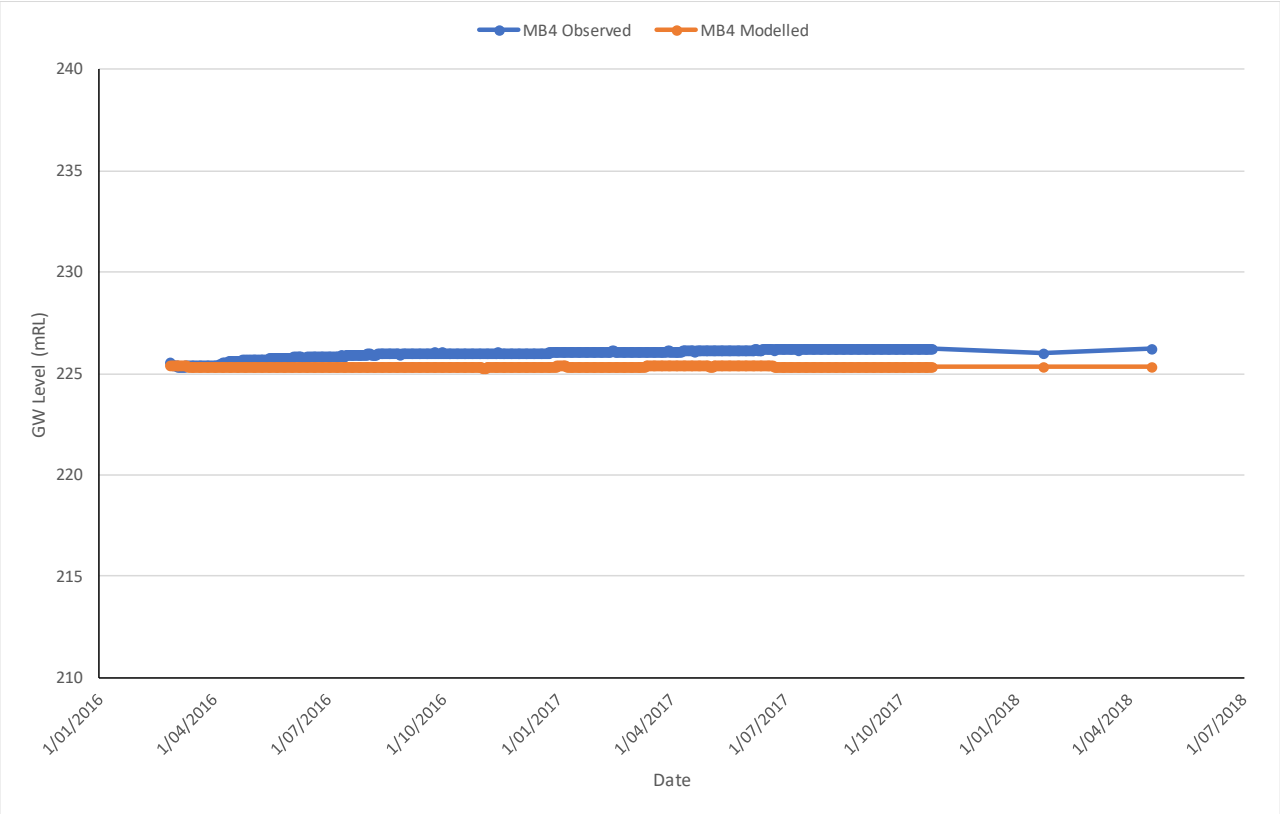

Figure A18: Modelled and observed groundwater levels from bore MB4

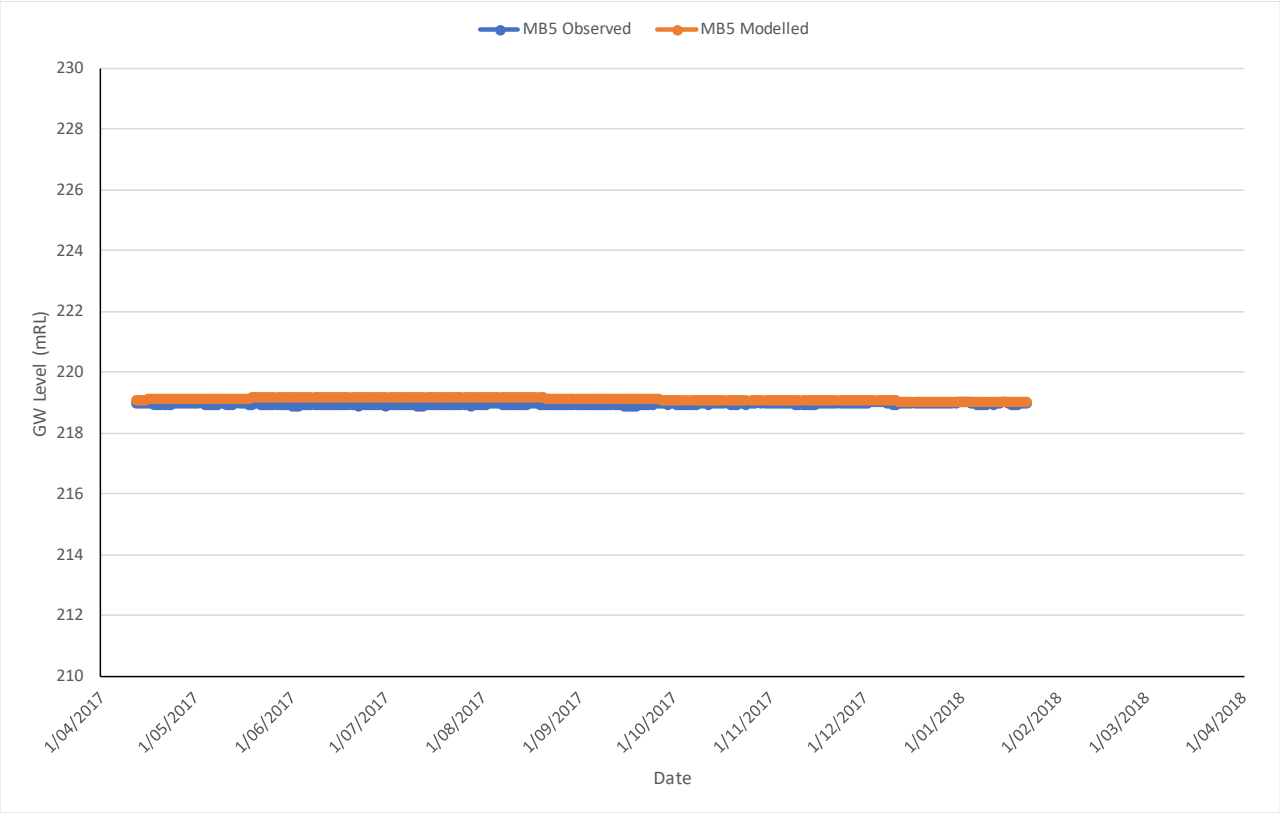

Figure A19: Modelled and observed groundwater levels from bore MB5

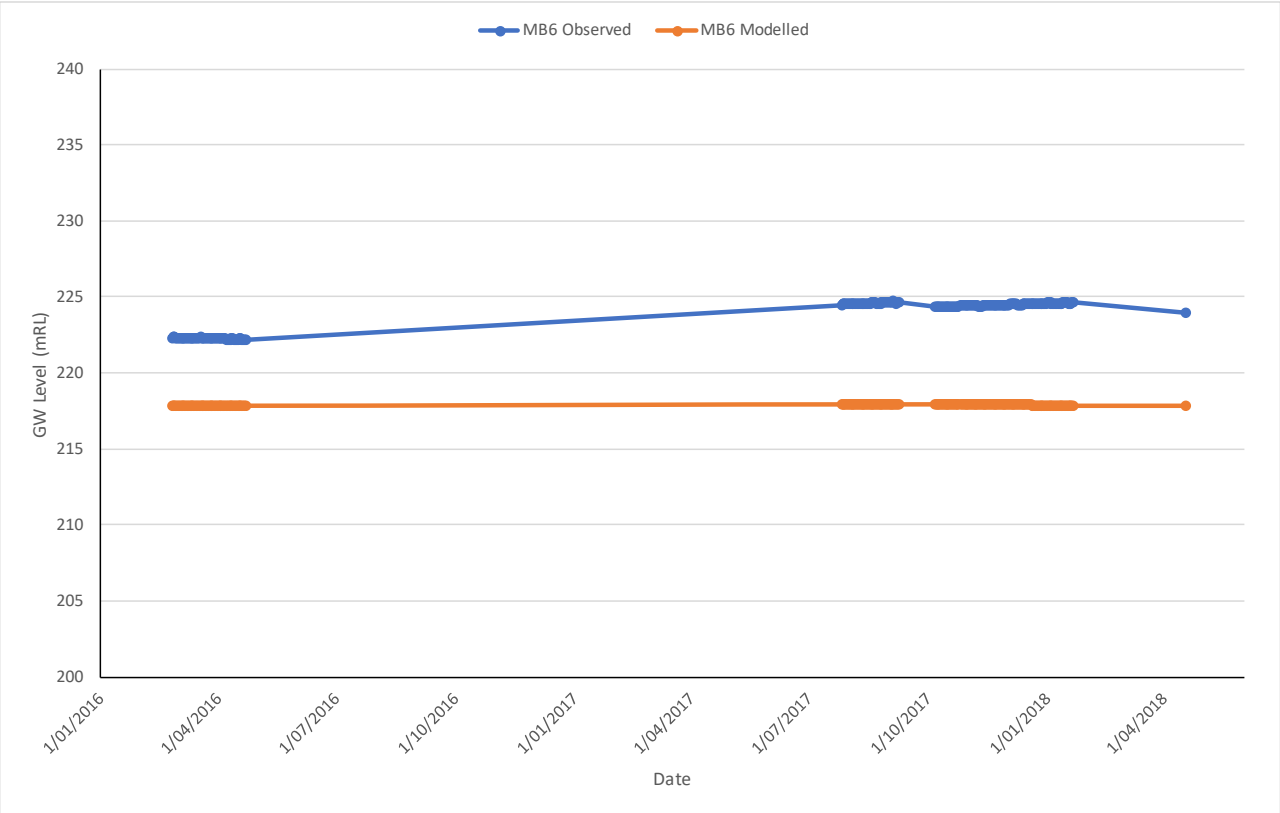

Figure A20: Modelled and observed groundwater levels from bore MB6

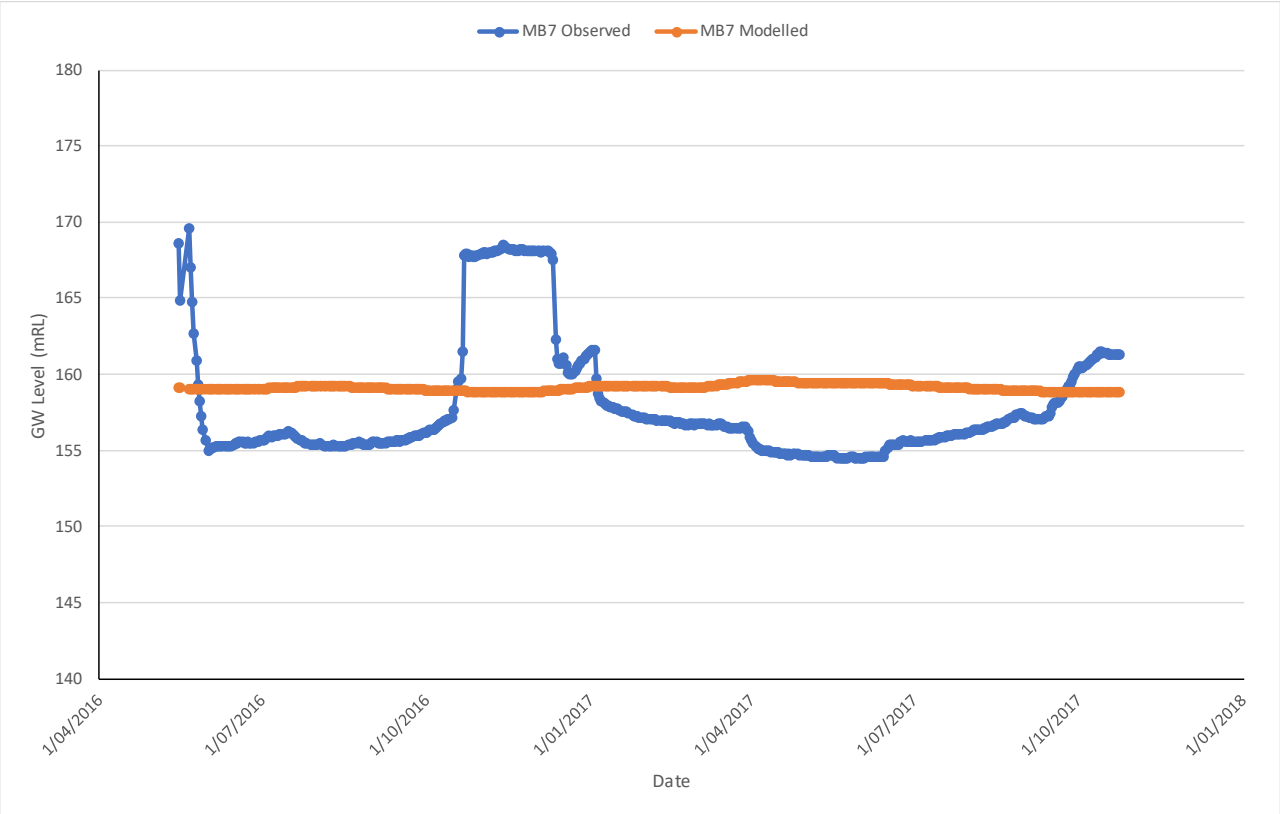

Figure A21: Modelled and observed groundwater levels from bore MB7

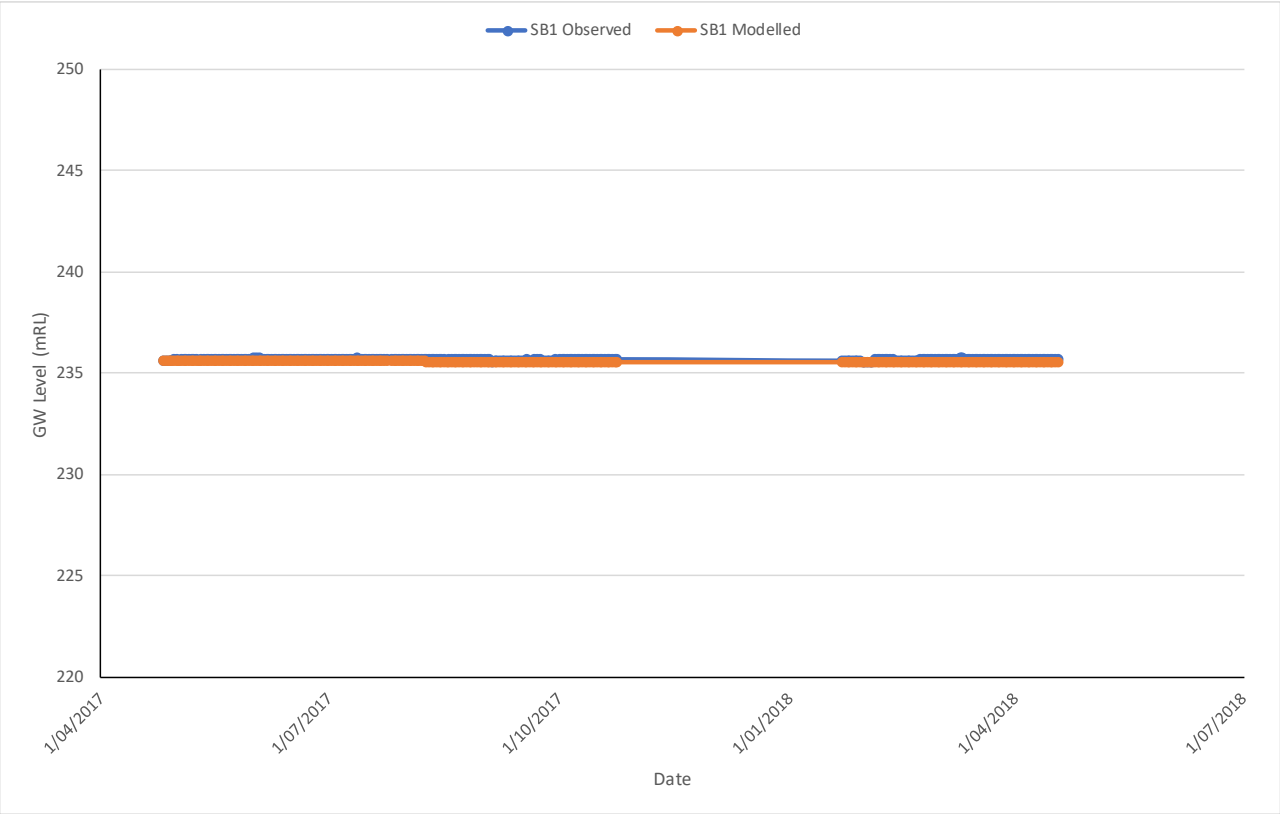

Figure A22: Modelled and observed groundwater levels from bore SB1

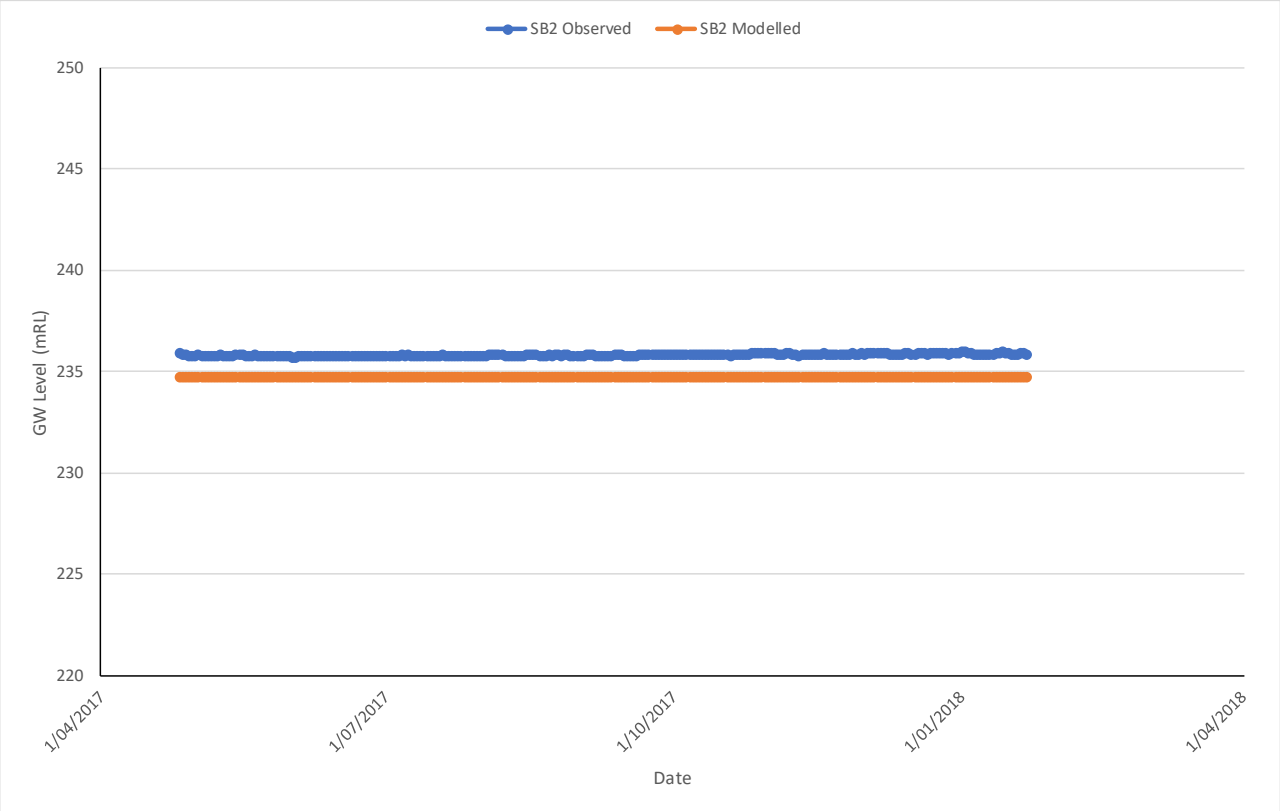

Figure A23: Modelled and observed groundwater levels from bore SB2

APPENDIX H GEOTECHNICAL REPORT (IPU)

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Geotechnical Assessment of Isaac Plains Underground Mine

For

Mastermyne and Stanmore Coal

DRAFT

Document Key : Isaac Plains UG Geotechnical Assessment		
Author	R Campbell	Principal Geotechnical Engineer
Checked	A Seccombe	Technical Manager
Approved	R Campbell	Managing Director
Revision Number	Date Created	BMS Review Date
Rev 2.0	28/07/2018	

Executive Summary

This report summarises a desktop study of the geotechnical assessment of the planned Isaac Plains Underground Mine within the Leichhardt Seam as part of an ongoing bankable feasibility report. Specifically, the study considers the geotechnical setting, and the applicability of extended plunge place changing development methods for first pass development. Along with secondary reserve extraction via bottom coal recovery, mining "bellouts" and pillar stripping using a modified Duncan Method proposed by the study team.

Isaac Plains Underground Project is a proposed brown fields operation in the northern Bowen Basin intended to be an additional reserve recovery option for the existing Isaac Plains Open cut operation. The Isaac Plains operation is located between Copabella and Moranbah townships.

The review considers the geotechnical and resource recovery risks associated with coal recovery using bord and pillar mining methods. The assessment is inclusive of first working and first workings followed by secondary extraction and includes a review of the geotechnical hazards that may limit regular mineability and reserve recovery using both first and second workings methods, considering both up-side and down-side risks.

Geotechnical Setting

The Isaac Plains Underground (IPU) project will extract coal from the 3.0 to 4.5m thick Leichhardt Seam within the Rangal Coal Measures. The planned working depth extends from around 90m at the highwall entries off the existing open cut operation to in excess of 350m to the eastern extent of the study area.

Exploration drilling, down hole geophysics, 3D seismic surveys and existing open cut mining operations over the years has defined the structural setting, along with typical seam thickness, dip, seam geometry and stratigraphic correlation. The geological interpretation and modelling of the data has identified some significant structures, both normal and reverse faults such is typical of the Rangal Coal Measures in this area of the Bowen Basin.

In addition, the exploration program has provided geotechnical data such as strata geomechanical characterisation, hydrological information, depth of cover and stress field quantification.

The data set is typical of a brown fields projects and of a suitable detail for bankable feasibility studies.

Stability Assessment

The assessment was undertaken using the empirical Coal Mine Roof Rating (CMRR) method, which has become an accepted methodology for quantifying coal mine strata geotechnical properties. The CMRR values combined with a statistical database can be used to give guidance on support requirements, plunge depths and roadway widths, as well as from different mines, coalfields and countries.

Typical CMRR values at IPU based on a stone roof beam forming the entire bolted section is typically between 40 and 50 and is classified as a "weak to moderate" roof, and the analysis indicates that mining to this roof horizon would be suited to extended cuts up to 15m at 6 to 6.5m width to a maximum depth of 250 to 300m. At depths of greater than 300m the empirical data base would suggest that extended plunges will not be viable.

In structured or deteriorating ground conditions the plunge depth would be reduced as controlled by a Trigger Action Response Plan (TARP).

It is proposed to use a multi-tiered TARP level of Code Green, Code Yellow and Code Orange, with Code Red being unexpected conditions requiring mining to be halted in that heading until a specific mining and support strategy is developed.

Code Green Plunge Depth at 6.0-6.5m width

- No more than 15m on stone roof

Code Yellow Plunge Depth at 6.0-6.5m width

- No More than 9m on stone roof

Code Orange Plunge Depth at 6.0-6.5m width

- No More than 6m on stone roof

In Code Red conditions, mining is to stop until a specific cut and support strategy is developed.

Support Recommendations

Analytical and empirical methods of support design analysis were used to provide guidelines for support density requirements for place change operations. The results indicate the following support levels would provide adequate Factor of Safety (FoS) criteria for bord and pillar drivage. Due to the range of depth of cover in the deposit two distinct depth domains have been used for the support recommendations, these being less than 250m DOC (depth of cover) and between 250m and 350m DOC.

Code Green Support 6.0m to 6.5m width to a depth of cover of 250m

ROOF SUPPORT

- For headings, a pattern of 4 x 1.8m roof bolts per 1.4m would be suitable for providing a stable mining environment to a depth of approximately 250m in unstructured ground.
- For intersections, a pattern of 6 x 1.8m roof bolts per 1.2m would be suitable for providing a stable mining environment to a depth of approximately 250m in unstructured ground.
- The roof should be meshed as a TARP response when needed.

RIB SUPPORT

- To a depth of 150m, rib support should be installed as a response to TARP conditions. Where rib support is installed a pattern of 2 x 1.2m rib bolts per 1.4m per rib would be suitable for providing a stable mining environment.
- From a depth of 150m to 250m, rib support should be installed on advance, a pattern of 2 x 1.2m rib bolts per 1.4m per rib.
- In intersections, the rib bolt spacing should match the roof bolt row spacing, where rib bolts are to be cut out during the formation of an intersection, cuttable rib dowels are to be used.
- Rib mesh should be considered as a TARP action when needed.

For structured ground or out of horizon development, a set of TARP's and support plans are required to manage the resultant geotechnical hazards. It is proposed to use a multi-tiered TARP level of Code Green, Code Yellow and Code Orange, with Code Red being unexpected conditions requiring mining to be halted and specific support plans to be developed.

Code Green Support 6.0m to 6.5m width to a depth of cover of 250 to 350m

ROOF SUPPORT

- For headings, a pattern of 6 x 1.8m roof bolts per 1.2m would be suitable for providing a stable mining environment to a depth of approximately 350m in unstructured ground.
- For intersections, a pattern of 6 x 1.8m roof bolts per 1.0m would be suitable for providing a stable mining environment to a depth of approximately 350m in unstructured ground.
- The roof should be meshed.

RIB SUPPORT

- From a depth of 250m to 350m rib support should be installed on advance, a pattern of 2 x 1.8m rib bolts per 1.2m per rib.
- In intersections, the rib bolt spacing should match the roof bolt row spacing, where rib bolts are to be cut out during the formation of an intersection, cuttable rib dowels are to be used.
- The rib should be meshed.

For structured ground or out of horizon development, a set of TARP's and support plans are required to manage the resultant geotechnical hazards. It is proposed to use a multi-tiered TARP level of Code Green, Code Yellow and Code Orange, with Code Red being unexpected conditions requiring mining to be halted and specific support plans to be developed.

Pillar Geometries

Depth of cover and extraction height are the main controlling factors for pillar size in bord and pillar sections. For the current IPU project, the environmental approvals limit the surface subsidence to 200mm and require a minimum of 1.6 FoS on all pillars. Analysis using the UNSW design criteria results in the following pillar size recommendations for the current mining areas extending out to 410m depth of cover.

Mining Height	**3.5m**			**4.0m**			**4.5m**		
Depth (m)	Size (m) centres	FoS	W/H	Size (m) centres	FoS	W/H	Size (m) centres	FoS	W/H
90	15.7x15.7	1.6	2.77	16.5x16.5	1.6	2.63	17.5x17.5	1.6	2.56
110	17.5x17.5	1.6	3.29	18.5x18.5	1.6	3.13	19.5x19.5	1.6	3.00
130	19x19	1.6	3.71	20.5x20.5	1.6	3.63	22x22	1.6	3.56
150	21x21	1.6	4.29	22.5x22.5	1.6	4.13	24.5x24.5	1.6	4.11
170	23x23	1.6	4.86	25x25	1.6	4.75	26.5x26.5	1.6	4.56
190	25x25	1.6	5.43	27x27	1.6	5.25	29.5x29.5	1.6	5.22
210	26.5x26.5	1.6	5.86	29x29	1.6	5.75	32x32	1.6	5.78
230	28x28	1.6	6.29	31x31	1.6	6.25	34x34	1.6	6.22
250	29.5x29.5	1.6	6.71	33x33	1.6	6.75	36x36	1.6	6.67
270	31x31	1.6	7.14	34.5x34.5	1.6	7.13	38x38	1.6	7.11
290	32x32	1.6	7.43	36x36	1.6	7.50	39.5x39.5	1.6	7.44
310	33.5x33.5	1.6	7.86	37.5x37.5	1.6	7.88	41x41	1.6	7.78
330	34.5x34.4	1.6	8.14	38.5x38.5	1.6	8.13	42.5x42.5	1.6	8.11

350	35.5x35.5	1.6	8.43	40x40	1.6	8.50	44x44	1.6	8.44
370	36.5x36.5	1.6	8.71	41x41	1.6	8.75	46x46	1.6	8.89
390	37.5x37.5	1.6	9.00	42x42	1.6	9.00	47x47	1.6	9.11
410	38.5x38.5	1.6	9.29	43.5x43.5	1.6	9.39	48.5x48.5	1.6	9.44

To optimise the place changing operational efficiencies in terms of plunges, a series of pillar designs that maintain a 30m length (two plunges) and varied the width up until the length becomes a limiting factor (i.e. wider than long) has been provided. At the point where the length is a limiting factor the project has opted for square pillars as per the above table.

Depth of cover (m)	Pillar width and length (m) centres			W/H Ratio
	3.5m mining height	4.0m mining height	4.5m mining height	
90	15 x 30	16 x 30	17 x 30	<4 Slender Pillars – higher risk of rapid deterioration
110	17 x 30	18 x 30	20 x 30	
130	18.5 x 30	21 x 30	23 x 30	
150	21 x 30	24 x 30	26 x 30	
170	23.5 x 30	26.5 x 30		
190	26 x 30			>4 squat pillars
210	29 x 30			

Modified Duncan Secondary Coaling Method

As part of the reserve optimisation process and assessment of a partial extraction method suitable for the deposit, the study team developed a pillar stripping design based on a modified Duncan Method. The modified Duncan method allows for secondary extraction of coal while proving for long term stable remanent pillars.

The design assumptions are similar as that used in the Duncan method with the same pillar FoS and subsidence restrictions. The modified Duncan method assumes no caving and the roof spans the extracted void with only minimal surface skin failure.

The analysis has been undertaken for 3.5 and 4.0m mining height.

DEPTH	HEIGHT					
130-150m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		20	31		1.8	4
Wide pillar		31	31		2.9	7.14
		Width Solids	Length Solids			
Remnant Pillar		25	25		1.7	7.14
DEPTH	HEIGHT					
130-150m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		20	34		1.63	3.5
Wide pillar		34	34		2.85	7
		Width Solids	Length Solids			
Remnant Pillar		28	28		1.7	7

DEPTH	HEIGHT					
150-170m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		20	32.5		1.6	4
Wide pillar		32.5	32.5		2.8	7.6
		Width Solids	Length Solids			
Remnant Pillar		26.5	26.5		1.7	7.6
DEPTH	HEIGHT					
150-170m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		22	36		1.65	4
Wide pillar		36	36		2.77	7.5
		Width Solids	Length Solids			
Remnant Pillar		30	30		1.7	7.5

DEPTH	HEIGHT					
170-190m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		22	34		1.66	4.57
Wide pillar		34	34		2.7	8
		Width Solids	Length Solids			
Remnant Pillar		28	28		1.65	8
DEPTH	HEIGHT					
170-190m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		24	38		1.66	4.5
Wide pillar		38	38		2.7	8
		Width Solids	Length Solids			
Remnant Pillar		32	32		1.67	8

DEPTH	HEIGHT					
190-210m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		23	36		1.6	4.86
Wide pillar		36	36		2.75	8.57
		Width Solids	Length Solids			
Remnant Pillar		30	30		1.68	8.57
DEPTH	HEIGHT					
190-210m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		25	40		1.6	4.75
Wide pillar		40	40		2.7	8.5
		Width Solids	Length Solids			
Remnant Pillar		34	34		1.67	8.5

DEPTH	HEIGHT					
210-230m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		25	37.5		1.63	5.4
Wide pillar		37.5	37.5		2.7	9
		Width Solids	Length Solids			
Remnant Pillar		31.5	31.5		1.64	9
DEPTH	HEIGHT					
210-230m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		27	42		1.6	5.25
Wide pillar		42	42		2.7	9
		Width Solids	Length Solids			
Remnant Pillar		36	36		1.65	9

DEPTH	HEIGHT					
230-250m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		26	39		1.6	5.7
Wide pillar		39	39		2.7	9.4
		Width Solids	Length Solids			
Remnant Pillar		33	33		1.63	9.4
DEPTH	HEIGHT					
230-250m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		29	45		1.6	5.75
Wide pillar		45	45		2.86	9.7
		Width Solids	Length Solids			
Remnant Pillar		39	39		1.7	9.7

DEPTH	HEIGHT					
250-270m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		28	41		1.65	6.29
Wide pillar		41	41		2.79	10
		Width Solids	Length Solids			
Remnant Pillar		35	35		1.66	10
DEPTH	HEIGHT					
250-270m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		30	47		1.6	6
Wide pillar		47	47		2.9	10.2
		Width Solids	Length Solids			
Remnant Pillar		41	41		1.77	10.2

DEPTH	HEIGHT					
270-290m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		29	42		1.6	6.6
Wide pillar		42	42		2.74	10.3
		Width Solids	Length Solids			
Remnant Pillar		36	36		1.6	10.3
DEPTH	HEIGHT					
270-290m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		32	49		1.6	6.5
Wide pillar		49	49		2.95	10.7
		Width Solids	Length Solids			
Remnant Pillar		43	43		1.78	10.7

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1 Introduction

Stanmore Coal Pty Ltd (Stanmore) has engaged Mastermyne Pty Ltd (Mastermyne) to undertake a bankable feasibility assessment of its proposed underground operations at the Isaac Plains Open Cut near Moranbah in the Bowen Basin. The project team is currently undertaking an assessment for the application of bord and pillar first and second workings for the area nominated as an underground reserve based on highwall entries from the existing open cut operation. Figure 1 depicts the project location.

Blackrock Mining Solutions Pty Ltd was engaged by Mastermyne as part of the study team to provide geotechnical and geological analysis for the proposed mining methods.

2 Project Scope of Works

Blackrock Mining Solutions has been commissioned by Mastermyne to undertake a review of the geological and geotechnical setting, and resource recovery opportunities and risks associated with coal recovery using bord and pillar mining methods inclusive of first working and first workings followed by secondary extraction.

The assessment scope includes a review of the existing geological and geotechnical data and reports that have been previously used in the prefeasibility and feasibility studies and draw on the information these provide, rather than initiate any new studies unless critical flaws or gaps in the data are identified. The scope included a review of mining hazards that may limit regular mineability and reserve recovery using both first and second workings methods, considering both up-side and down-side risks.

Typical bord and pillar and secondary working mining scenarios have been assessed applying existing industry standard designs to the current understanding of the geological, geotechnical and structural setting of the deposit.

Figure 1: Location Plan Isaac Plains OC and proposed Isaac Plains Underground Reserve

3 Geological and Geotechnical Setting

Information Sources

The Mastermyne Group has provided Blackrock Mining Solutions with a set of geological and geotechnical reports, resource assessment reports and plans from the Stanmore Coal project library. The full listing of those used is included in Appendix 1. Only sections considered relevant to the mining system selection study are reproduced in this report, and the author encourages the reader to review the significant volume of work contained in the Geological Overview documents and other reports as listed in Appendix 1 for a full understanding of the geological and geotechnical setting.

Geological Setting

Exploration drilling, down hole geophysics, 2D and 3D seismic surveys and existing adjacent OC mining operations over the recent years has defined the structural setting, along with typical seam thickness, dip, seam geometry and stratigraphic correlation. In addition, the exploration program has provided geotechnical data such as strata geomechanical characterisation, hydrological information, depth of cover and stress field quantification. The program also identified some significant structures and potential intrusions. The vast majority of the IPU reserve area is covered by 3D seismic survey that has successfully identified the majority of the structural features (faults, and seam rolls).

IPU will extract the 3.5 to 4.5m thick Leichhardt Seam within the Rangal Coal Measures. The planned working depth extends from around 90m at the highwall entries off the existing open cut operation to in excess of 350m to the eastern extent of the study area. The Leichhardt Seam in the reserve area between faults dips to the ENE to E, at between 1 in 9 and 1 in 13, but steepens around the larger fault features.

Figure 2 summarises the current drill hole locations and 3D seismic features in the lease area. Figure 3 depicts a generalised stratigraphic column for the project area

The available information and data set is typical of brownfields and expansion project evaluations and assessments.

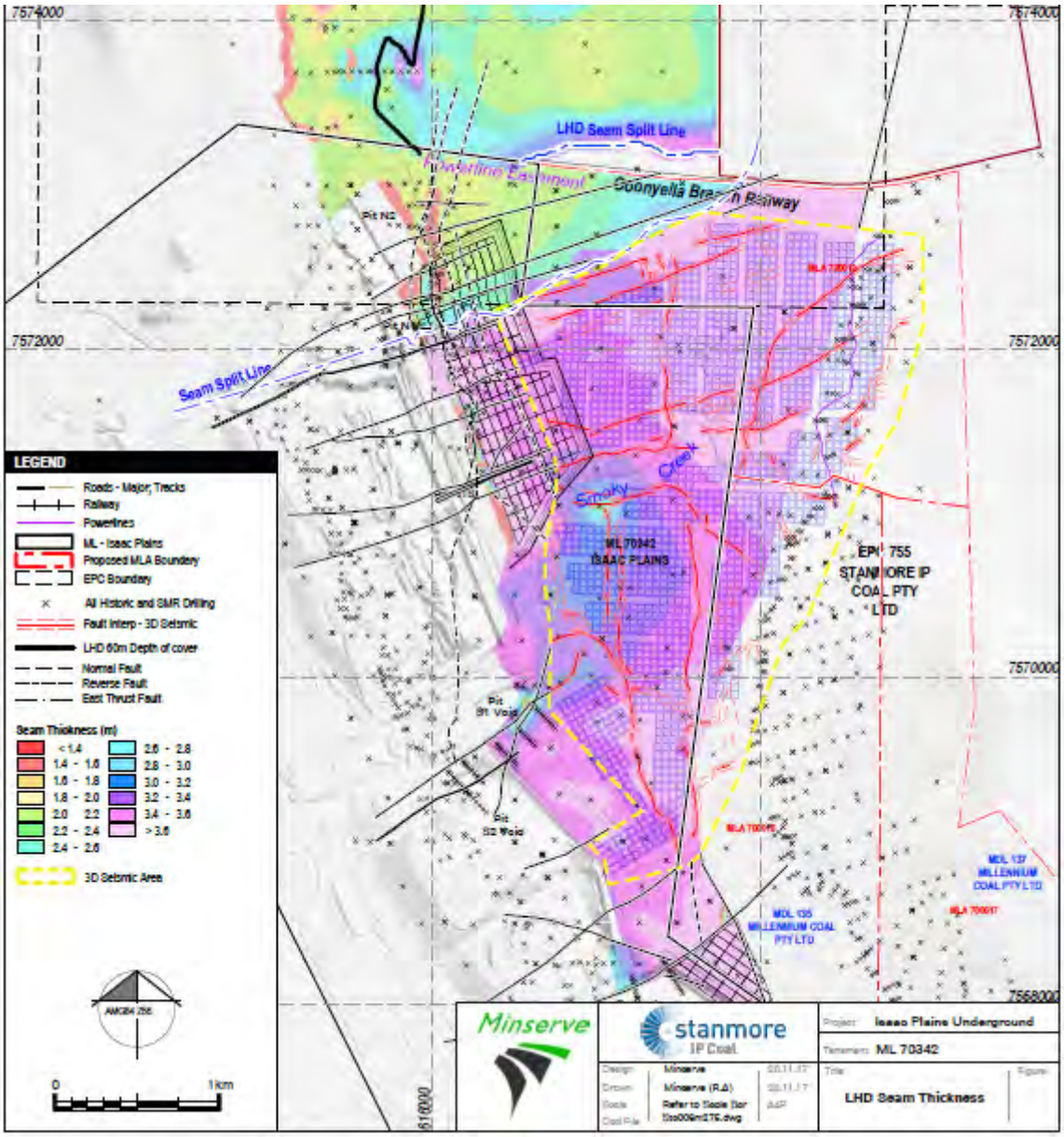


Figure 2: IPU drill hole data set and 3D seismic structural data set.

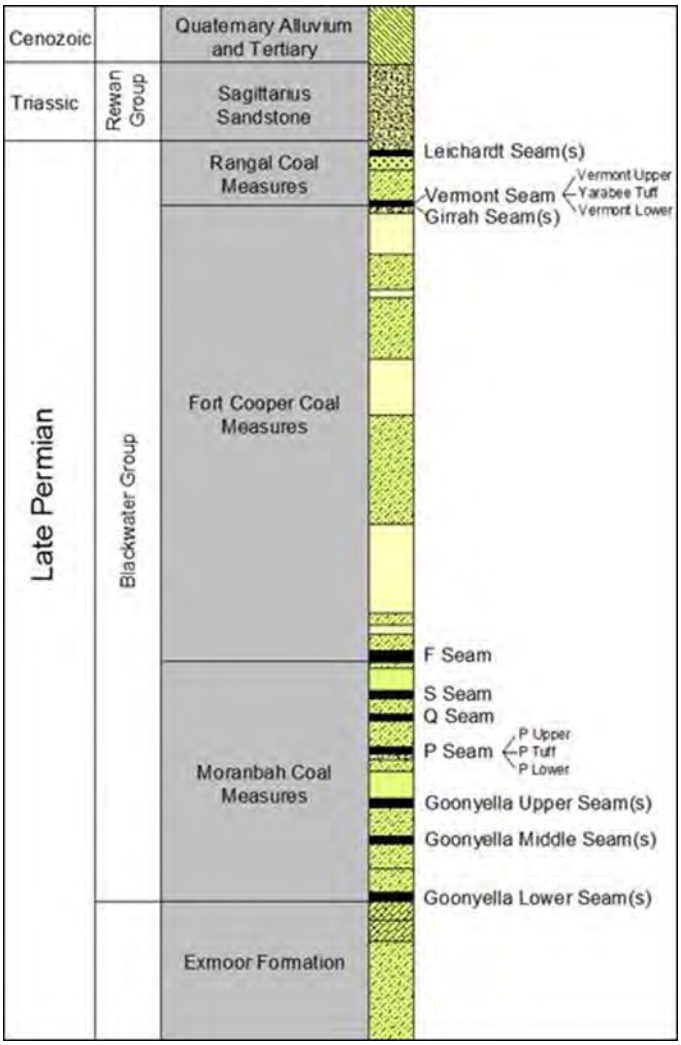


Figure 3: Stratigraphic section for the Leichhardt Seam in the Isaac Plan Underground lease area.

A review of the geological logs and geophysical data shows the roof strata varies across the deposit from fine grained shales/mudstones to siltstones and sandstones with the variation occurring over relatively short distances. Stanmore had commissioned SCT Operations to undertake a strata characterisation study in the IPU reserve area and the results are summarised here from SCT report "Stanmore Coal Sonic Velocity to UCS Correlation, Geotechnical Characterisation and Acoustic Scanner Analysis" (STAN4781 15 January 2018).

Part of the characterisation of the geology that SCT undertook was to analyse the geophysical logs to determine the shale fraction (V-shale) as a guide to the roof lithologies and the variation across the reserve area. V-shale is determined from the gamma log data using the following relationship:

$$\frac{\gamma_{avg.} - \gamma_{sand.}}{\gamma_{clay.} - \gamma_{sand.}}$$

Where the average gamma count minus the gamma count of a pure sandstone is divided by the difference between the gamma count of a pure claystone and a pure sandstone. Each deposit will have its own unique gamma data ranges and site specific data is needed to develop the relationship. In the IPU reserve the endmembers for claystone are 200API and for clean sandstone 60API.

The shale content can be used to provide a spatial analysis of the lithological changes across a mining area both vertically above the roof and laterally between boreholes. Typically, the higher the shale content, the greater the bedding and weaker the rockmass.

The resultant data set, based on 34 holes was used by SCT to develop a series of contour maps showing the roof strata shale content across the mining area, with the results indicating that there is not a great deal of variation at different intervals into the roof, but the major variations occur spatially across the reserve. In general, the eastern area has a lower shale content and is sandier than the western region which has a higher shale content. Suggesting the roof strata rock mass will be better to the east of the deposit as the sandier fraction increases.

Table 1 summarises the roof strata inferred shale fractions showing the lack of variation vertically in the strata column. Figure 4 and Figure 5 show the shale content for each of the roof horizons composites across the IPU reserve. (Note the mine plan outline in these figures differs from the current design but the area covered is the same.)

Table 1: Roof strata inferred shale fractions

	0-0.5m above the seam	**0-1.0m above the seam**	**0-2.0m above the seam**	**0-4.0m above the seam**	**0-6.0m above the seam**	**0-8.0m above the seam**
Minimum	0.21	0.14	0.16	0.20	0.30	0.29
Maximum	0.79	0.71	0.64	0.69	0.72	0.72
Average	0.51	0.49	0.46	0.47	0.56	0.56

In addition to the shale content analysis, a series of geological type sections were developed along approximately north-south section lines, as depicted in Figure 6 below. The section lines effectively demonstrate the strata variations around the Leichhardt Seam. Section one, Figure 7 is to the west of the deposit and section two, Figure 8 is towards the eastern side.

The section lines are based on geological and geophysical logs and show the consistent siltstone/carbonaceous siltstone immediate roof that exists across the majority of the reserve, ranging from 0.3m to 2.0m in thickness which corresponds to the typically weaker roof horizon. Also shown is the consistent thicker competent sandstone unit that forms the majority of the immediate and upper roof horizon in all boreholes in the reserve area. The sandstone is typically 2m to 4m thick and sits immediately above the weaker siltstones.

The floor strata consists of a weaker interbedded siltstone to carbonaceous siltstone and mudstone, with the boreholes towards the south of the reserve having thin coal seams in the floor around 1.0m below the Leichhardt seam.

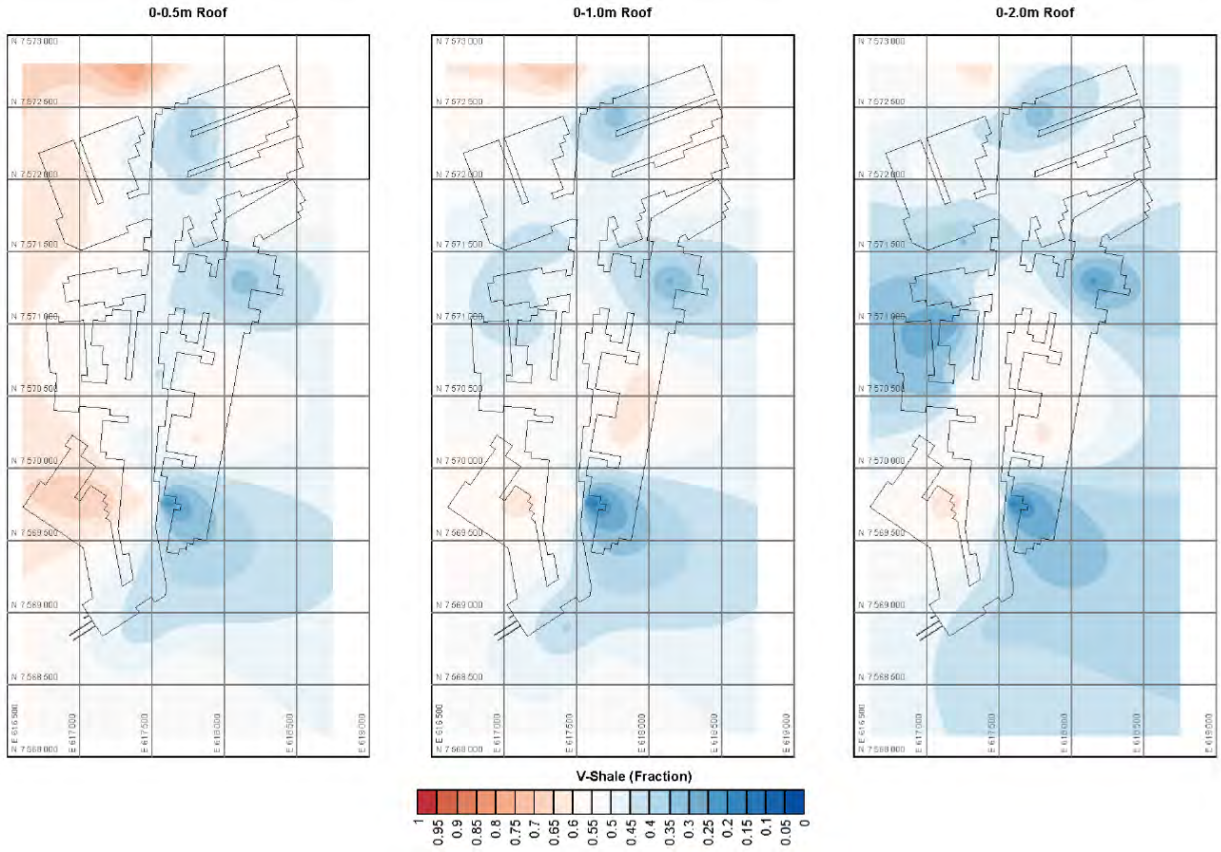


Figure 4: Shale content contours for 0-0.5m, 0 – 1.0m and 0-2.0m roof strata composites *(after SCT report STAN4781)*

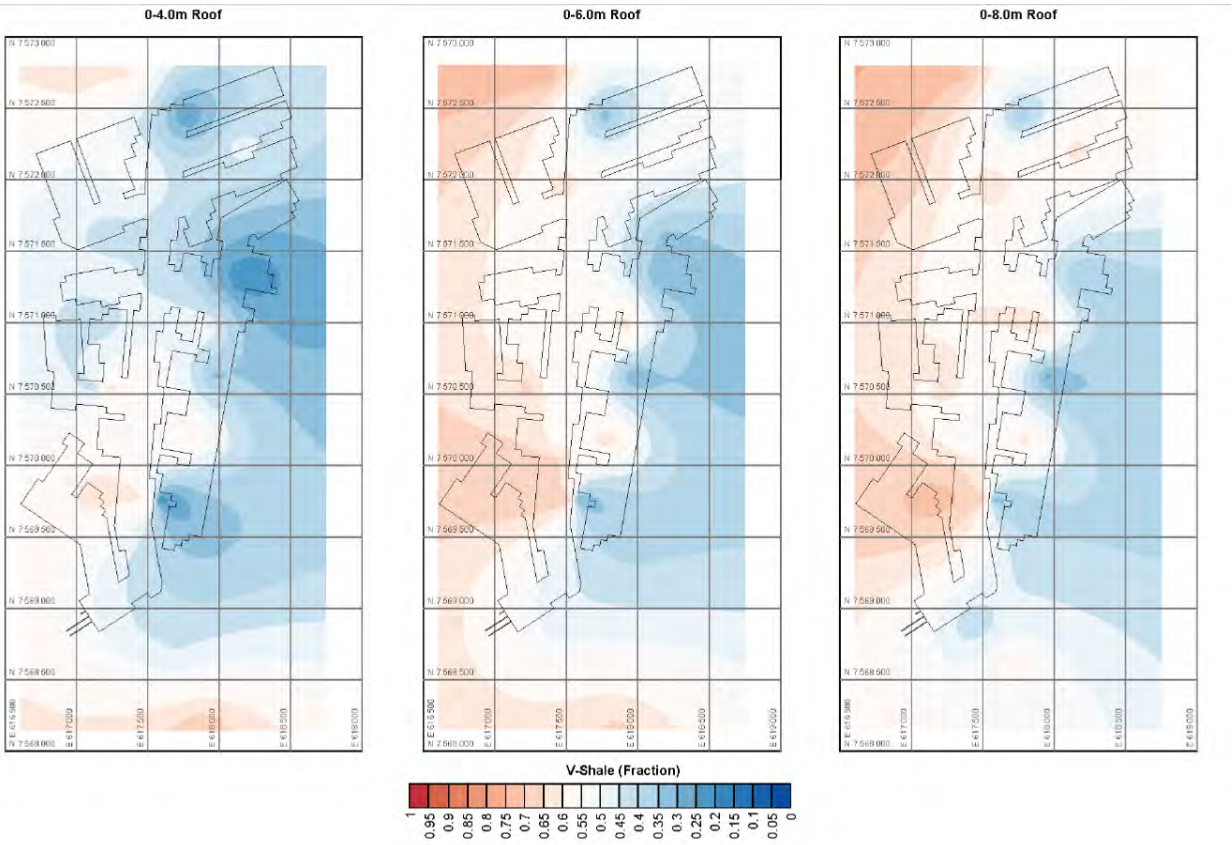


Figure 5: Shale content contours for 0-4.0m, 0-6.0m and 0-8.0m roof strata composites *(after SCT report STAN4781)*

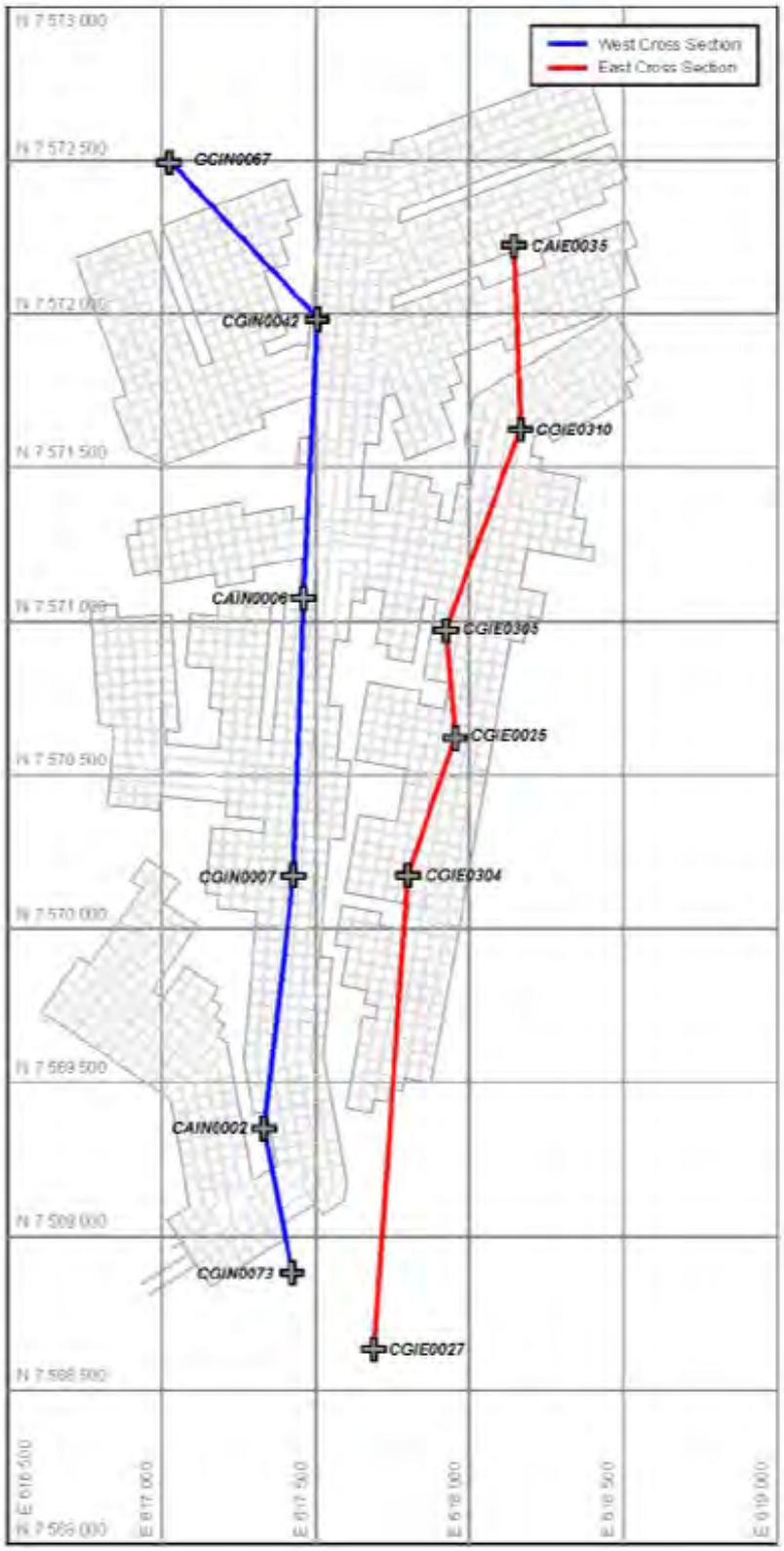


Figure 6: Geological section lines ***(after SCT report STAN4781)***

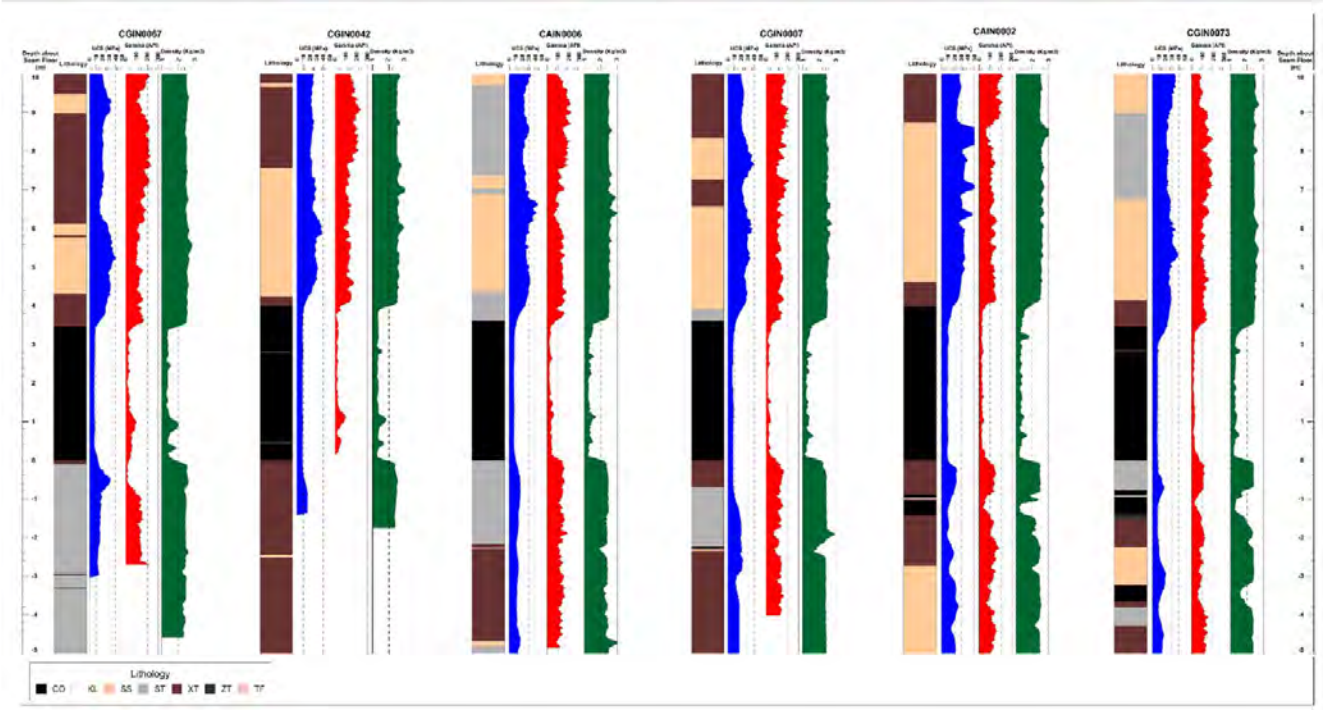


Figure 7: Western Cross Section depicting the lithology, inferred sonic to UCS data and density profiles for 10m above and 5m below the Leichardt Seam *(after SCT report STAN4781)*.

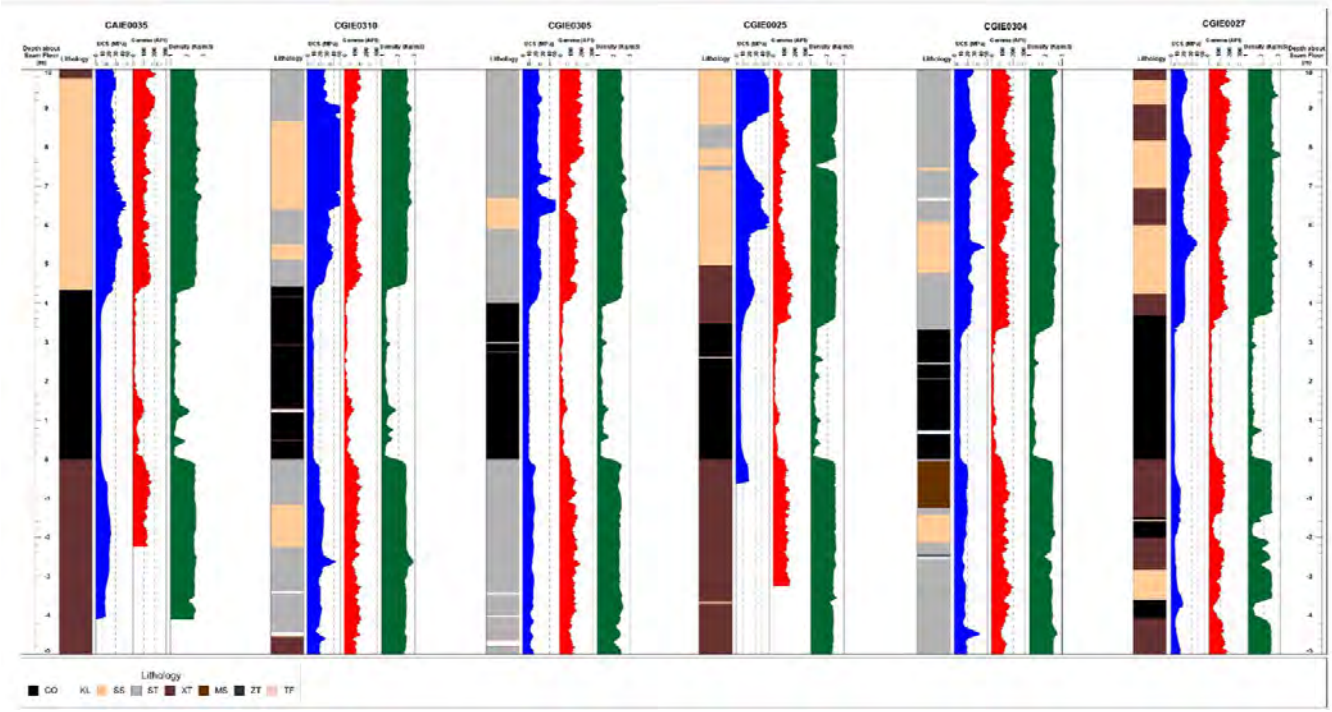


Figure 8: Eastern Cross Section depicting the lithology, inferred sonic to UCS data and density profiles for 10m above and 5m below the Leichardt Seam *(after SCT report STAN4781)*

Acoustic scanner data and image logs were used by SCT to determine the cleat direction across the reserve area. The image files can be used to interpret the open fractures in the coal seam that are not bedding or lithological contacts, to determine the orientation of the face and butt cleat. The results are depicted in Figure 9.

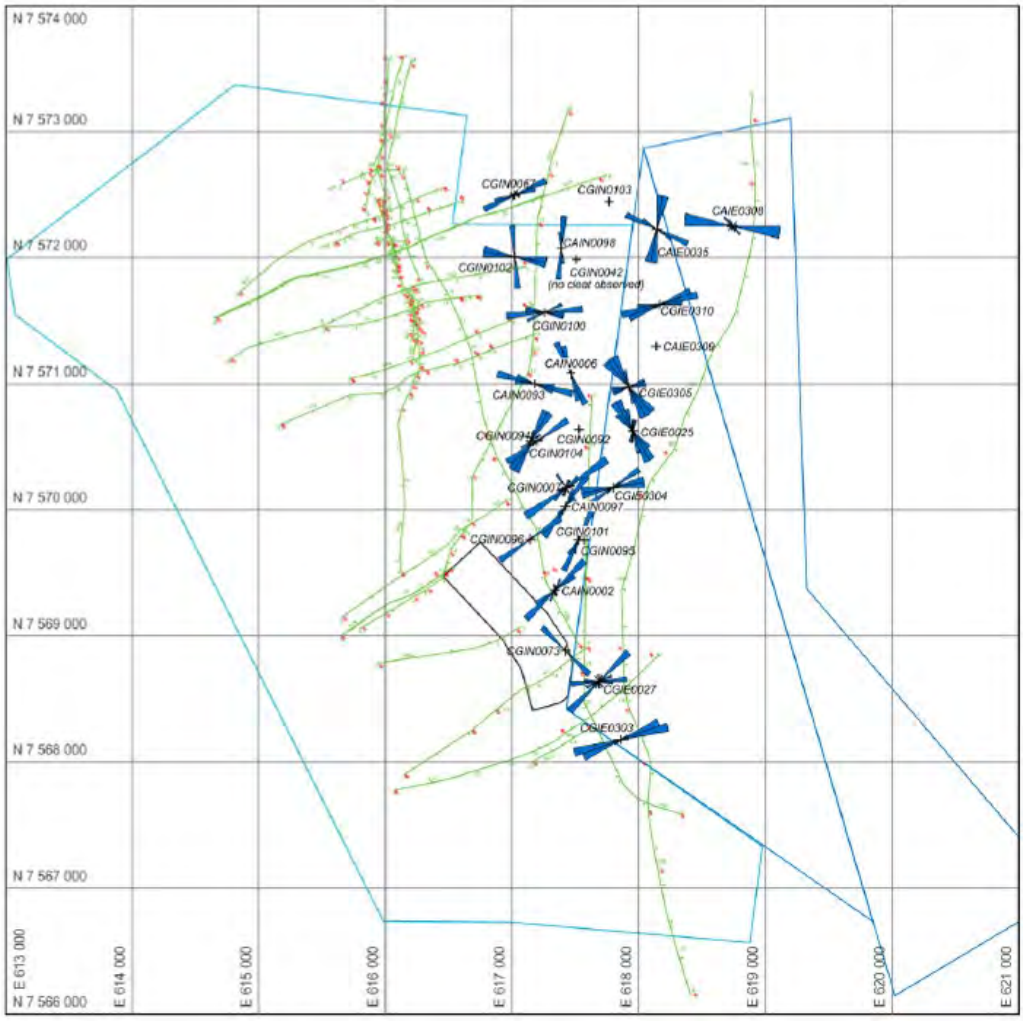


Figure 9: Leichhardt Seam Cleat orientation map from acoustic scanner data *(after SCT report STAN4781)*.

In summary, the analysis of 24 boreholes shows a general consistency in the southern area with most holes showing an ENE-WSW to NE-SW face cleat orientation. In the northern area, there is an apparent rotation of the face cleat to a more NNW-SSE orientation in several holes, with the remainder showing the similar orientation of N-S and E-W face to butt cleat orientation. The rotation of the cleat is typically associated with geological structures in the Leichhardt Seam as evidenced at Carborough Downs. No data relating to overburden jointing is available.

Cleat direction has the potential to negatively impact of rib stability as the working extend to a depth of cover greater than 200 to 250m. At this depth roadways driven parallel or sub-parallel to the cleat direction may experience increased rib spall and buckling of the cleats. The hazard can be managed by the use of rib mesh as a TARP response during mining.

4 Geotechnical Environment

Depth of Cover

Depth of cover across the IPU ranges from 90m, close to the existing highwalls and dips to in excess of 350m in the down dip north-eastern extent of the reserve. The depth of cover is depicted below in Figure 10, and typical W to E cross sections are illustrated in Figure 11.

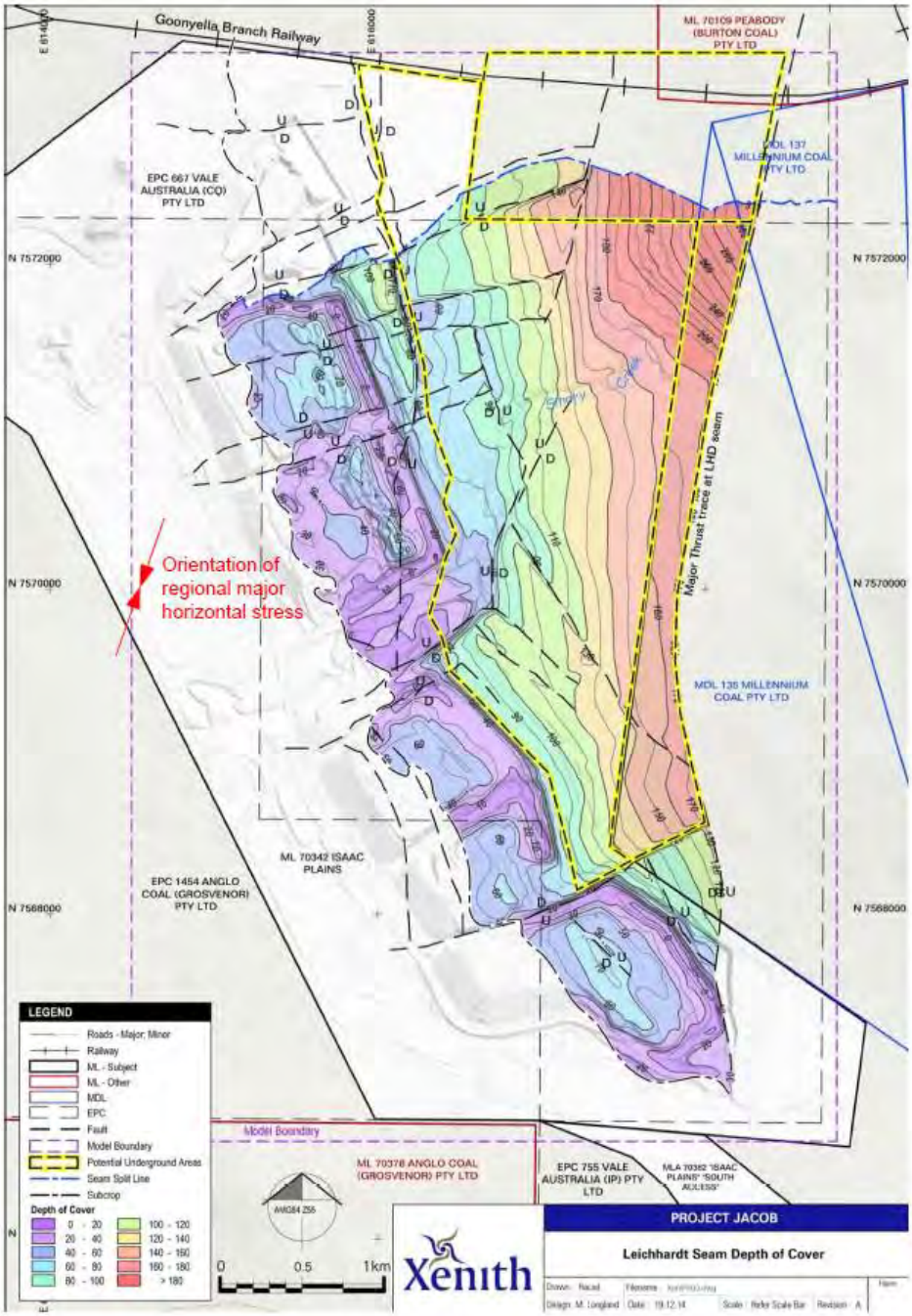


Figure 10: Depth of cover in the IPU reserve area

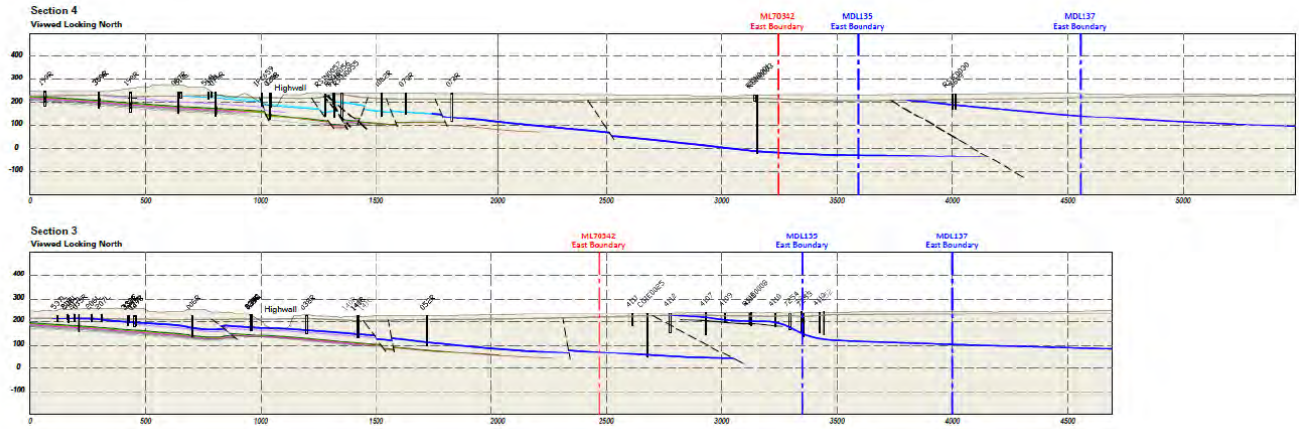


Figure 11: Typical IPU reserve cross sections W to E looking North

Seam Thickness and Working Sections

The Leichhardt Seam at IPU ranges from approximately 3.0 to 4.5m across the underground reserve and averages approximately 3.77m and typically un-banded and has no marker horizons. The mine plan currently has the full seam height being extracted to maximise the reserve recovery, hence the mining height will vary across the deposit. Nominal development height is 2.8 to 3.0m, with the remaining coal bottoms being taken in a second pass, essentially working from stone roof to stone floor.

Immediate Roof and floor strata

The strata about the Leichhardt seam at IPU is characterised by a weak immediate roof overlain by moderately bedded, stronger siltstone and sandstone units. SCT's report "Stanmore Coal Sonic Velocity to UCS Correlation, Geotechnical Characterisation and Acoustic Scanner Analysis" – Jan 2018 (STAN4781) provides a detailed summary of the geomechanical property testing and analysis that has been completed for the IPU deposit. The data set and results are summarised below.

- The IPU data set contains the following geotechnical information:
- 202 UCS tests (includes that standard modulus, moisture, density and poisons ratio)
- 44 Laboratory sonic velocity tests
- 32 slake durability tests
- 3779 point load tests (diametral and axial)
- 24 boreholes with acoustic scanner images

UCS Data

A total of 202 UCS tests have been collected, with the majority of these taken from close proximity of the Leichhardt Seam and have been sampled from a range of different lithologies surrounding the seam, providing a non-biased high quality data set.

The UCS data indicates the rock strength ranges from 2MPa to 80MPa, with 85% of the results falling between 5 and 45MPa. Figure 12 summarises the range of UCS data for the samples.

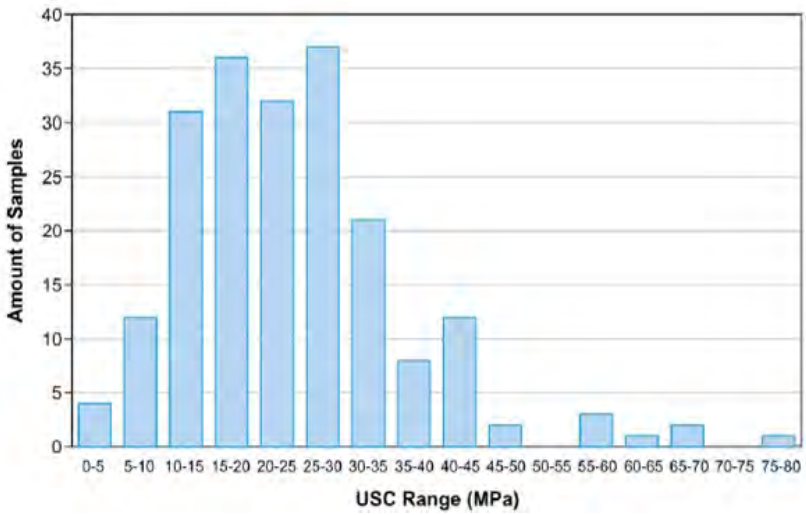


Figure 12: Histogram showing the UCS test result distribution (after SCT report STAN4781)

As is typical for coal measure strata, there is a general trend of increasing rock strength with increasing grain size. This is illustrated in Figure 13 which shows the relationship between UCS and rock type.

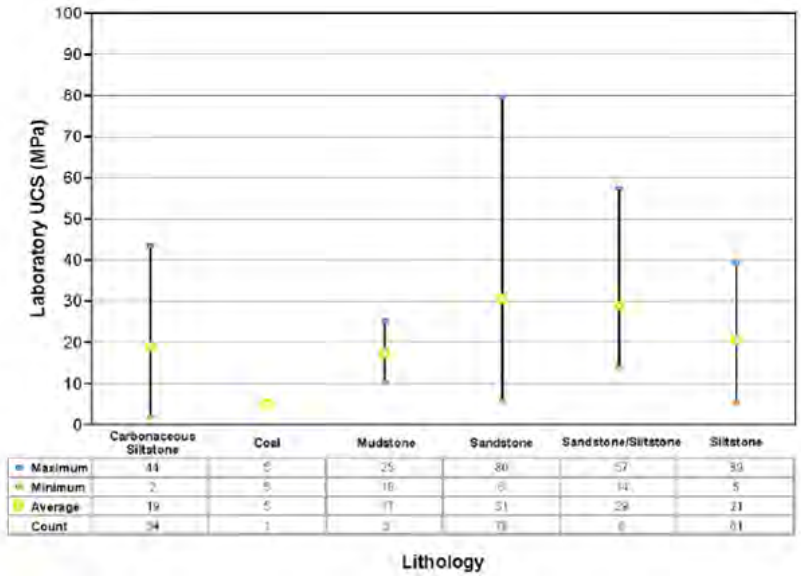


Figure 13: Relationship between UCS test results and rock type (after SCT report STAN4781)

The majority of the IPU UCS data set are taken from the 10m above the seam and 5m below the seam horizons. Figure 14 plots the UCS data points relative to the roof and floor of the Leichhardt seam to provide an indication of the range of rock types and UCS values for the roof and floor strata.

The immediate 1m roof horizon shows very few data points and a medium UCS of around 30MPa, this is considered anomalous as the sonic and point load data all point to a weaker immediate roof horizon. The immediate floor lithologies are typically carbonaceous shales and siltstones, there are only five samples of the immediate 0.5m floor horizon which is of the most importance when considering floor trafficability, with a range of 0.5 to 26MPa.

The median roof strata strength over 1m intervals is between approximately 22 and 35 MPa and for the floor its between 15 and 24 MPa.

The typical relationship of stronger roof and weaker floor is exhibited and the range of strengths are similar to that seen in nearby Leichhardt Seam mines and projects.

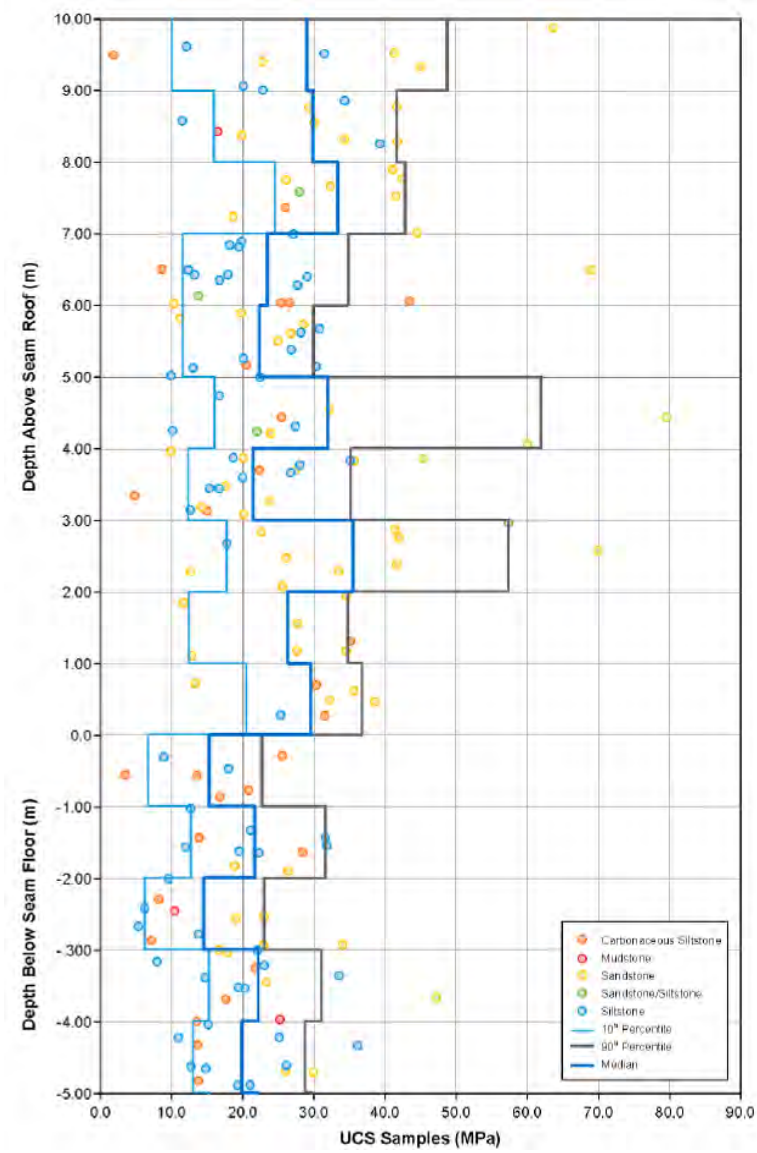


Figure 14: Relationship between UCS test results and location relative to the Leichhardt Seam roof and floor (after SCT report STAN4781)

Young's Modulus

The Young's Modulus quantifies the stiffness of the strata types, in the data set available there is the typical trend of increasing Modulus with increasing UCS. The analysis by SCT indicates the relationship is:

$$E\ (GPa) = 0.4034 \times UCS\ (MPa)$$

With the UCS is approximately 2.5 times the Modulus in GPa. Lithologies with a higher ratio of Modulus to UCS are stiffer, with a lower relative UCS and will attract increased stresses and have the potential to fail earlier as an excavation occurs. If the stiff but weaker rock types are in the immediate roof horizon overstressing may occur and induce roof deformation. Figure 15 plots the relationship between UCS and Young's Modulus, the stiffer and weaker lithologies are the points above the blue line.

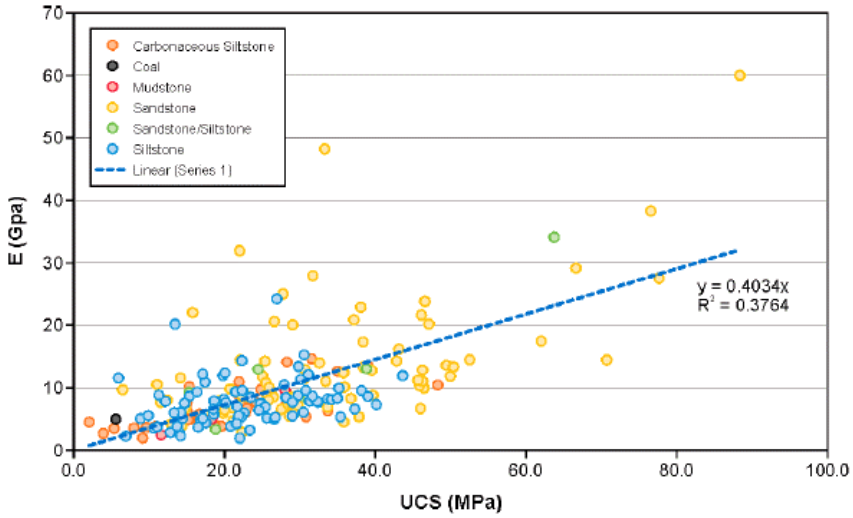


Figure 15: Relationship between UCS test results, rock type and Young's Modulus (after SCT report STAN4781)

5 Geotechnical Characterisation

Sonic Velocity to UCS Correlation

In order to plot an estimation of the spatial variation in UCS in different roof and floor horizons a correlation between the sonic velocity from wireline geophysics and the UCS laboratory data was developed by SCT and presented in the report STAN4781, the results are summarised below.

The data set contained 143 UCS samples across 34 boreholes with sonic velocity geophysical traces. The UCS samples we depth corrected and the average sonic velocity for the test interval used. The results show a reasonable correlation to the following equation:

$$\textit{Sonic UCS (MPa)} = 1.4711 \times \exp^{(0.0008 \times \text{sonic velocity m/s})}$$

The data set and relationship and illustrated in Figure 16 below. The majority of the sample points are between the 2500 – 4000m/s velocity range and caution needs to be applied to using this equation for velocities outside of this range.

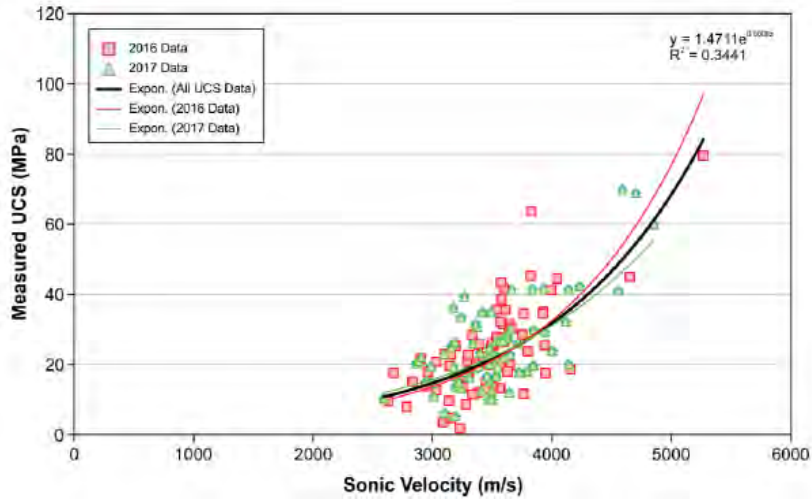


Figure 16: Relationship between UCS test results and wireline sonic velocity (after SCT report STAN4781)

Using the sonic UCS equation, a series of contours of the inferred UCS strengths across the IPU reserve area were generated, Figure 17 shows the borehole locations, please note the mine layout in this figure is not the same as is currently proposed as part of the BFS, but the area of the reserve is the same. The contours of multiple horizons within the roof and floor are illustrated below in Figure 18, Figure 19 and Figure 20.

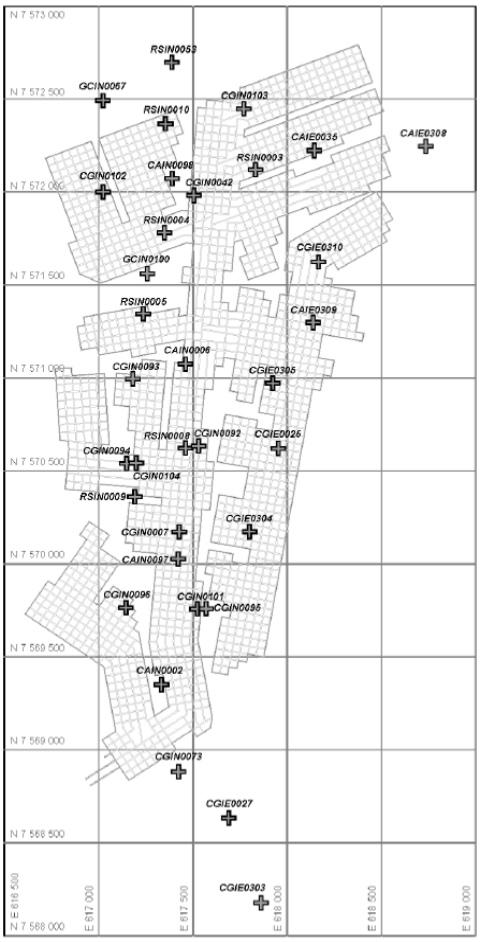


Figure 17: Map showing the locations of boreholes with geophysics used in the sonic UCS contour plots (after SCT report STAN4781)

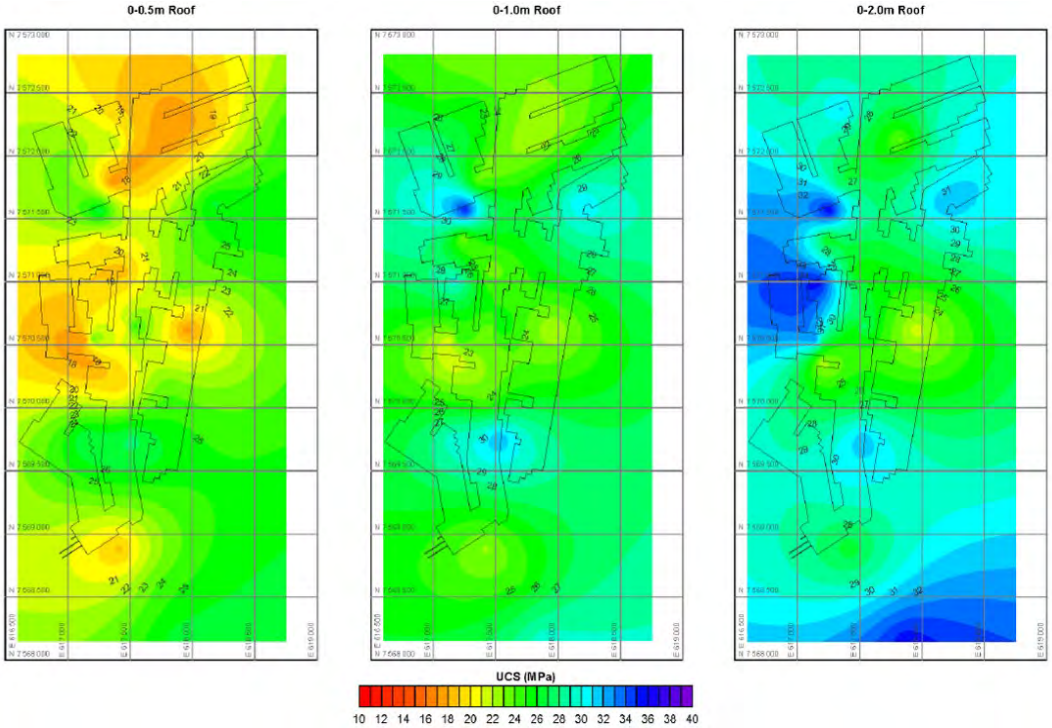


Figure 18: Sonic UCS contours for the seam roof strata at 0-0.5m, 0-1.0m and 0-2.0m horizons (after SCT report STAN4781)

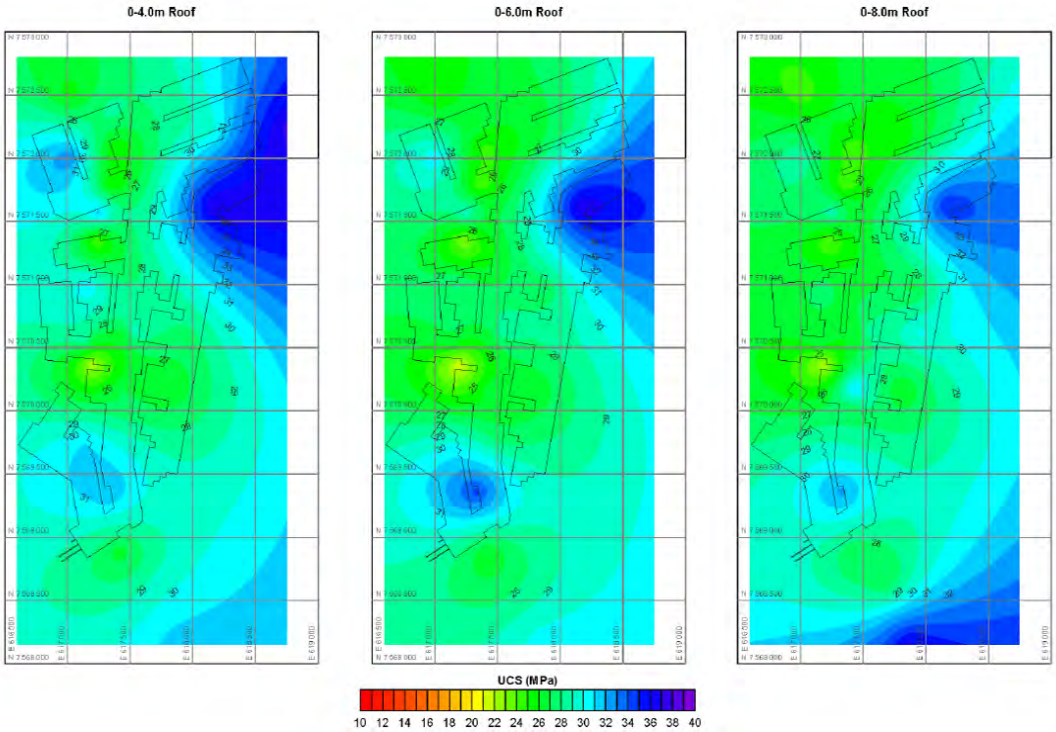


Figure 19: Sonic UCS contours for the seam roof strata at 0-4.0m, 0-6.0m and 0-8.0m horizons (after SCT report STAN4781)

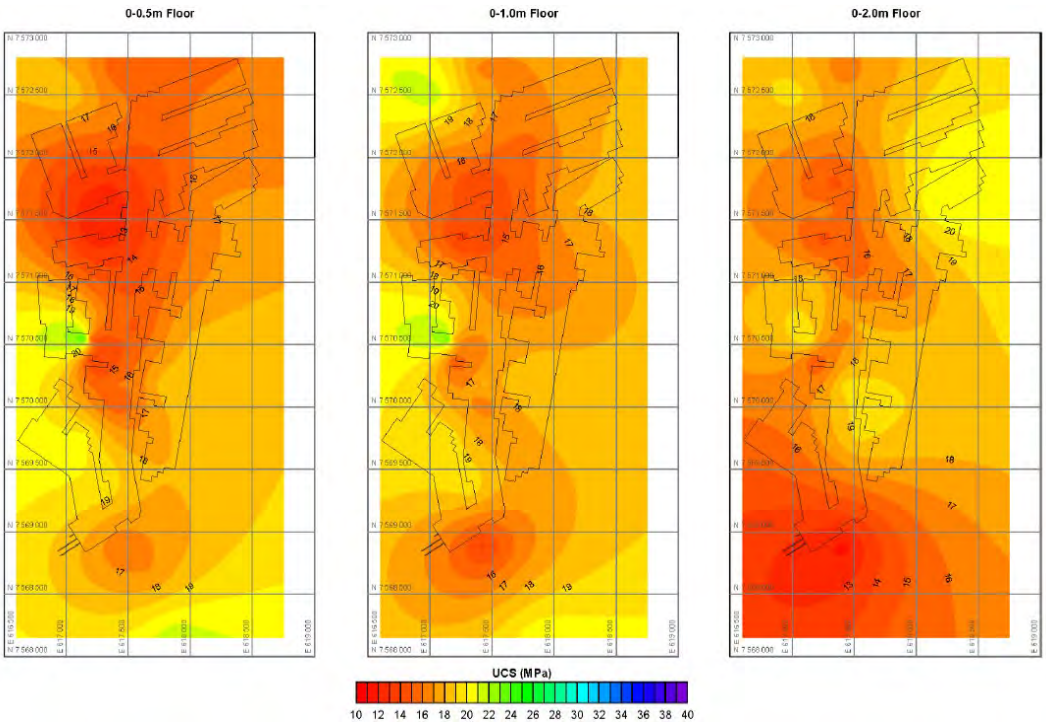


Figure 20: Sonic UCS contours for the seam floor strata at 0-0.5m, 0-1.0m and 0-2.0m horizons (after SCT report STAN4781)

The contour plots show a reasonably consistent UCS profile across the IPU reserve area with the immediate 0-0.5m roof range from 17MPa to 27MPa, with a trend of being weaker towards the North-West of the IPU reserve area. The remaining roof horizons are consistent between 21MPa to 37MPa across the reserve.

The floor contours also so a consistent UCS range across the reserve area ranging from 12MPa to 24MPa, which would be characterised as a low to medium strength floor, consistent with the laboratory results for the carbonaceous shales and siltstones. These lower strength materials may result in poor floor trafficability issues if water is not actively managed.

Coal Mine Roof Rating Data

The Coal Mine Roof Rating (CMRR) is an indication of the competency of the roof bolted horizon in a given coal strata and is based on the strength of the rock type and the spacing and condition of bedding planes within the rockmass, with adjustment factors to account for joint spacing, anisotropy and water conditions. In general terms, CMRR values <35 is classified as a very weak roof, 35 to <45 is a weak roof, 45 to <55 as a moderate roof and >55 as a strong roof.

Very limited CMRR data gathered directly from cores exists in the IPU reserve area, with only three holes being analysed at the time of drilling with high quality geotechnical logging and detailed point load testing giving a credible CMRR value. These holes are CAIE0309, CGIE0310 and CGIE0304. The range of results reported by Mine Advice (December 2017) being between 42 and 48. While previous estimation by Golder Associates (January 2015) gave an expected range of 38 to 50 depending on the lithology type in the bolted horizon based on experience at other sites.

To supplement the existing limited data, 24 additional holes with detailed digital photography taken from within the drillers splits, with detailed geological logs and point load data were reviewed and an estimation of the CMRR generated. In addition, the three holes analysed at the time of drilling (CAIE0309, CGIE0310 and CGIE0304) and

discussed by Mine Advice were reviewed and used as "calibration holes" for the generation of the CMRR data from core photos and geological logs.

The data set generated ranged from CMRR of 38 to 55 with a mean of 46 (standard deviation of 3.85) for the 1.8m roof bolt horizon. The lowest values of 38 and 39 are considered as lower bound values as the geological logs noted faulted conditions in the immediate roof. The range of data is summarised in Figure 21.

Comparison between 1.6m and 2.1m bolted horizons were also undertaken with very minimal difference, such that at 1.6m the mean CMRR is 45.8 and at 2.1m the mean CMRR is 46.2. This suggests that there is no benefit to going to 2.1m bolts and there is perhaps a potential to reduce the bolted length to 1.6m, but this assessment should be made after actual mining experience is gained in the deposit.

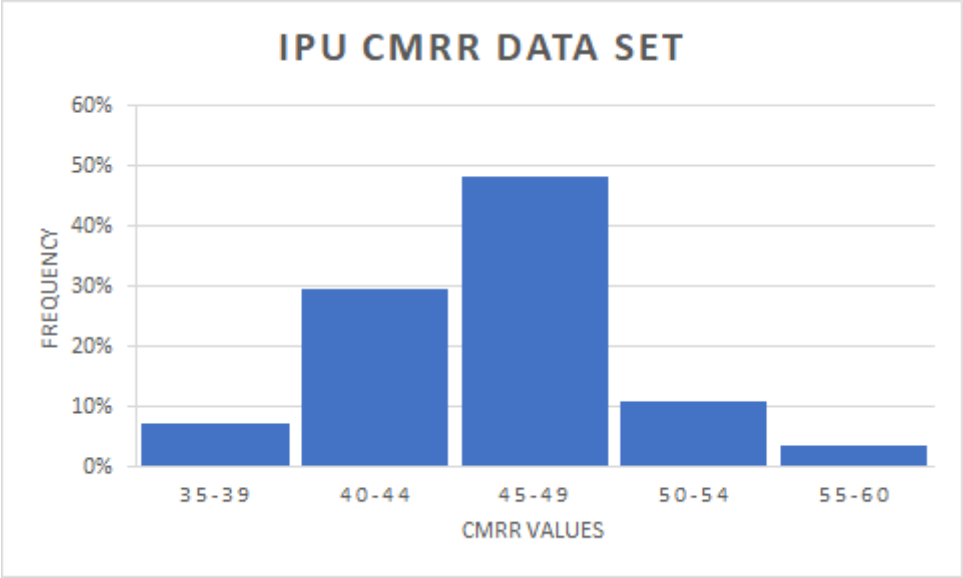


Figure 21: Summary of the CMRR data set for IPU reserve area

It must be noted that the data set is not sufficient to use as a specific design tool, as data points are widely spaced and the known geological structures will over ride and control the actual rockmass conditions. It can however, be used as a characterisation guide and a range of values used as an input for design. The variation between a coal and stone roof common in the majority of thick coal environments.

Based on the study conducted by Mark and Molinda (2003), the immediate roof strata can be classified as a "Weak to Moderate" roof. A CMRR of between 40 and 50 for the stone roof in the IPU reserve has been assumed for design analysis.

Coal Strength

The Leichhardt Seam at Isaac Plains is typically a banded formation of dull and bright coals, with no or minimal stone bands. Based on extensive laboratory and field testing of coal from several sites in Australia, the field UCS has consistently been found to be lower than laboratory results and have a consistent and small range of actual rockmass strengths. For IPU, in normal un-faulted conditions, the rockmass strength of the coal seam is expected to be in the range of 5 to 8MPa, with the bright coal bands being in the lower bound, and the dull coal being the higher bound value.

In Situ Stress Regime

No actual stress measurements have been undertaken in the IPU region, but as reported by Frith and Colwell 2006 the 3D typical virgin stress field can be estimated using the depth of cover, Tectonic Stress Factors for the major and minor horizontal stress field, and Young's Modulus (E) of the strata. The equations for this estimation are as follow (Frith and Colwell 2006):

$$\sigma_H = \sigma_V \times (V/1-V) + E \times TFS_H$$

$$\sigma_h = \sigma_V \times (V/1-V) + E \times TFS_h$$

$$\sigma_V = p \times g \times h$$

Where : σ_H = major horizontal stress

σ_h = minor horizontal stress

σ_V = Vertical stress due to weight of overburden

V = Poissons Ratio

E = Young's Modulus

TSF = Tectonic Stress Factors (H for major and h for minor stresses)

(v/1-v) = numerical determination of K_0

The three equations above allow for the estimation of the TSF_H and TSF_h which in turn provide the general intensity of the horizontal stress in the deposit. The magnitude of the major horizontal stress is of the greatest interest in terms of impact on roof stability and support requirements.

Typical values for Rangal coal measures are reported by Frith 2018 as being between 0.41 to 0.89 for TSF_H and 0.44 to 0.55 for TSF_h. These values are in line with stress measurements undertaken in nearby Leichhardt Seam operations and considered to be representative for the IPU reserve. A mid range TSF_H value of around 0.45 to 0.55 has been assumed for the IPU area, as this value aligns with actual measurements at nearby Leichhardt Seam operations and project sites at similar depths.

It is recommended that stress quantification measurements be undertaken at IPU if over stressing or stress driven deformation is becoming apparent in the mining operations.

Horizontal Stress Direction

The horizontal stress direction was characterised via borehole breakout analysis by SCT and reported in "Stanmore Coal Sonic Velocity to UCS Correlation, Geotechnical Characterisation and Acoustic Scanner Analysis" – Jan 2018 (STAN4781). A total of 24 holes were analysed for break out of which 6 had clearly defined break out from which a horizontal stress direction could be estimated. The lack of breakout in the majority of the holes is expected as the seam and scanned interval is relatively shallow and the induced stresses would not be high enough relative to the rock strength to induce rock fracture.

The analysis by SCT reported in STAN4781 indicates there is a general ENE-WSW to NE-SW orientation to the maximum horizontal stress which is consistent with the regional stress field measured in this area of the Bowen Basin. The results of the stress analysis are illustrated in Figure 22 below.

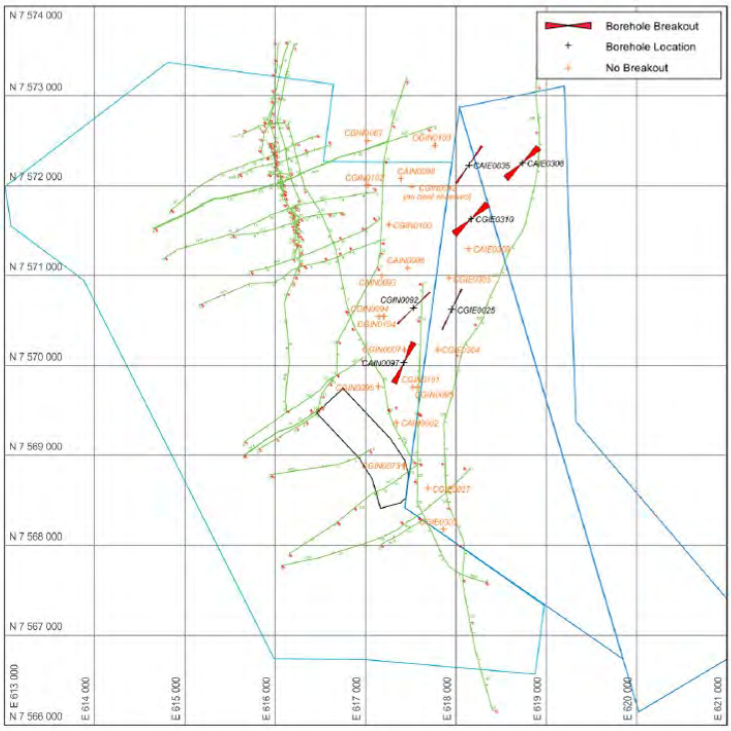


Figure 19: Stanmore Stress Map based on borehole breakout assessment with regional stress rossette shown

Figure 22: IPU stress map based on borehole breakout analysis (after SCT report STAN4781)

The magnitude of the horizontal stress estimated using the relationship above in terms of tectonic stress factor (TSF) have been plotted together with measurements from the database of Australian coal mines, as depicted in Figure 23. The results show the stress magnitudes expected at IPU are expected to be in the lower range relative to other measurements taken in Australian coal mines, which is a consistent finding from other Rangal Coal Measures operations and projects.

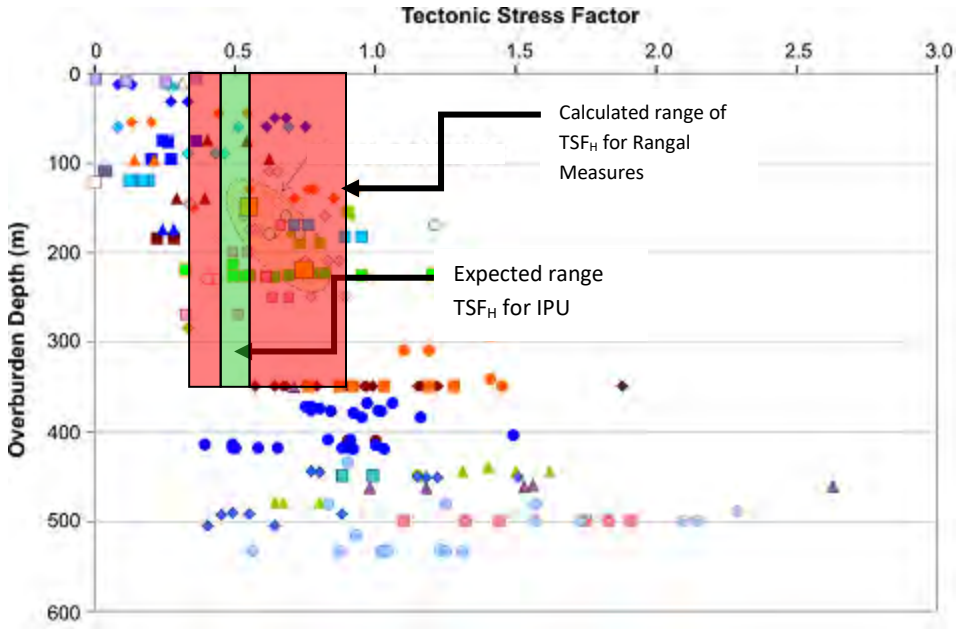


Figure 22: Stress magnitudes normalised for rock stiffness for Australian coal mines, showing the IPU anticipated TSF$_H$ data range.

Most coal measures strata, including coal, is typically stable until the stress applied is greater than the strength of that strata. In coal this is true for both horizontal and vertical stress, and the magnitude that is typically considered as being the threshold for both is 6MPa – equal to a depth of cover in excess of 300-350m deep for horizontal stress.

For the vertical stress, potentially affecting the rib sides, the critical depth is in the region of 250m, although this is often found to be between 230 to 240m depending on the cleat spacing and relative drivage direction to the cleat orientation. At most Bowen Basin mines there is an obvious step change in rib deformation at a depth of approximately 250m.

This general relationship appears to be consistent at IPU based on the stress estimation and analysis done for the IPU reserve. As such, over stressing and shearing of the weaker immediate shale rich roof beam material is not expected to occur until the depth of cover exceeds 250m, which aligns with the experience base at nearby operations.

Rib deformation and yield are expected to occur from a depth of around 230m. At this point an increased level of rib support is likely to be considered necessary as the depth exceeds 230m.

At a working depth of greater than approximately 300m over stressing of the immediate roof section may occur in headings driven at a high angle to the horizontal stress direction. Typically this will take the form of guttering biased to one side of the roadway, or roof sag in the centre of the roadway, depending on the drivage direction to stress direction. Detailed geotechnical mapping and roof support TARP's that reflect the affects of stress driven deformation are recommended to manage and react the associated risks.

Geological Structures

There are numerous faults that have been interpreted from 3D seismic and exploration drilling. Figure 23 is the current interpretation of the actual geological features in the study area. In this plan, red means high confidence, blue is medium confidence and green is likely features.

The Leichhardt Seam is known to be relatively heavily structured as experienced in the near bye Carborough Downs UG operation and seen in highwall exposures in the same region. The 3D seismic data set has resolved faults down to around 2m displacement and where possible the larger faults have been used to define the extents of panels, minimising the need to mine through these structures.

Individual assessment of the effects of geological structures is not possible until they are exposed, but the following general statements can be made:

- The impact of a geological structure is proportional to the density of jointing and angle of the roadway relative to the structure.
- Typically, structures running sub-parallel to a roadway (<20 degrees) will result in a reduction in both roof and rib stability.
- The impact of joint zones and small normal faults (<1m) have proven to be of little issue on development, with the deterioration being managed by the use of TARP controlled mesh and bolts along with supplementary roof monitoring.
- Larger scale normal faults (>2m displacement) are readily identified by 3D seismic and exploration drilling - where these are known and planned to be encountered, fault management plans and grade plans are a simple method of managing conditions. Typically, these will include a prescribed increase in support levels and monitoring in the affected areas.

- Low angle thrust-type features are difficult to identify from exploration or 3D seismic surveys and they typically have minimal impact on development headings, with TARP's being proven to be a simple and effective method of managing the changes in conditions.

The Rangal Coal Measures are renown for the high number of structural features and existing operations in the same seam require a high level of geological and geotechnical input to actively manage the mine planning and operational risks.

Where the mine plane requires headings to traverse significant faults detailed flight plans and horizon control systems will be needed, along with prescriptive support densities, the implementation monitoring strategies and regular geotechnical inspections during mining.

To efficiently manage the operational risks of the known faults, where headings are planned to traverse the fault planes and the smaller faults that are not resolved by the 3D seismic survey (<2m typically) detailed TARP's and regular geological & geotechnical mapping is recommended as a means to adequately manage the operational risks associated with faulted ground.

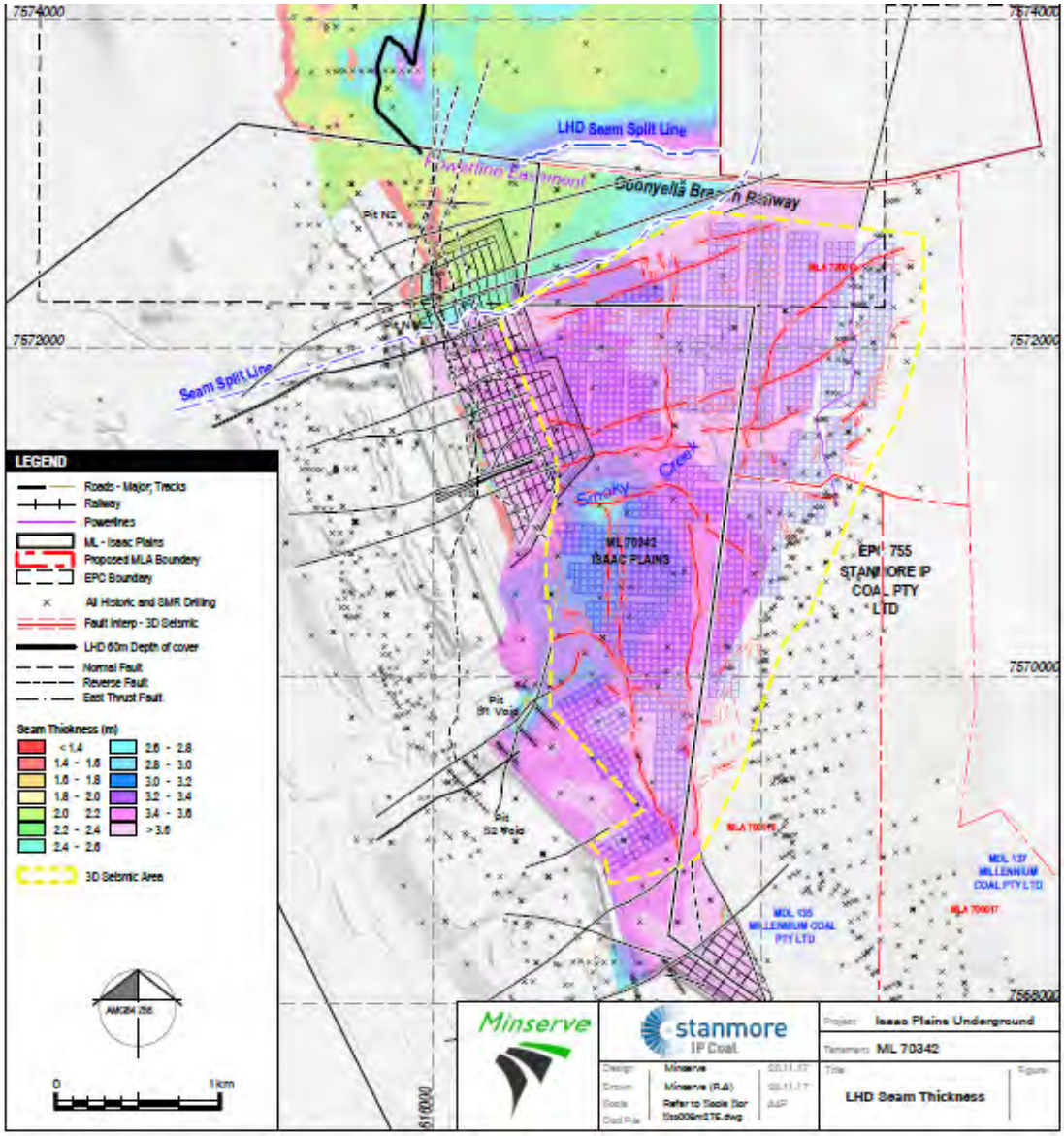


Figure 23: Geological features interpreted from 3D seismic and exploration drilling.

6 Bord and Pillar Options

Introduction

The Leichhardt Seam in the Isaac Plains Underground Project area is being assessed as a bord and pillar operation with some secondary extraction of floor coal, bell outs and pillar stripping. Through discussions with the project team it has been stipulated that two-pass place changing bord and pillar type methods be used as the base case for this assessment, cutting a nominal 6.0m to 6.5m wide heading at nominal height of between 2.8 and 3.2, followed by extraction of floor coal and potential pillar stripping, along with belling out the stub ends of any headings where possible with no strata support.

Bord and pillar mining methods are a financially successful and productive means of recovering reserves typically where faulting, intrusive features or lease boundary and subsidence constraints rule out higher productivity longwall operations. Typically, for successful bord and pillar operations, the conditions and equipment allow for extended cuts of up to 15m in good conditions requiring limited strata reinforcement, say 4 to 6 x 1.8m bolts per metre to 1.4 metres. Ideally, the operation will have limited areas (less than 10%) of reduced length plunges, or areas needing higher support density because when plunges reduce to less than 6m the ability to maintain cost effectiveness reduces rapidly.

Recent examples in the Bowen Basin where bord and pillar operations have been successful are limited to Carborough Downs, Moranbah North, Cook Colliery, Aqulia Colliery, Ensham Mine and Bundora Colliery. Each of these operations utilised a traditional two pass place changing type first workings, with Carborough Downs Ensham Mine and Cook Colliery including second workings partial extraction. At Carborough Downs and Cook Colliery, bord and pillar workings were used to extract remnant blocks, very shallow coal, and faulted blocks where longwall panels could not fit the geometry, while at Ensham Colliery bord and pillar extraction is the only extraction method being used.

First Working Bord and Pillar Operations Stability Assessment

Productive place change mining depends on the ability to extract extended cuts, requiring limited support to be installed as the bolter follows. As bord and pillar workings are developed roof support becomes a major operating cost item. Support requirements and costs vary considerably and are dependent on the physical conditions of the roof strata above the seam and are typically related directly to depth of working.

Leichhardt Seam Extended Cut and Stability Assessment

The stability assessment was undertaken using the empirical Coal Mine Roof Rating (CMRR), which has become an accepted methodology for quantifying coal mine strata geotechnical properties along with a review of previous successful bord and pillar workings at Carborough Downs. The CMRR values combined with a statistical data base can also be used to give guidance on support requirements, plunge depths and roadway widths based on experience gained from different mines, coalfields and countries.

As previously discussed, the typical CMRR values for the IPU reserve area range from 38 to 55 for 1.8m roof bolting horizon. In CMRR terms, a roof is typically classified as a “Weak to Moderate” roof and a typical CMRR

range for the stability assessment is assumed to be 40 to 50. The typical CMRR values are the same as found at the near bye Carborough Downs operation where extended 15m cuts are routinely achieved at similar depths.

The Leichhardt seam mining assessment assumes all development mining will be to the stone roof, allowing coal bottoms to be extracted. The depth of cover for the study area ranges between 90m to 350m which aligns with the stress-based limits of stability discussed previously.

The depth of cover assessment assumes place changing with extended cuts (>6m) is desirable for productivity. Using the CMRR against depth relationship from *Molinda et al* (1994), the range and depth of cover and CMRR for the Leichhardt seam as illustrated in Figure 25. The relationship suggests that extended cuts (>6m) may not be stable when mining with a stone roof past a depth of cover of around 250 to 300m.

The current experience base of extended cut place changing in areas with similar CMRR values in the Leichhardt Seam at Carborough Downs extends to a depth of 250m. The empirical evidence supports the assumption that the extended cut relationship in Figure 24 is conservative and extended cuts at depths up to 250m can be achieved.

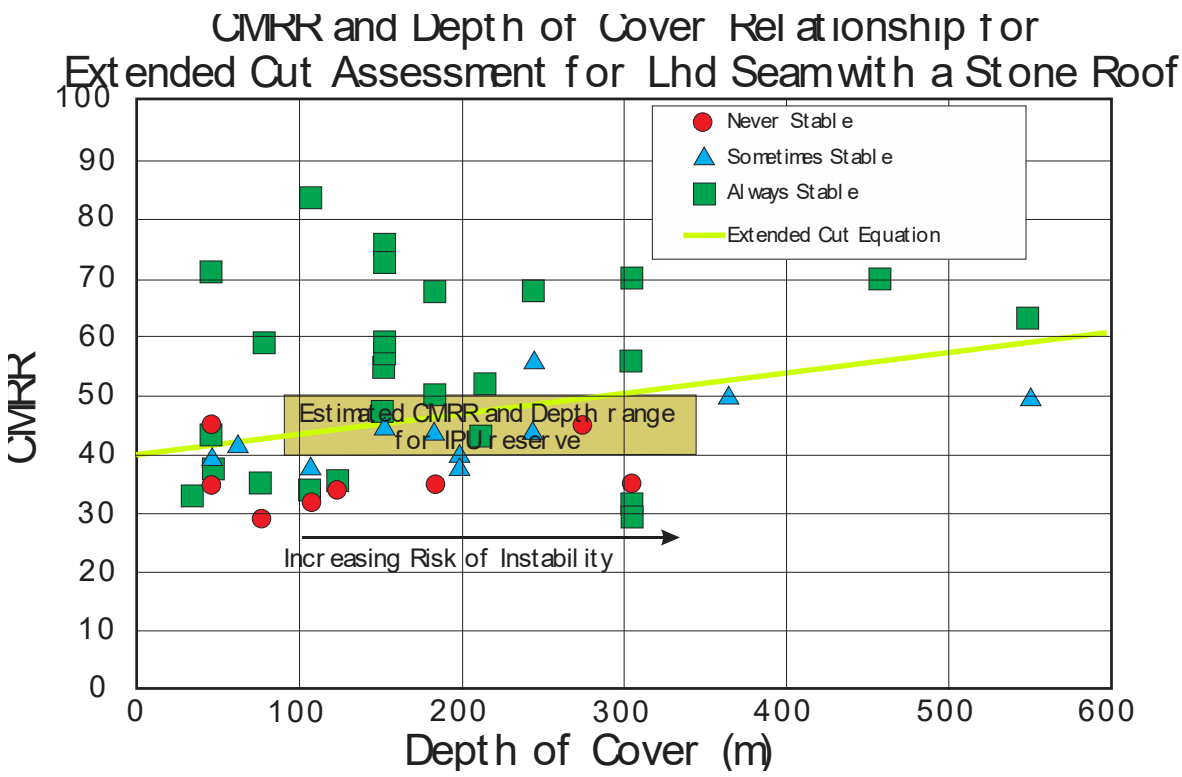


Figure 24: Extended cut assessment for depth of cover and CMRR for the Leichhardt Seam at Isaac Plains Underground.

Figure 25 below depicts the relationship between the CMRR data and plunge depth as per the study of *Molinda et al (1994)*, with the expected conditions for the Leichhardt seam at Isaac Plains. It can be seen there is a group of data points indicating unstable conditions exists for extended cuts (>6m) when CMRR falls below approximately 35. The range of geotechnical conditions for the Isaac Plains stone roof are expected to be "mostly to always stable" when extended plunges are taken.

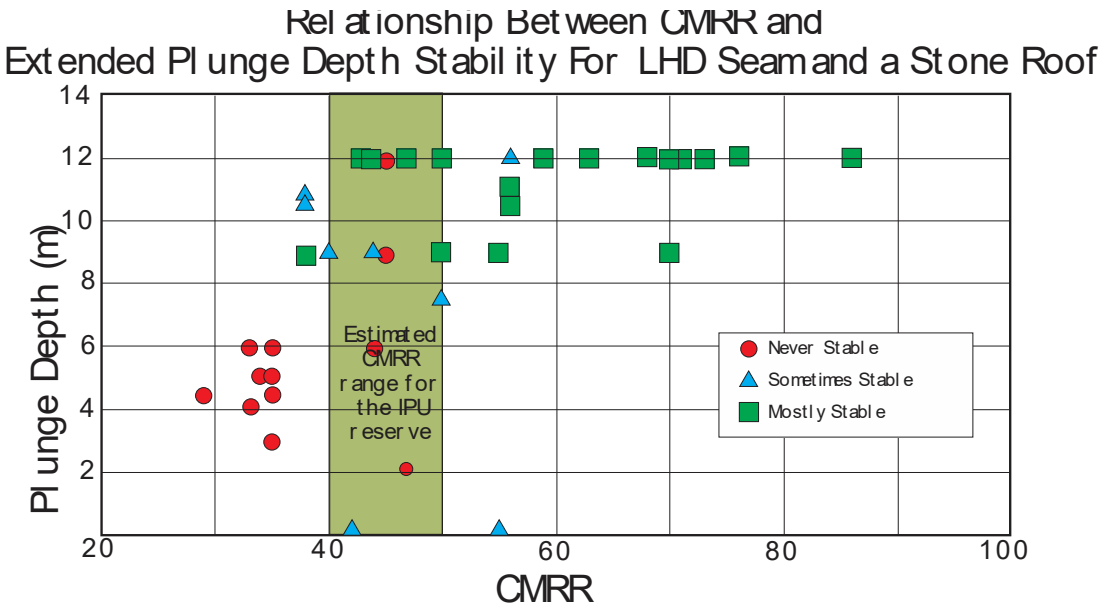


Figure 25: Extended cut assessment for depth of cover and CMRR for the Isaac Plains Underground Reserve.

The empirical experience base at Carborough Downs in similar geotechnical environments has shown that extended cuts to15m are routinely achieved in bord and pillar panels suggesting the relationship expressed in Figure 26 is potentially conservative in nature.

The width of heading assessment assumes a two-pass place change operation cutting a 6.0 to 6.5m wide heading, as is typical of place change operations that have been successfully undertaken at the nearby Carborough Downs operations. The relationship developed by *Molinda et al* (1994) was used to assess the stability of extended cuts using the using the expected range of CMRR and typical heading with of 6.0 to 6.5m, as depicted in Figure 26 below.

The results indicate that conditions for a stone roof horizon is mined the 6.0-6.5m heading width falls within the "never to sometimes stable" range and is below the extended cut out line defined by *Molinda et al* (1994) and above the Bianiawski stand up time equation. Hence it is expected that 6.5m or wider headings would be stable for a period of time prior to bolting. The empirical experiance base generated at the nearby Carborough Downs operation where the geotechnical environment is similar to that at Isaac Plains shows that heading widths of 6.5m are routinely stable when extended cuts are achieved, suggesting the Molinda et al (1994) relationship is of a conservative nature when applied to the Leichhardt Seam in this region.

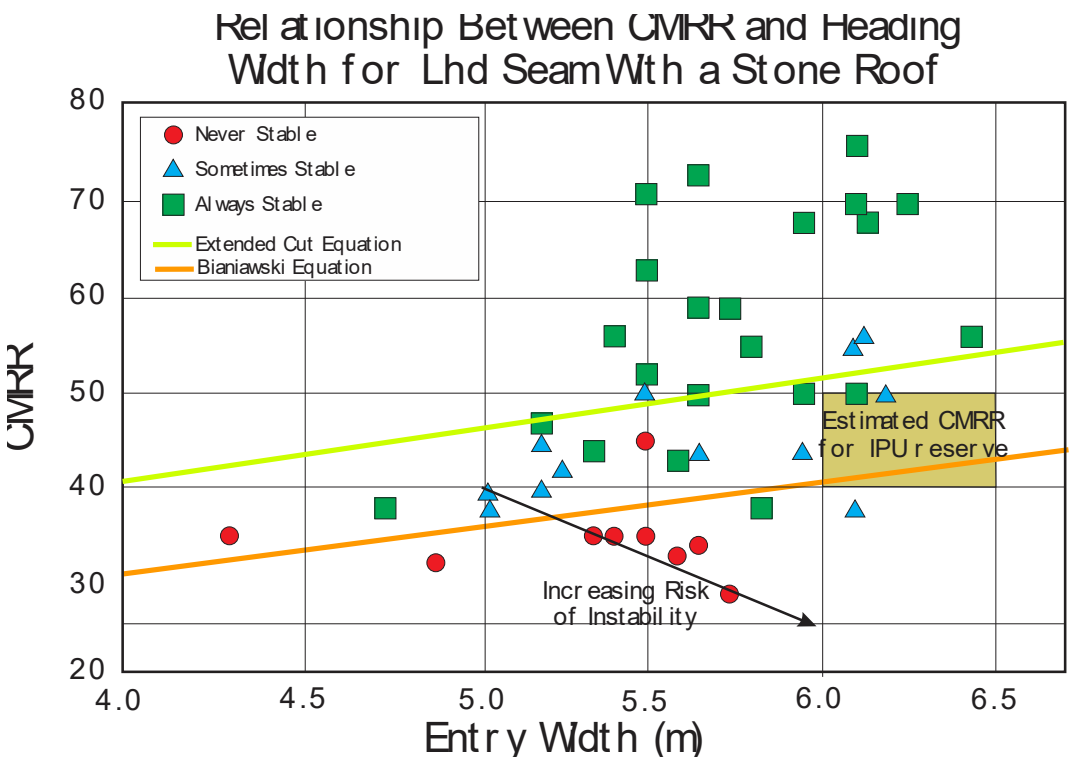


Figure 26: Extended cut assessment for width of heading and CMRR for the GU0 seam.

The most common support problem in bord and pillar workings occurs at the intersections of headings and cut throughs. The exposed roof spans are greatest at these points. The intensity of roof support must also be greatest there if roof failures are to be avoided. An assessment using the expected CMRR for the Leichhardt seam for a stone roof horizons and intersection span was undertaken using the relationship developed by *Molinda et al (1994)* was undertaken. Typical intersection spans, measured as the sum of the diagonals in two pass place change operations in Australia range from 17 to 28m.

Belling out the end of stubs will react in a similar manner as the widened intersections, as such, belling out will be a viable method of reserve recovery.

Figure 27 depicts the estimated range of Leichhardt seam conditions and span, with the results indicating that the stability of intersections greater than 19m at the upper bound of CMRR expected would be at a marginal stability. All efforts should be made to minimise the intersection spans to maximise stability, as is good mining practice. The Carborough Downs experience base is that intersection spans upto 28m wide on the diagonals are stable in the long and short term.

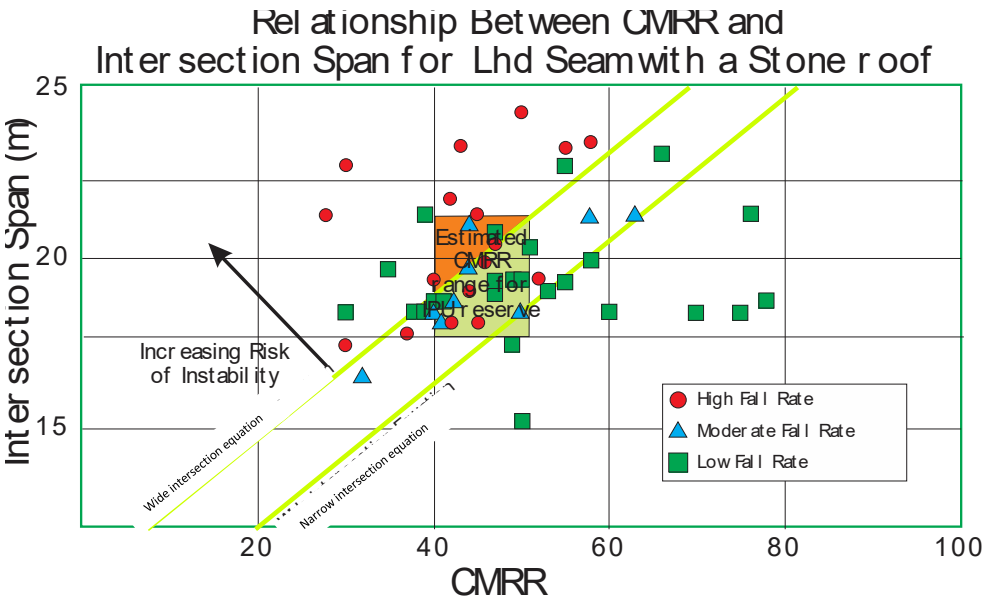


Figure 27: Extended cut assessment for intersection span and CMRR for the Leichhardt seam.

Summary and Recommendations for Plunge Depth and Width of Headings

Typical CMRR values at IPU based on a stone roof beam forming the entire bolted section is typically between 40 and 50 and is classified as a "weak to moderate" roof, and the analysis indicates that mining to this roof horizon would be not always be suited to extended cuts up to 15m at 6 to 6.5m width to a maximum depth of 250 to 300m. At depth of greater than 300m the empirical data base would suggest that extended plunges will not be viable.

The experience base from the nearby Carborough Downs Mine, where extensive bord and pillar operations have been and are currently being undertaken in a similar depth and CMRR range has demonstrated that extended plunges of upto 15m at 6.5m width are stable and economic place changing operations are viable.

In structured or deteriorating ground conditions the plunge depth would be reduced as controlled by a Trigger Action Response Plan (TARP).

It is proposed to use a multi-tiered TARP level of Code Green, Code Yellow and Code Orange, with Code Red being unexpected conditions requiring mining to be halted in that heading until a specific mining and support strategy is developed.

Code Green Plunge Depth at 6.0-6.5m width

- No more than 15m on stone roof

Code Yellow Plunge Depth at 6.0-6.5m width

- No More than 9m on stone roof

Code Orange Plunge Depth at 6.0-6.5m width

- No More than 6m on stone roof

In Code Red conditions mining is to stop until a specific cut and support strategy is developed.

7 Support Recommendations

Design principals

Numerous Geotechnical roof support design methodologies have been developed over a number of years, both within Australia and globally. These methodologies are based on empirical, analytical and/or numerical methods. As the underlying principles and the databases used in the development of these methodologies vary, their applicability to geotechnical systems also vary. As such no single method or analysis for design should be used and hence several should be employed to test for compliance.

The design criteria for drivage at Isaac Plains is based on the following:

- Geotechnical environment.
- Predicted geological structure.
- The design life cycle of the roadways – during development and followed potential secondary extraction. With the assumption that secondary support, as deemed necessary, will be installed outside of the development process.
- Equipment specifications and planned excavation geometry.
- *Insitu* performance of support consumables intended to be used.
- Historical monitoring and performance of similar excavations at nearby mines in the same seams.

In general, the design methodologies for roadway reinforcement design can be classified into the following six categories:

- Analytical methods (shear loading, dead-weight loading, buckling theory),
- Field testing and monitoring (monitoring and testing),
- Numerical modelling (2D and 3D modelling),
- Geotechnical classification (mainly CMRR etc),
- Empirical models (data/experience), and
- Physical modelling (laboratory modelling).

These methodologies require extensive input parameters and numerous assumptions with regard to support and rock properties. The assumptions made should be based on either site-specific information and/or published, widely accepted information available in the literature.

Within the design process, where possible, sound geotechnical engineering practice should include:

- Use of a "combined support design methodology" which considers all methods listed above, with the exception of physical modelling, so as to ensure that the design is sound and acceptable, or
- Use of a single model for the design and one or more of the others to back analyse/check the design results. To this end, this section summarises analytical design methodologies that may be used in the roof support design. The findings of this design should be checked against the local experience, actual monitoring data, experience at the operation and the engineering judgement of the design personnel.

Regardless of the design method used, the key inputs are the geotechnical characterisation, previous experience and an understanding of the failure modes that can result in uncontrolled deterioration in conditions.

Design Criteria

Various definitions of acceptable design criteria are used within the industry, one such commonly referenced criteria are presented below in Table 2.

Table 2: Geotechnical Design Criteria.

Classification	Recommended FoS	Risk Category
Long-life and/or strategic excavations - 10 to 20 years (e.g. shafts, install and take-off roads)	≥ 2.0	Very Low
Medium-term life excavations - 5 to 10 years (e.g. main headings)	1.8 to 2.0	Low
Short-life excavations 1 – 5 years (e.g. bord and pillar production panels, gate roads)	1.5 to 1.8	Moderate
0 – 1 years very short-life excavations (e.g. temporary excavations)	≥ 1.5	High

Analysis of Failure Modes

When the possible loading/failure mechanism can be estimated with high accuracy, then the relevant methodology (e.g., shear loading, dead-weight, buckling etc) can be used in isolation with the above recommended safety factors. However, in cases where the loading mechanism is not well known, then an evaluation using analysis of each mechanism should be conducted and the minimum safety factor should correspond to the above given recommended safety factors.

Details of each failure mechanism and analysis method are provided in Appendix 2 for completeness. This information is taken from various sources to allow for simple review and the reader is directed to the referenced material for further information.

General analytical and numerical analysis cannot take into account geological structures or natural variations in horizontal stress associated with seam rolls or structures. Variability in strength and geological nature of the ground is an unavoidable feature of the geotechnical environment. Similarly, the mine placed rock bolt properties may vary from the estimates used from typical data. The results therefore, should be viewed as providing an overview of the ground under the conditions modelled.

8 Analytical Analysis Results

Height of Softening Assumptions

In all analytical roadway design studies, the key assumption required for input is an estimation of the range of conditions that result in the height of softening expected to occur.

Tell-tale data and numerical modelling from existing mines in the same seam, with similar conditions show that from a depth of cover of 90m to approaching 300m, the height of softening is expected to be less than the length of the 1.8m roof bolts, where the horizontal stress is less than 6 MPa.

At depths, greater than 300m, the height of softening rapidly increases to greater than the length of the bolts, and as such longer tendon style support is likely to be required to satisfy the design criteria for gate roads.

Suspension Mechanism

Analysis of the suspension model for a nominal 6.0 to 6.5m wide standard drivage as considered in this design document. The additional 100mm width was used to simulate the effect of rib spall and off centre drivage. As expected the results show the sensitivity of the 4 bolt system to height of softening, and bolt spacing. The height of softening in non-structured areas is expected to be controlled by the depth of cover, where the deeper the heading is the higher the horizontal stress applied to the strata.

The suspension failure mode was analysed for both normal width roadways and for an approximation of the span of an intersection. The analysis for this justification was done in consideration of increasing height of softening, as the depth increases.

The results show that for the depth (90m to 250m) and associated stress magnitudes that this design specification applies to a 4 x 1.8m long bolt at 1.4m row spacing and provides a FoS of greater than the 1.5 required for bord and pillar panels and mains development. The same analysis was undertaken for intersections, assuming an approximate span of 10m. The results also show that in terms of suspension, the 4 x 1.8m long bolts per 1.4m spacing also provide a sufficient FoS to satisfy the design criteria. Figures 28 and 29 summarise the suspension failure mode analysis for both 6.5m roadways and intersections.

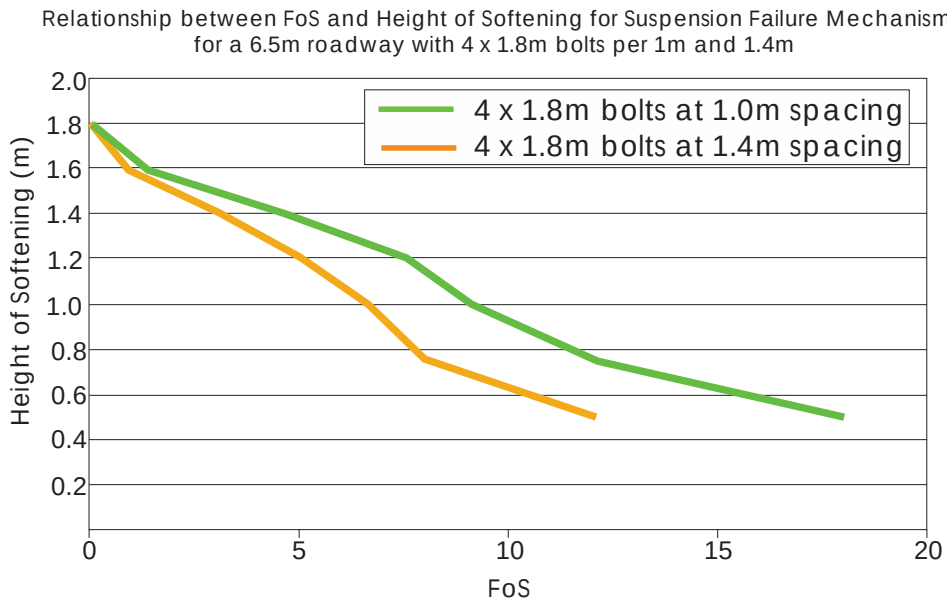


Figure 28: FoS for 4 x 1.8m bolts in 6.0 to 6.2 m wide roadway at varying heights of softening

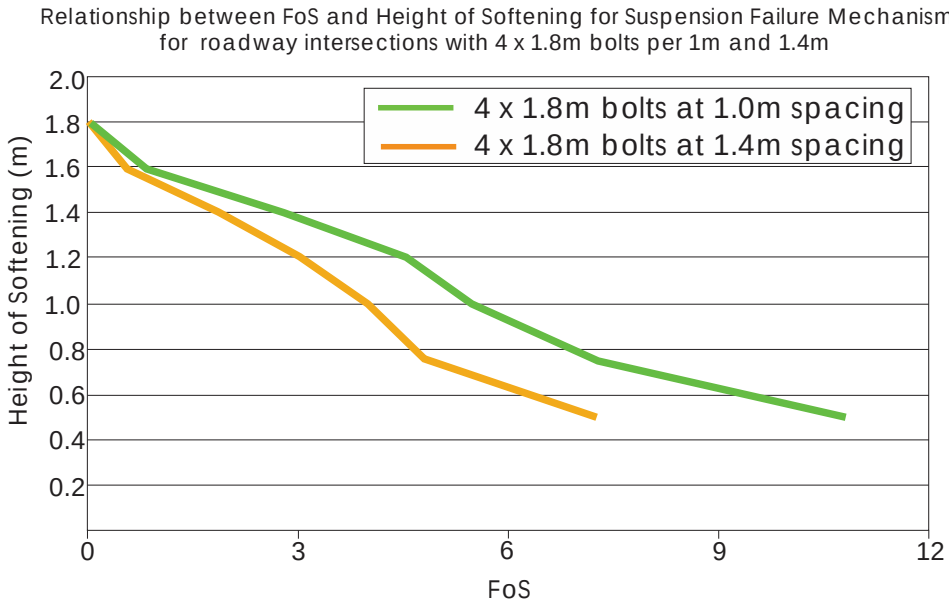


Figure 29: FoS for 4 x 1.8m bolts in intersections at varying heights of softening

Experience shows that rapid onset of softening can occur resulting in structured roof conditions. As such consideration should be given to continue with the practice of installing increased levels of bolting (1.0 to 1.4m spacings) and using TARP's with low trigger levels for roof movement to ensure the rapid increase in softening and dilation of the roof is minimised and controlled in an effective manner.

Roof Bolt Failure Mechanism

Analysis of the capacity of the bolts to maintain their effectiveness as reinforcement elements under shear loading, dead weight loading failure and bolt slippage or bond failure was undertaken for the proposed 6.0 to 6.5m wide roadway and the current 4 x 1.8m bolting pattern at 1.4m and 1.0m row spacing. Again, the same analysis was done for an approximation of the span of an intersection. The analysis was done considering increasing height of softening as the depth increases.

The results of the analysis of a 6.0 to 6.5m roadway show that each of the tested failure mechanisms returned an acceptable FoS, as the full range of height of softening was applied from 90m depth to 300m depth.

The analysis of bolt failure under dead load and by failure of the bond between the rock and bolt, both show that at no time does the bolting system come near failure right up to the height of softening going above the length of the roof bolt.

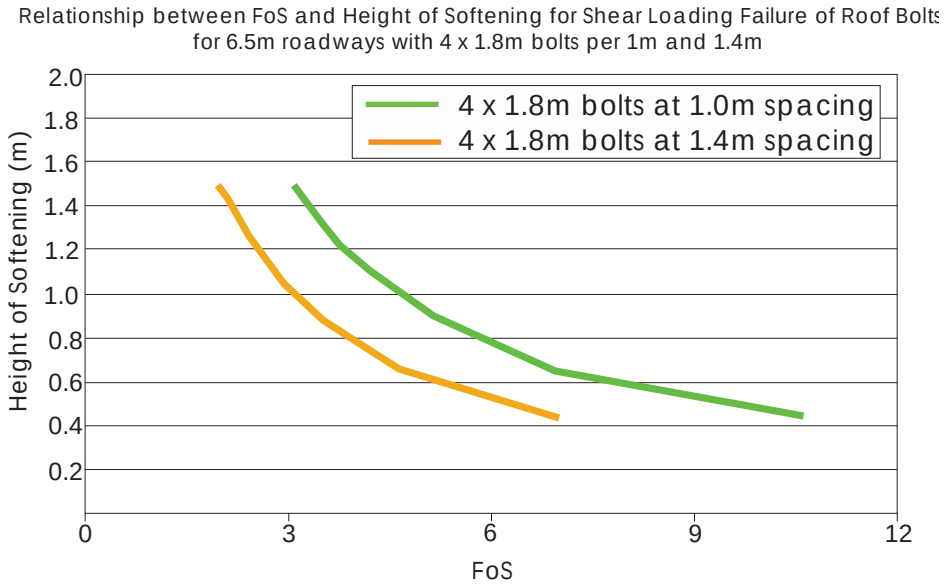
The bolt failure under shear loading analysis indicates that the bolts approach a FoS of 2 and 3.1 for a 1.4m and 1.0m row spacing respectively, as the height of softening reaches the top of the bolted horizon. Both of these results are within the design criteria of a FoS of >1.5 for bord and pillar panels and between 1.8 and 2.0 for mains headings. The analysis results are summarised in Figure 30.

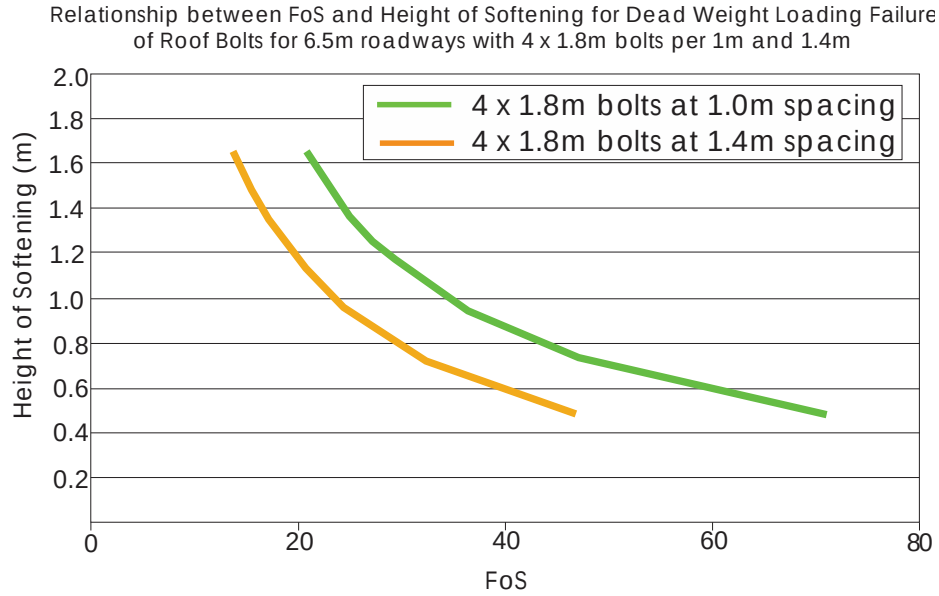
Analysis of the intersections, as expected, shows an increase in sensitivity to the height of softening, as depicted in Figure 31. For both dead weight loading and by failure of the bond between the rock and bolt due to the increased span and loading, neither mechanisms approach a FoS less than that defined in the design criteria (FoS 1.8 for mains and 1.5 for bord and pillar panels).

The shear failure mechanism is particularly sensitive to the span of the intersection and the analysis shows that the 4 bolts x 1.5m strap spacing at the highest depth, has a marginal FoS for the bolt capacity, and once the height of softening approaches 0.6m to 0.8m this FoS rapidly becomes less than the required 1.5 for bord and

pillar panels and 1.8 to 2.0 for mains headings. At a bolting density of 4 bolts x 1.0m strap spacing the FoS remains acceptable to a greater depth/height of softening but does not meet the design criteria once the height of softening reaches around 1.0m.

The analysis indicates care is needed when considering the span of the intersections formed (especially when using roof bolts alone once the depth reaches around 250m). Where the horizontal stress is expected to increase to a critical level and the deformation therefore has the potential to increase to the point where softening rapidly approaches or exceeds 1.0m. Consideration should be given to the use of tendon support in the intersections at depth of greater than 250m.





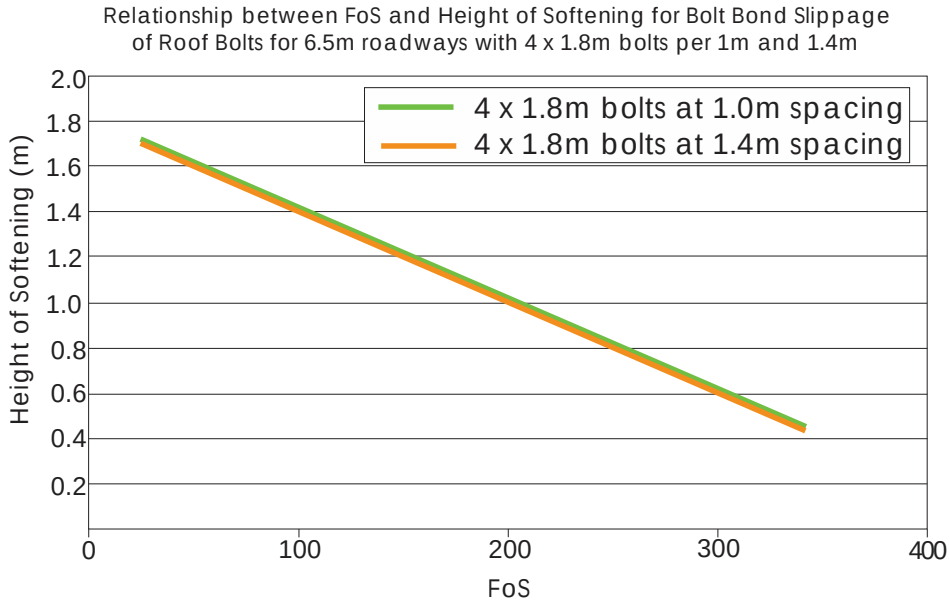
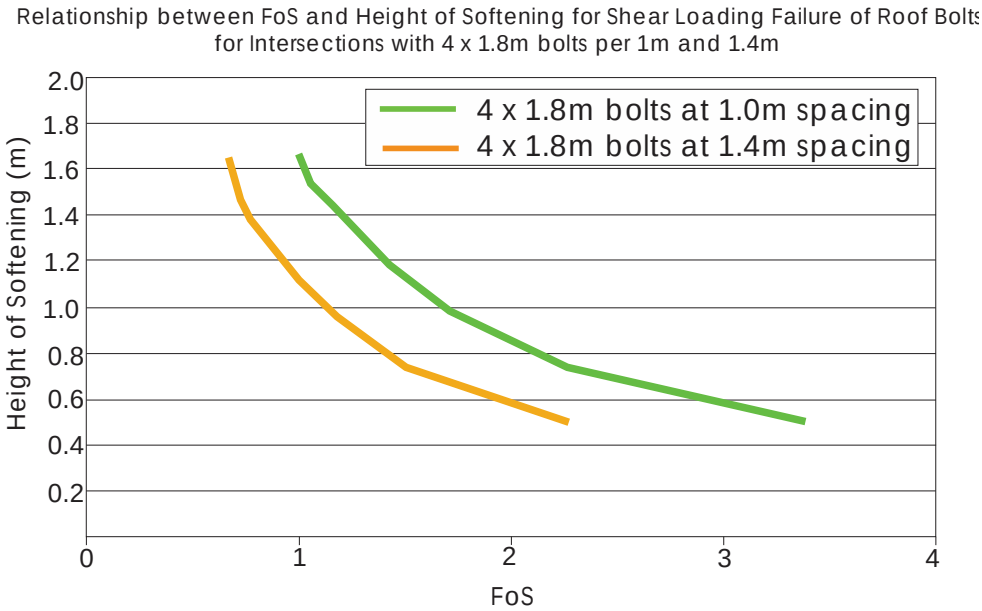
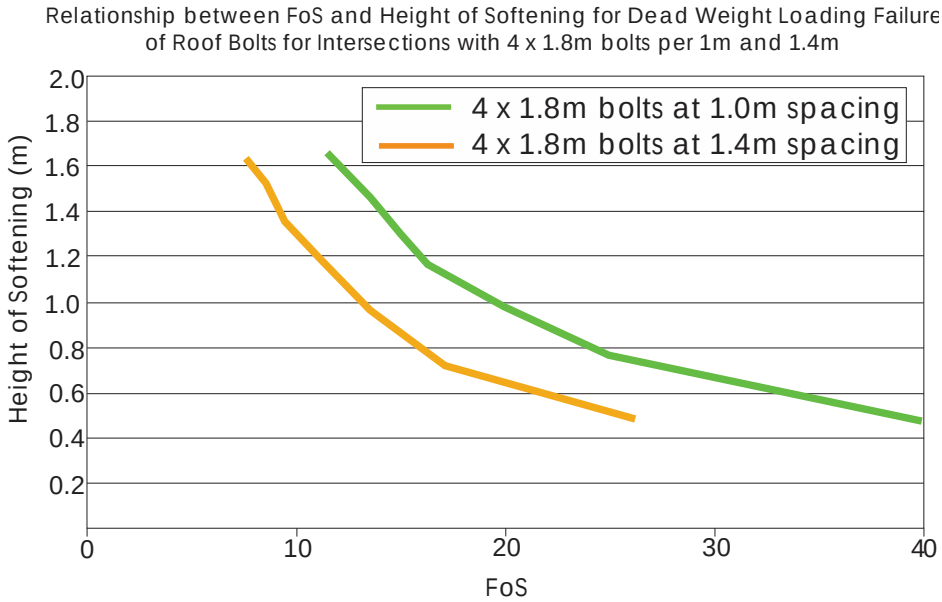


Figure 30: Bolt failure analysis for 6.5m roadways as the height of softening increases due to depth





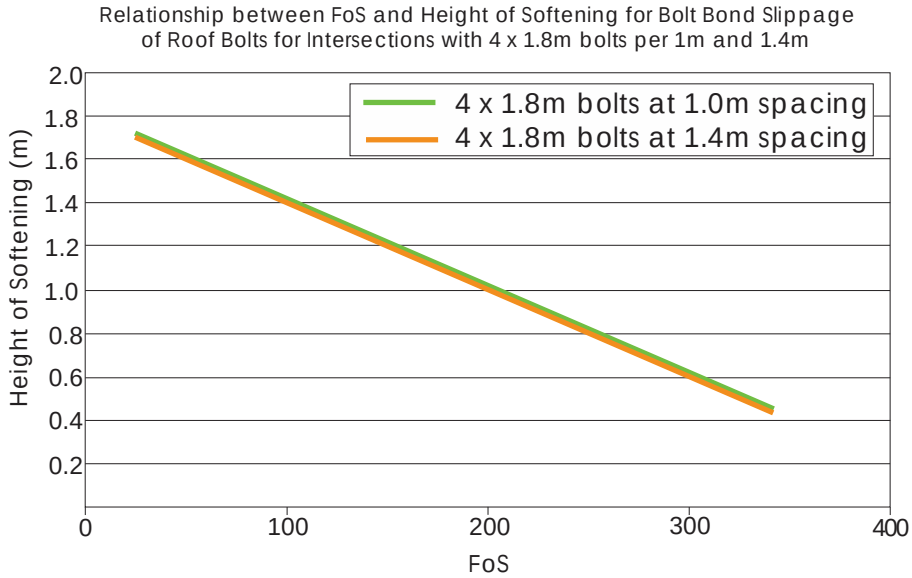


Figure 31: Bolt failure analysis for intersections as the height of softening increases due to depth

Buckling Model

The Buckling analysis for the 6.0 to 6.5m wide roadways requires additional input from the assumptions regarding the stress field, rock properties, bolt pattern and height of softening as a result of increased depth of cover.

Critical to this analysis is the anticipated orientation of the major horizontal stress to the drivage orientation. Based on the stress map data generated by SCT, the drivage directions in the study area has been developed.

Bucking analysis sensitivity is strongly influenced by the depth of cover and the height of softening, and as seen in the above discussion there is a step change in behaviour at a depth of around 300m where the height of softening increases rapidly due to increasing stress. Figure 32 summarises the sensitivity analysis undertaken, showing the 4 bolts at 1.5m and 1.0m strap spacing rapidly moves from an acceptable FoS greater than the design criteria of a FoS 1.5-2.0 to being below that design criteria at 260m and 280m DOC respectively.

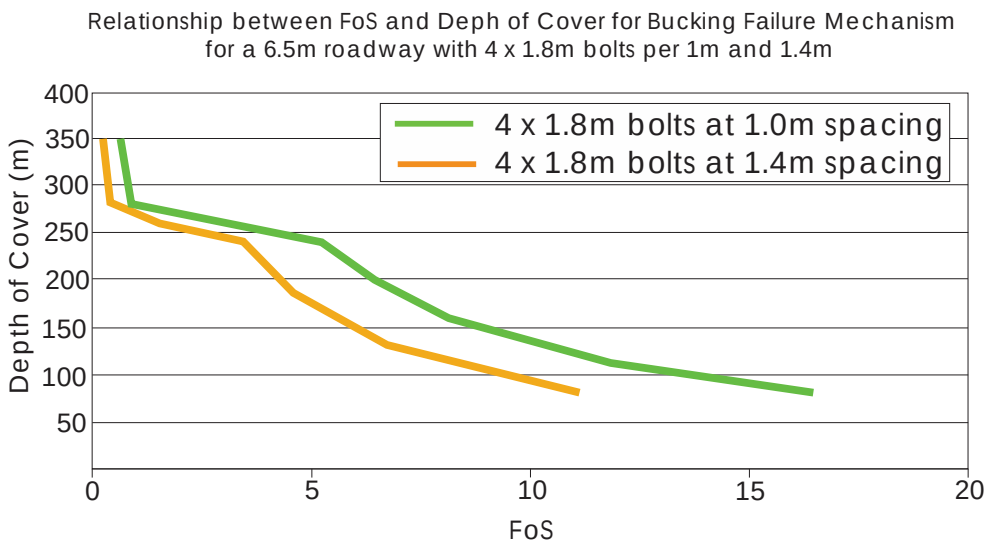


Figure 32: Summary of the buckling analysis

Empirical Methods Using the Primary Reinforcement Density Index

The Primary Reinforcement Density Index (PRDI) is a measure of the installed support capacity in MN per square meter of roof. The review of the IPU reserve by Golder Associates (January 2015) provided an indication of the likely PRDI requirements based on their propriety empirical database of successful primary roof support designs from over 80 mines across Australia, New Zealand, UK, South Africa and Europe. The relationship quoted by Golder Associates involves the Strength/Stress Ratio (SSR) – the ratio of Depth of cover /CMRR and the PRDI value. The Golder Associates report provides an estimation of the required PRDI need to fit within the industry range of successful design, based on a limited estimation of CMRR data.

With the additional data generated from this study and the support analysis presented above a review of the Golder Associates recommendation has been undertaken to update the analysis with the current data set.

Figure 33 is the Golder Associates database expressed as SSR and PRDI, also shown is the area where IPU will sit on the data base in terms of industry experience.

The proposed support density at depths of less than 250m are 4 x 1.8m X-grade bolts per 1.4m in a 6.0 to 6.5m wide roadway provides a PRDI of between 0.27 and 0.25. For intersections 6 x 1.8m X-grade bolts per 1.2m provides a PRDI of between 0.48 and 0.44 for 6.0 and 6.5m width respectively.

For depths greater than 250m up to 350m the proposed support density is 6 x 1.8m X-grade bolts per 1.2m in a 6.0 to 6.5m wide roadway provides a PRDI of between 0.48 and 0.44 for 6.0 and 6.5m width respectively. For intersections 6 x 1.8m X-grade bolts per 1.0m provides a PRDI of between 0.58 and 0.53 for 6.0 and 6.5m width respectively.

The Stress/ Strength ratio ranges from 2.25 to 1.8 at 90m depth of cover for a CMRR of 40 and 50 respectively and at 350m depth of cover the SSR is 8.75 and 7.0 for a CMRR of 40 and 50 respectively.

When these ranges of data are plotted on the previous graphical representation of the Golder Associates data base as illustrated below is Figure 33 for roadways and Figure 34 for intersections, the proposed support densities fall within the ranges of experience in the Golder Associates empirical data base or successful support strategies for the Australian data set. Based on this comparison against the industry data set the proposed support design would be deemed as adequate under normal (code green) conditions.

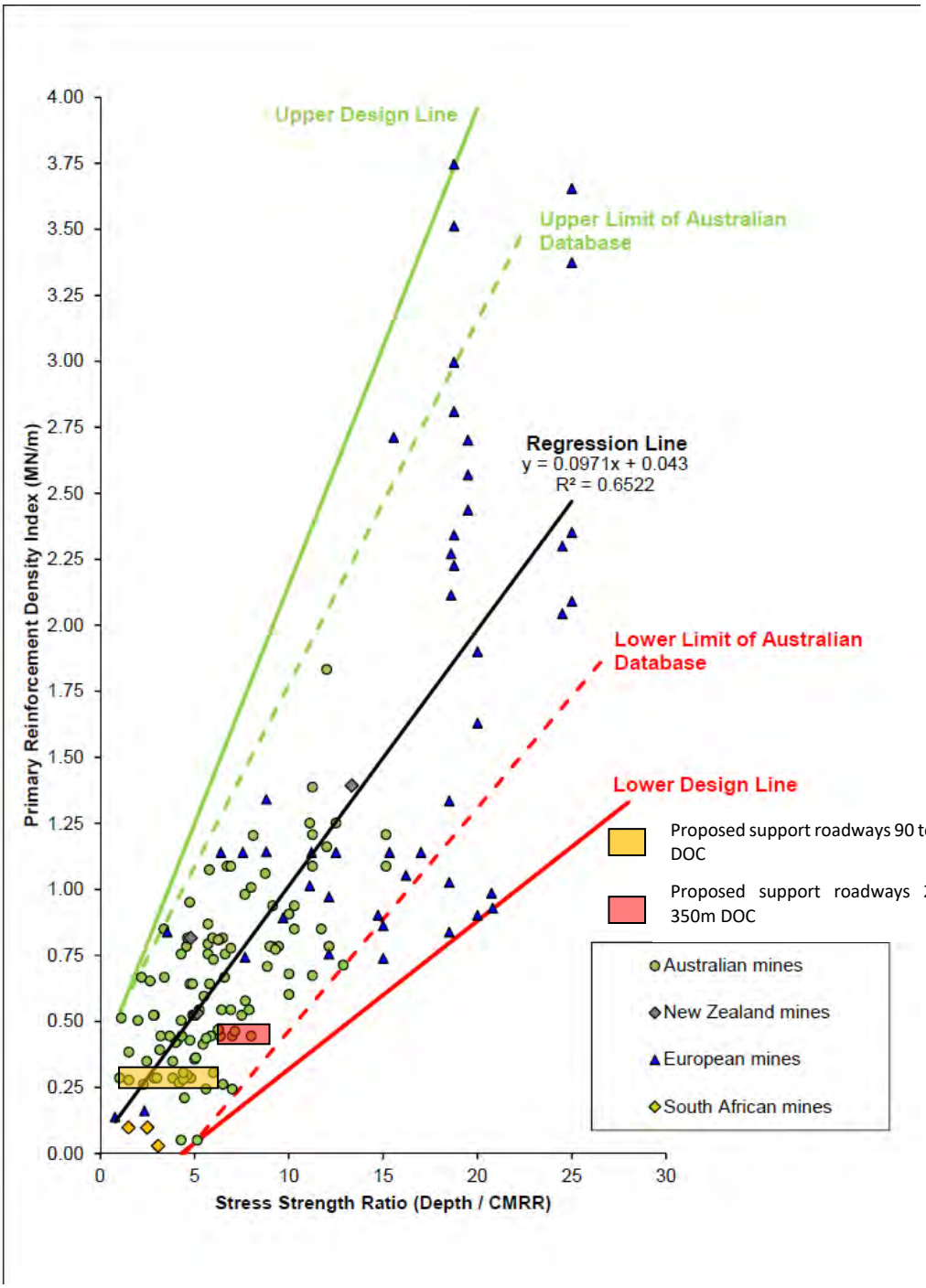


Figure 33: Golder Associates Primary Support Database showing the proposed support density (PRDI) for Isaac Plains Underground roadways at the two different depth domains of less than 250m and between 250 and 350m.

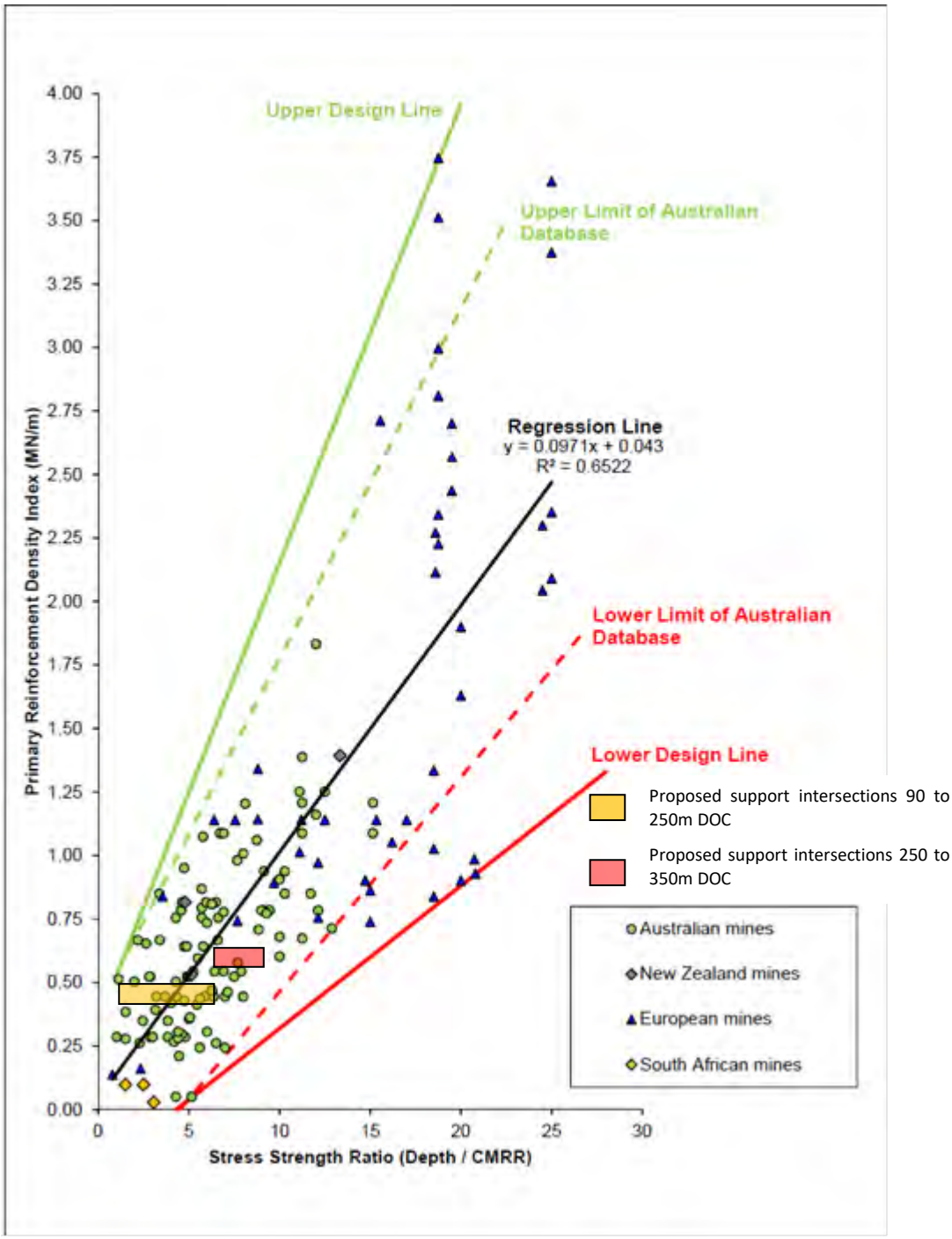


Figure 34: Golder Associates Primary Support Database showing the proposed support density (PRDI) for Isaac Plains Underground intersections at the two different depth domains of less than 250m and between 250 and 350m.

Rib Support Review

Based on ACARP 'Rib Support Design Methodology for Australian Collieries' C11027, 2004 the rib support analysis indicates rib bolts will only be needed as a TARP response to a depth of around 150m, when bots are required 2 x 1.2m bolts per 1.4m per rib is recommended. After a depth of around 150m to 250m 2 x 1.2m bolts per 1.4m per rib is recommended as a pattern.

At a depth of 250m to 350m a pattern of 2 x 1.8m rib bolts per 1.2m per rib is recommended with mesh as a TARP response as needed.

Details of the analysis are included in Appendix 1.

9 Summary of Support Recommendations

Analytical and empirical methods of support design analysis were used to provide guidelines for support density requirements for place change operations. The results indicate the following support levels would provide adequate Factor of Safety (FoS) criteria for bord and pillar drivage. Due to the range of depth of cover in the deposit two distinct depth domains have been used for the support recommendations, these being less than 250m DOC and between 250m and 350m DOC.

Code Green Support 6.0m to 6.5m width to a depth of cover of 250m

ROOF SUPPORT

- For headings a pattern of 4 x 1.8m roof bolts per 1.4m would be suitable for providing a stable mining environment to a depth of approximately 250m in unstructured ground.
- For intersections a pattern of 6 x 1.8m roof bolts per 1.2m would be suitable for providing a stable mining environment to a depth of approximately 250m in unstructured ground.
- The roof should be meshed as a TARP response when needed.

RIB SUPPORT

- To a depth of 150m rib support should be installed as a response to TARP conditions. Where rib support is installed a pattern of 2 x 1.2m rib bolts per 1.4m per rib would be suitable for providing a stable mining environment.
- From a depth of 150m to 250m rib support should be installed on advance, a pattern of 2 x 1.2m rib bolts per 1.4m per rib.
- In intersections the rib bolt spacing should match the roof bolt row spacing, where rib bolts are to be cut out during the formation of an intersection, cuttable rib dowels are to be used.
- Rib mesh should be considered as a TARP action when needed.

MONITORING

- Monitoring using tell tales at intersections in the belt road and travel road and around structures as a TARP response is recommended.

For structured ground or out of horizon development a set of TARP's and support plans are required to manage the resultant geotechnical hazards. It is proposed to use a multi-tiered TARP level of Code Yellow and Code Orange, with Code Red being unexpected conditions requiring mining to be halted and specific support plans to be developed.

Code Yellow Support 6.0m to 6.5m width to a depth of cover of 250m

ROOF SUPPORT

- For headings a pattern of 6 x 1.8m roof bolts per 1.4m would be suitable for providing a stable mining environment to a depth of approximately 250m in moderately structured ground.
- For intersections a pattern of 6 x 1.8m roof bolts per 1.2m would be suitable for providing a stable mining environment to a depth of 250m in moderately structured ground.
- The roof should be meshed as a TARP response when needed.

RIB SUPPORT

- A pattern of 2 x 1.2m rib bolts per 1.4m per rib would be suitable to a depth of approximately 250m.
- Rib mesh should be considered as a TARP action when needed where structures are present
- In intersections the rib bolt spacing should match the roof bolt row spacing, where rib bolts are to be cut out during the formation of an intersection, cuttable rib dowels are to be used.

MONITORING

- Monitoring using tell tales at intersections in the belt road and travel road and around structures as a TARP response is recommended.

Code Orange 6.0m to 6.5m width to a depth of cover of 250m

ROOF SUPPORT

- For headings a pattern of 6 x 1.8m roof bolts per 1.2m, with 2 x 4m point anchored 48t TTX tendons (or equivalent) per 2.4m (tendons to replace the 2nd and 5th bolt in every second row of bolts) would be suitable to a depth of approximately 250m in structured ground.
- For intersections a pattern of 6 x 1.8m roof bolts per 1.0m, with 2 x 4m point anchored 48t TTX tendons (or equivalent) per 2.0m (tendons to replace the 2nd and 5th bolt in every second row of bolts) would be suitable to a depth of approximately 250m in structured ground
- The roof should be meshed.

RIB SUPPORT

- A pattern of 2 x 1.2m rib bolts per 1.2m per rib would be suitable to a depth of approximately 250m.
- Rib mesh should be considered as a TARP action when needed where structures are present
- In intersections the rib bolt spacing should match the roof bolt row spacing, where rib bolts are to be cut out during the formation of an intersection, cuttable rib dowels are to be used.

MONITORING

- Monitoring using tell tales at intersections and around structures, typically one on each side of the identified structure.

Code Red 6.0m to 6.5m width to a depth of cover of 250m

- Stop mining and seek advice and specific support plans.

Code Green Support 6.0m to 6.5m width to a depth of cover of 250 to 350m

ROOF SUPPORT

- For headings a pattern of 6 x 1.8m roof bolts per 1.2m would be suitable for providing a stable mining environment to a depth of approximately 350m in unstructured ground.
- For intersections a pattern of 6 x 1.8m roof bolts per 1.0m would be suitable for providing a stable mining environment to a depth of approximately 350m in unstructured ground
- The roof should be meshed

RIB SUPPORT

- From a depth of 250m to 350m rib support should be installed on advance, a pattern of 2 x 1.8m rib bolts per 1.2m per rib.
- In intersections the rib bolt spacing should match the roof bolt row spacing, where rib bolts are to be cut out during the formation of an intersection, cuttable rib dowels are to be used.
- The rib should be meshed.

MONITORING

- Monitoring using tell tales at intersections in the belt road and travel road and around structures as a TARP response is recommended.

For structured ground or out of horizon development a set of TARP's and support plans are required to manage the resultant geotechnical hazards. It is proposed to use a multi-tiered TARP level of Code Yellow and Code Orange, with Code Red being unexpected conditions requiring mining to be halted and specific support plans to be developed.

Code Yellow Support 6.0m to 6.5m width to a depth of cover of 250 to 350m

ROOF SUPPORT

- For headings a pattern of 6 x 1.8m roof bolts per 1.0m would be suitable for providing a stable mining environment to a depth of approximately 350m in moderately structured ground.
- For intersections a pattern of 6 x 1.8m roof bolts per 1.0m with 2 x 4m point anchored 48t TTX tendons (or equivalent) per 2.0m (tendons to replace the 2nd and 5th bolt in every second row of bolts) would be suitable to a depth of approximately 350m in moderately structured ground.
- The roof should be meshed.

RIB SUPPORT

- From a depth of 250m to 350m rib support should be installed on advance, a pattern of 2 x 1.8m rib bolts per 1.0m per rib.
- Where rib bolts are to be cut out during the formation of an intersection, cuttable rib dowels are to be used.
- The rib should be meshed.

MONITORING

- Monitoring using tell tales at intersections in the belt road and travel road and around structures as a TARP response is recommended.

Code Orange 6.0m to 6.5m width to a depth of cover of 250 to 350m

ROOF SUPPORT

- For headings a pattern of 6 x 1.8m roof bolts per 1.0m, with 2 x 4m point anchored 48t TTX tendons (or equivalent) per 2.0m (tendons to replace the 2nd and 5th bolt in every second row of bolts) would be suitable to a depth of approximately 350m in structured ground.
- For intersections a pattern of 6 x 1.8m roof bolts per 1.0m, with 2 x 6m point anchored 48t TTX tendons (or equivalent) per 2.0m (tendons to replace the 2nd and 5th bolt in every second row of bolts) would be suitable to a depth of approximately 350m in structured ground
- The roof should be meshed.

RIB SUPPORT

- A pattern of 3 x 1.8m rib bolts per 1.0m per rib would be suitable to a depth of approximately 350m.
- Where rib bolts are to be cut out during the formation of an intersection, cuttable rib dowels are to be used.
- The rib should be meshed.

MONITORING

- Monitoring using tell tales at intersections and around structures, typically one on each side of the identified structure.

Code Red 6.0m to 6.5m width to a depth of cover of 250 to 350m

- Stop mining and seek advice and specific support plans.

Residual Risks

It is considered that there are two main residual risks remaining in this support design:

- Geological Variations not picked up in the exploration program;
- Support not being installed to design.

The FoS applied somewhat control this possible variation. However, additional measures such as the application of a monitoring regime, TARP systems and use of the Secondary Support Installation Guidelines (including auditing ground condition reporting templates) further aid in reducing these risks to acceptable levels.

10 First Working Pillar Sizes

A desktop review of possible bord and pillar first workings pillar sizes was conducted to investigate typical dimensions for a bord and pillar extraction type layout using the UNSW analysis method. The analysis is based on a typical multi entry layout at nominal depth ranges from 90 extending to a depth of 410m, measured against the criteria listed in Table 3 below (Canbulat pers com).

Table 3: Geotechnical Design Criteria for Pillar Design.

Classification	Recommended Safety Factor
Short-life excavations 1 – 5 years (e.g. bord and pillar production panels, gate roads)	1.5 to 1.8
Medium-term life excavations - 5 to 10 years (e.g. main headings)	1.8 to 2.0
Long-life and/or strategic excavations - 10 to 20 years (e.g. Drifts, shafts, install and take-off roads)	≥ 2.0

Depth of cover and extraction height are the main controlling factors for pillar size in bord and pillar sections. For the current IPU project the environmental approvals limit the surface subsidence to 200mm and require a minimum of 1.6 FoS on all pillars.

Deign assumptions are for 6m wide roads and extraction heights of 3.5m, 4.0m and 4.5m in an attempt to assess full seam height extraction across the mining area with no secondary extraction of the pillars. All dimensions are pillar centres. The results are summarised in Table 4.

The W/H ratios for the shallowest pillars are below the 4 standard, but the FoS is greater than 1.6 as such they will be stable due to the low loading environment, excluding any areas where structural features such as faults are present. In faulted cases each pillar should be considered prior to the floor coal being taken.

Table 4: Standard pillar sizes for Isaac Planes Underground.

Mining Height	**3.5m**			**4.0m**			**4.5m**		
Depth (m)	Size (m) centres	FoS	W/H	Size (m) centres	FoS	W/H	Size (m) centres	FoS	W/H
90	15.7x15.7	1.6	2.77	16.5x16.5	1.6	2.63	17.5x17.5	1.6	2.56
110	17.5x17.5	1.6	3.29	18.5x18.5	1.6	3.13	19.5x19.5	1.6	3.00
130	19x19	1.6	3.71	20.5x20.5	1.6	3.63	22x22	1.6	3.56
150	21x21	1.6	4.29	22.5x22.5	1.6	4.13	24.5x24.5	1.6	4.11
170	23x23	1.6	4.86	25x25	1.6	4.75	26.5x26.5	1.6	4.56
190	25x25	1.6	5.43	27x27	1.6	5.25	29.5x29.5	1.6	5.22
210	26.5x26.5	1.6	5.86	29x29	1.6	5.75	32x32	1.6	5.78
230	28x28	1.6	6.29	31x31	1.6	6.25	34x34	1.6	6.22
250	29.5x29.5	1.6	6.71	33x33	1.6	6.75	36x36	1.6	6.67
270	31x31	1.6	7.14	34.5x34.5	1.6	7.13	38x38	1.6	7.11
290	32x32	1.6	7.43	36x36	1.6	7.50	39.5x39.5	1.6	7.44
310	33.5x33.5	1.6	7.86	37.5x37.5	1.6	7.88	41x41	1.6	7.78
330	34.5x34.4	1.6	8.14	38.5x38.5	1.6	8.13	42.5x42.5	1.6	8.11
350	35.5x35.5	1.6	8.43	40x40	1.6	8.50	44x44	1.6	8.44
370	36.5x36.5	1.6	8.71	41x41	1.6	8.75	46x46	1.6	8.89
390	37.5x37.5	1.6	9.00	42x42	1.6	9.00	47x47	1.6	9.11
410	38.5x38.5	1.6	9.29	43.5x43.5	1.6	9.39	48.5x48.5	1.6	9.44

It should be noted the analysis aimed to maintain a square pillar layout, where as in reality pillar widths can be maintained and the lengths increased as the depth increases to maintain the same FoS. Each panel should be optimised such that the minimal pillar size is designed with consideration given to the plunge depths and equipment.

To optimise the place changing operational efficiencies in terms of plunges, a series of pillar designs that maintains a 30m length and varied the width up until the length becomes a limiting factor (ie wider than long) has been provided. At the point where the length is a limiting factor the project has opted for square pillars as per the above table.

The current EA conditions call for pillars under the flood plain to be designed at a minimum FoS of 1.6 and under the designated channel of Smokey Creek the pillars shall be maintained at a FoS of 2.11, the mine plan has been designed to account for these restrictions.

Table 5: Standard pillar sizes for Isaac Planes Underground for optimised plunge depths.

Depth of cover (m)	Pillar width and length (m)			W/H Ratio
	3.5m mining height	4.0m mining height	4.5m mining height	
90	15 x 30	16 x 30	17 x 30	<4 Slender Pillars – higher risk of rapid deterioration
110	17 x 30	18 x 30	20 x 30	
130	18.5 x 30	21 x 30	23 x 30	
150	21 x 30	24 x 30	26 x 30	
170	23.5 x 30	26.5 x 30		
190	26 x 30			>4 squat pillars
210	29 x 30			

11 Secondary Extraction Options

Secondary workings involve the recovery of reserves after first working have developed a block of coal, typically secondary recovery occurs in thicker seams by removing floor coal and/or by stripping the ribs, or fendering or splitting into pillars. In these examples caving is not promoted and the result is a partial extraction situation where the roadways remain open.

Recent examples of secondary extraction in the Bowen Basin are Cook Colliery, Ensham Colliery, Carborough Downs and Bundora Colliery. At Cook, Ensham and Bundora Collieries secondary extraction involves pocketing into large pillars or rib stripping. While at Carborough Downs floor coal was recovered from bord and pillar panels which were driven on the stone roof. All three of four operations are producing or have successfully produced coal from these methods.

Geotechnical Considerations for Secondary Extraction

Secondary extraction methods are a financially successful and productive means of recovering reserves typically where faulting, intrusive or lease boundary and subsidence constraints rule out higher productivity longwall operations. For secondary extraction to be a reliable and sustainable method of coal recovery it is normally a requirement that first workings bord and pillar place change operations are also feasible.

Continuous miner based secondary extraction systems are relatively low capital cost and extremely flexible in conditions of disturbed ground, fault bound blocks and steep grades. A number of methods can be used and should be evaluated against factors such as:

- Potential for more favourable panel orientation should faults, stress magnitudes or concentrations, intrusions or seam dip, have significant impacts on geometry or productivity.
- Higher ratio of lower cost and productive secondary extraction to primary development coal when considering comparable layouts for ground stability.
- Benefits of minimising primary development on advance (improved floor conditions, improved ventilation and reduction in long standing multi-purpose roadways).

For safe and efficient secondary workings, either bottom coal or rib stripping and pillar splitting the key geotechnical parameters include:

- Stable roof conditions,
- Confined and stable rib conditions,
- A regular shaped panel design,
- Small intersections,
- Adequate pillar dimensions,
- Durable floor conditions,
- Disciplined extraction sequencing.

Bottom Coaling

The Leichhardt Seam has potential for floor coal extraction, due to the thick nature of the seam. A risk exists in terms of rib stability due to the stone banding present and height of the rib which has resulted in rib spall and crushing if not adequately confined by mesh and bolts.

In general terms, a six pillar, 7-entry system of primary extraction has found wide success for secondary recovery of bottom coal. This system can be used to optimise shuttle car cycle times via alternative wheeling routes to a central belt road. Such a layout may be utilised for secondary extraction via pillar stripping or split and lift type methods, however such methods are usually accompanied by several hazards.

A recent example of successful bottom coal recovery can be found at Carborough Downs Coal Mine, where a 5.2m thick seam was developed using a typical 7 to 9 heading place change operation. In this case the headings where driven to a very strong stone roof, leaving a full 2.0 thickness of floor coal to be stripped. Secondary extraction occurred once the panel reached its limits and the operation started ramping down into the floor.

Depth of cover is a controlling factor when considering bottom coaling operations, as once floor stripping occurs the rib line height increases and is subject to rapid bucking and failure. Experience shows that as the depth increases to greater than approximately 250m normal rib heights of 3.0 to 3.5m experience bucking and failure due to vertical stress. Typically, this failure is only to a depth of 0.5 to 1.0m and is managed by rib bolting and the use of mesh.

Modified Duncan Method

As part of the reserve optimisation process and assessment of a partial extraction method suitable for the deposit the study team developed a pillar stripping design based on a modified Duncan Method. The modified

Duncan method allows for secondary extraction of coal while proving for long term stable remanent pillars of a FoS of 1.6 under flood plain areas and 2.11 under the Smokey Creek designated channel as required by the project's environmental approvals.

The design assumptions are similar as that used in the Duncan method with the same pillar FoS and subsidence restrictions. The modified Duncan method assumes no caving and the roof spans the extracted void with only immediate roof failure over time. The proposed layout is illustrated in Figure 35. The intention is to develop a row narrow pillars adjacent to larger pillars and extract all or at least 15m of the width of the narrow pillar when retreating out of the panel.

The proposed mining method will require control of the strata immediate to and around the lifting face, a full operational risk assessment will be required to assess the requirements for standing support, breaker line supports or other options as well as mining sequence and positioning of operators and other personal.

The design criteria stipulate that once the narrow pillar has been extracted the larger remanent pillars are to maintain a FoS of a minimum of 1.6, be stable and maintain a subsidence value of less than 200mm, as per the requirements of the environmental approvals.

As the extraction panels get deeper the size of the narrow and larger pillars increases to maintain the FoS of 1.6 after the extraction of the narrower strip of pillars. At a depth of around 190m the width of the narrower pillar becomes greater than the 15m of solid coal the miner can reach, at this point a thin fender of coal will be left on the inbye side. The assumption is that this fender offers no support to the strata as its w/h ratio and FoS would be such that its yield and failure would be almost certain.

The analysis of this pillar system has been undertaken for 3.5 and 4.0m mining height.

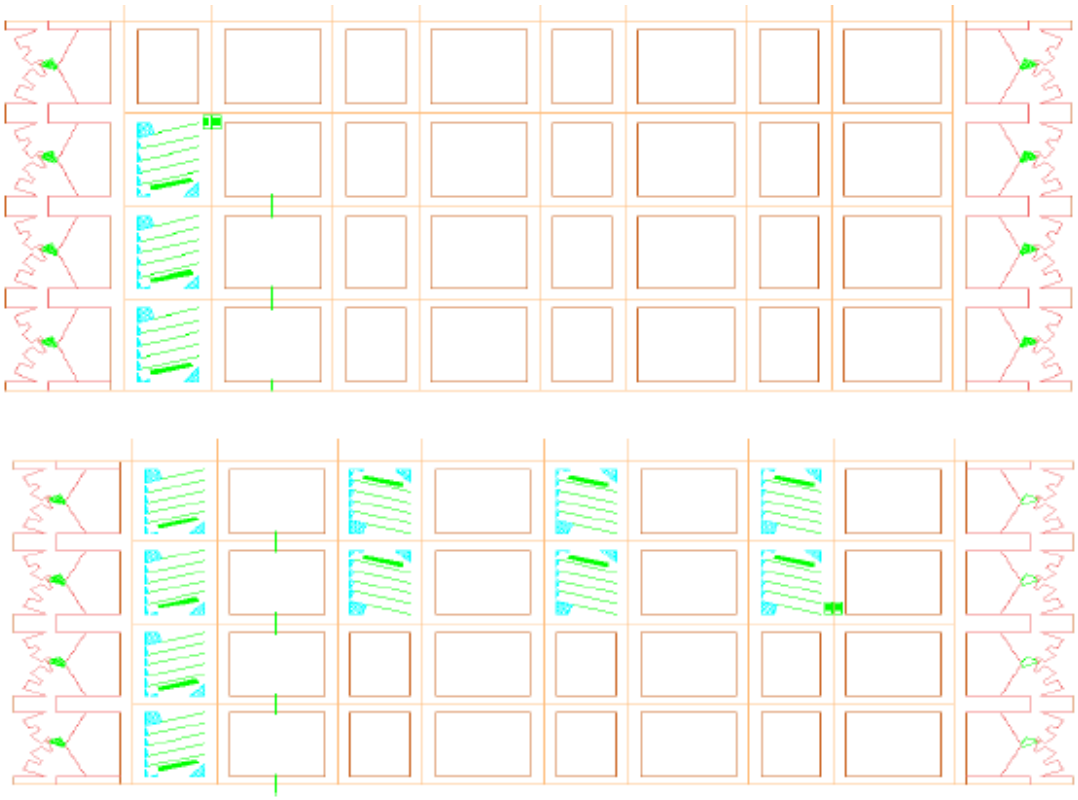


Figure 35: Depiction of the Modified Duncan partial extraction method

Table 6: Standard pillar sizes for the proposed modified Duncan secondary extraction method.

DEPTH	HEIGHT					
130-150m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		20	31		1.8	4
Wide pillar		31	31		2.9	7.14
		Width Solids	Length Solids			
Remnant Pillar		25	25		1.7	7.14
DEPTH	HEIGHT					
130-150m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		20	34		1.63	3.5
Wide pillar		34	34		2.85	7
		Width Solids	Length Solids			
Remnant Pillar		28	28		1.7	7

DEPTH	HEIGHT					
150-170m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		20	32.5		1.6	4
Wide pillar		32.5	32.5		2.8	7.6
		Width Solids	Length Solids			
Remnant Pillar		26.5	26.5		1.7	7.6
DEPTH	HEIGHT					
150-170m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		22	36		1.65	4
Wide pillar		36	36		2.77	7.5
		Width Solids	Length Solids			
Remnant Pillar		30	30		1.7	7.5

DEPTH	HEIGHT					
170-190m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		22	34		1.66	4.57
Wide pillar		34	34		2.7	8
		Width Solids	Length Solids			
Remnant Pillar		28	28		1.65	8
DEPTH	HEIGHT					
170-190m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		24	38		1.66	4.5
Wide pillar		38	38		2.7	8
		Width Solids	Length Solids			
Remnant Pillar		32	32		1.67	8

DEPTH	HEIGHT					
190-210m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		23	36		1.6	4.86
Wide pillar		36	36		2.75	8.57
		Width Solids	Length Solids			
Remnant Pillar		30	30		1.68	8.57
DEPTH	HEIGHT					
190-210m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		25	40		1.6	4.75
Wide pillar		40	40		2.7	8.5
		Width Solids	Length Solids			
Remnant Pillar		34	34		1.67	8.5

DEPTH	HEIGHT					
210-230m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		25	37.5		1.63	5.4
Wide pillar		37.5	37.5		2.7	9
		Width Solids	Length Solids			
Remnant Pillar		31.5	31.5		1.64	9
DEPTH	HEIGHT					
210-230m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		27	42		1.6	5.25
Wide pillar		42	42		2.7	9
		Width Solids	Length Solids			
Remnant Pillar		36	36		1.65	9

DEPTH	HEIGHT					
230-250m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		26	39		1.6	5.7
Wide pillar		39	39		2.7	9.4
		Width Solids	Length Solids			
Remnant Pillar		33	33		1.63	9.4
DEPTH	HEIGHT					
230-250m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		29	45		1.6	5.75
Wide pillar		45	45		2.86	9.7
		Width Solids	Length Solids			
Remnant Pillar		39	39		1.7	9.7

DEPTH	HEIGHT					
250-270m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		28	41		1.65	6.29
Wide pillar		41	41		2.79	10
		Width Solids	Length Solids			
Remnant Pillar		35	35		1.66	10
DEPTH	HEIGHT					
250-270m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		30	47		1.6	6
Wide pillar		47	47		2.9	10.2
		Width Solids	Length Solids			
Remnant Pillar		41	41		1.77	10.2

DEPTH	HEIGHT					
270-290m	3.5m	width centres	length centres		FoS	w/h
Narrow Pillar		29	42		1.6	6.6
Wide pillar		42	42		2.74	10.3
		Width Solids	Length Solids			
Remnant Pillar		36	36		1.6	10.3
DEPTH	HEIGHT					
270-290m	4m	width centres	length centres		FoS	w/h
Narrow Pillar		32	49		1.6	6.5
Wide pillar		49	49		2.95	10.7
		Width Solids	Length Solids			
Remnant Pillar		43	43		1.78	10.7

Bell-Outs

Part of the planned extraction of the IPU reserve is to undertake bell outs off stubs driven out around the edges of the panels. Bell outs are an effective method of maximise coal recovery on the margins of panels. The planned bell outs are unsupported plunges, up to 15m driven in a fan shape, opening up an area up to 28m wide. Similar methods are successfully used at Carborough Downs and Ensham Mines. The general design of the bell out is depicted in Figure 36.

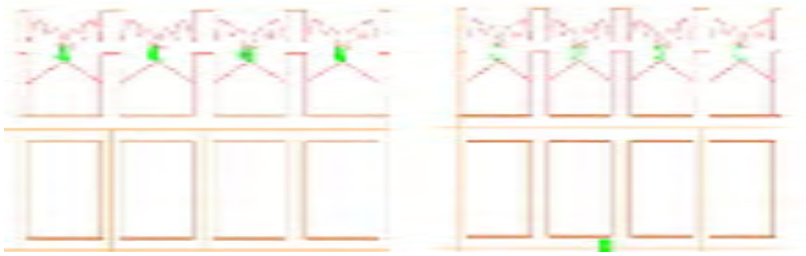


Figure 36: General configuration of bell outs at the margins of a panel.

The stability of a bell out is dependent on the condition of the roof rockmass, condition of any geological structures depth/stress and time. Detailed analysis of the stability of a given bell out is not possible, as no specific design tools exist. But the general stability and stand up time can be estimated using the empirical database of Unsupported Tunnel Limits (Bieniawski, 1993, 1989).

Using the design curve developed by Bieniawski 1989 as shown in Figure 37 below, and the rock mass rating for the roof strata at Isaac Plains it is possible to estimate the stand-up time for the bell outs.

It must be acknowledged that as with any empirical method the range of results given is a guide and are subjected to a number of variables inherent in any rock mass and mining situation. Hence the resolution of the result will tend to be broad, and the result should be calibrated with site-based experience.

In the bell out analysis the following assumptions are made:

- On average the expected maximum unsupported span at bell outs is to be 15m x 28m.
- Rock Mass Rating (RMR) for the stone roof through this area is between 45 and 50.

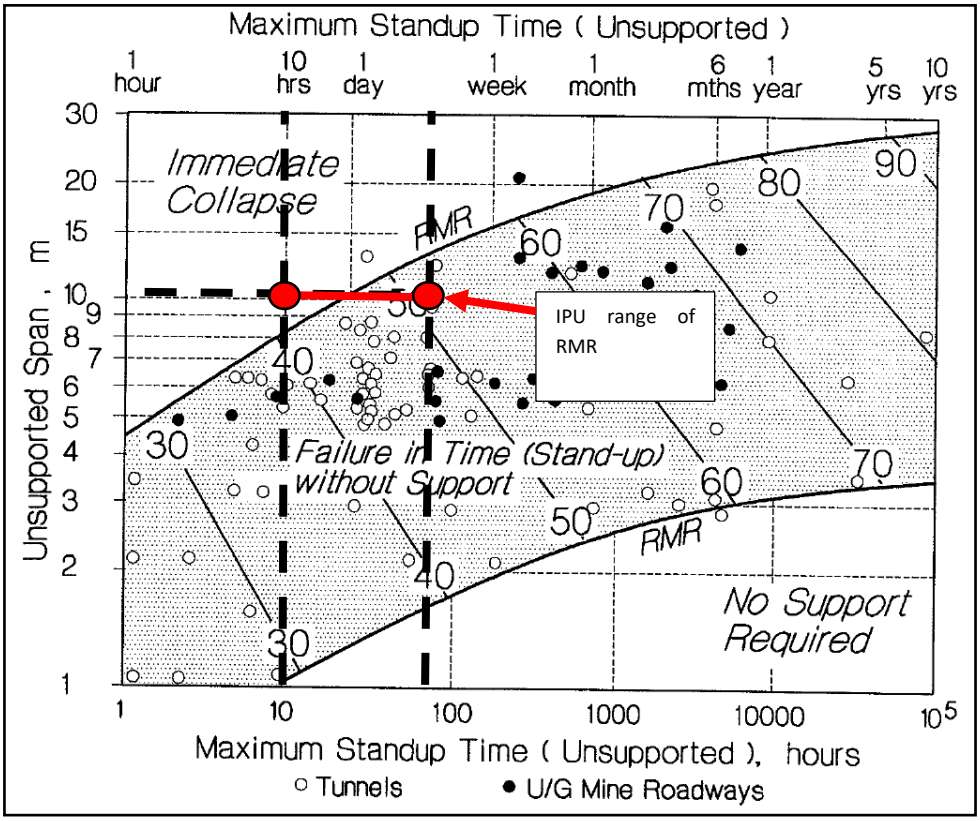


Figure 37: Tunnel standup time (after Bieniawski 1993 & 1989)

The results show the estimated standup time for a bell out will be between 10 hours and 1 day. The analysis is highly variable on geological conditions such as structures, mining variables such as sequencing and horizon.

Based on experience at Carborough Downs and Ensham where similar excavation dimensions and rockmass conditions exist the stand-up time is underestimated by Bieniawski as the majority of the bell outs are seen to stay open and stable for periods of weeks at a time.

The Leichhardt Seam experience base suggests that roof stability in the bell outs would be at the more stable end of the range provided by the Bieniawski RMR analysis and the bell outs would remain stable while the continuous miner is completing the extraction sequence. It would be expected that these bell outs would be self-supporting for two weeks to a month, with perhaps only minor skin slabbing or poor conditions when mining in or around faulted ground where the RMR will reduce to less than 40.

When a bell out is completed there may be some degree of abutment loading on the supported roadway outbye of the bell out, with this loading increasing as several adjacent bell outs are formed. As such the pillars formed between adjacent roadways and bell outs must be such that the increasing tributary loading can be carried by sufficiently large pillars. The stand-up time analysis indicated that the bell outs will not cave while mining is occurring as such the pillars will be subjected to an increasing tributary loading as the bell out is formed.

Any deterioration that would occur in the pillar would be experienced at the inbye end of the supported roadway immediately adjacent to the bell out. This zone will see the maximum increase in tributary loading and is the most at risk from over stressing and deterioration of the roof or rib. To manage this risk, a higher density of roof and rib support should be included to act as a breaker line of support if the load becomes such that the pillar edge starts to deteriorate. For the initial bell outs, an increase the roof and rib bolt density by halving the row spacings for three rows is suggested as a minimum. If once several bell outs are successfully completed this increased density should be reviewed.

Secondary Extraction Geotechnical Risks

The planned extraction of the narrow pillar and formation of the bell outs around the perimeter of the panel will result in wide unsupported pans spans, which are subject to increased stress concentrations and buckling. Localised failure in these situations can occur rapidly with little warning. Typically, successful extraction using these methods is undertaken in areas where place change development is successful and is under strong roof and shallow conditions.

Key reasons for the development of partial extraction methods include:

- Minimising the time pillars stand before extraction
- Concentration of working places and reduction in miner tramming
- Simple and effective ventilation
- High productivity
- Establishing a safe working environment in difficult conditions
- High resource recovery.

12 Subsidence Predictions

In contrast to high extraction mining such as longwall mining, partial pillar extraction areas are not planned to cave or induce caving related subsidence. Any surface subsidence above stable bord and pillar areas such as those with FoS of 1.6 and width to height ratios greater than 5 is almost entirely as a result of elastic compression of the coal pillars and the resulting sag of the overlying strata.

The subsidence at the surface above the pillars can be estimated to equal the expected elastic compression of the pillars and the immediate roof and floor strata. The elastic compression of the pillars can be estimated based on solid mechanics principals as follows:

For pillar compression, the following is assumed:

$$P_{pillar} = \frac{\sigma_c h}{E}$$

Where:

σ_c = vertical stress change (MPa)
h = pillar height (m)
E = Young's Modulus of pillars (MPa)

For roof and floor compression, the following is assumed:

$$P_{pillar} = \frac{\sigma_c w_m (1-\upsilon^2)}{E}$$

where w_m = proposed pillar width (m)
E = Young's Modulus of roof and/or floor (MPa)
υ = Poisson's ratio (assumed to be 0.3)

The change in vertical stress on the pillars can be estimated as:

$$\sigma_c = Tributary\ Area\ Stress - Virgin\ Stress$$

Based on the equations for elastic compression above the expected surface deflection above the first workings panels, based on the pillar dimensions provided at all depths of the IPU reserve will be in the order of 20-60mm. The limit of resolution is typically 20mm on subsidence surveys and indeed the swell and shrink of the soils in the Bowen Basin will mask this level of movement.

Above the secondary working Modified Duncan panels where the narrow pillars and bell outs are extracted the remaining larger pillars have a FoS of 1.6 and W/H ratios in excess of 7. As such these are considered as long term stable pillars with minimal risk or floor punching. The unsupported spans in these extraction panels may result in some degree of roof spall and sag, but no true caving of the strata is expected. In the Modified Duncan panels the level of surface deflection is expected to be in the region of 100mm to 150mm. This level is consistent with partial extraction subsidence values at Ensham, Carborough Downs, Duncan Colliery (Tasmania) and Clarence Colliery (NSW).

13 Summary and Conclusions

This report details the results of a concept level study of the applicability of bord and pillar first and second workings in the Leichhardt Seam at the proposed Isaac Plains Underground Coal Mine. Many sources of

information have been provided by the resource owner Stanmore Coal from the project library and the assessment draws on experience gained by the authors from working at other Leichhardt Seam bord and pillar operations.

This review considers the geotechnical and resource recovery risks associated with coal recovery using bord and pillar mining methods at Isaac Plains. The assessment is inclusive of first working and first workings followed by secondary partial extraction and include a review of the geotechnical hazards that may limit regular mineability and reserve recovery using both first and second workings methods, considering both upside and down side risks.

The stability assessment was undertaken using the empirical Coal Mine Roof Rating (CMRR) method, which has become an accept methodology for quantifying coal mine strata geotechnical properties. The CMRR values combined with a statistical data base can also be used to give guidance on support requirements, plunge depths and roadway widths based on experience gained from different mines, coalfields and countries.

Typical CMRR values based on a coal roof beam forming the entire bolted section is typically between 40 to 50. In CMRR terms a stone roof is typically classified as a 'weak to moderate' roof, which is typically suited to extended cuts up to 15m at 6 to 6.5m width to a maximum depth of 250 to 300m. In structured or deteriorating ground conditions the plunge depth would be reduced as controlled by a TARP. At depths of greater than 300m the empirical data base would suggest that extended plunges will not be viable.

Analytical and empirical methods of support design analysis were used to provide guide lines for support density requirements for place change operations. The results indicate that low density support levels would provide adequate Factor of Safety (FoS) criteria for bord and pillar drivage not subjected to longwall/caving abutments.

The analysis, supported by empirical data indicates that to a depth of 250m, extended cut, two pass bord and pillar workings can be undertaken using what is considered a low support density with a suitable TARP system to accommodate deteriorating or structured conditions. At depths of greater than 250m the support density is required to increase.

Analysis of the pillar geometries was undertaken using the UNSW criteria using a range of extraction heights from 3.0m through to 4.5m full seam extraction. The analysis undertaken was based on the assumption that the FoS was maintained at a minimum of 1.6 under the flood plain areas and 2.11 under the designated Smokey Creek Channel as per the environmental approval requirements.

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Appendix 2: Design Methodologies

Suspension Mechanism

Suspension mechanism is the most easily understood roof bolting mechanism. The suspension mechanism is considered a valid failure mode in the shallow low stress environment represented by the drifts. The design of roof bolt systems based on the suspension principle has to satisfy the following requirements:

- The strength of the roof bolts has to be greater than the relative weight of the loose roof layer that has to be carried.
- The anchorage forces of the roof bolts have to be greater than the weight of the loose roof layer.

The safety factor (SF_{sus}) of a bolting system in suspension mechanism is given by:

$$SF_{sus} = \frac{nP_f}{\rho g t_{lam}} \qquad [1]$$

where, ρ = density of suspended strata (kg/m^3)
g = gravitational acceleration (m/sn^2)
P_f = resistance of bolting system calculated from SEPT (kN)
t_{lam} = thickness of loose layer or layers (m)
n = number of bolts/m^2

n can be calculated as follows:

$$n = \frac{k}{Ld} \qquad [2]$$

where d = distance between the rows of roof bolts (m)
L = span (m)
k = number of bolts in a row

The factor of safety of resistance to sliding of the bolting system (SF_{slide}) can be calculated using the bond length (B_s) between the resin, rock and bolt using the following formula:

$$SF_{slide} = \frac{kB_S l_{cap}}{Lt_{lam} d\rho g}$$

Where B_S = Bond strength or grip factor (kN/mm)
l_{cap} = capsulation length (bolt length – t_{lam}) (m)

Bond strength (B_S) is defined as:

$$B_S = \frac{Maximum\ Load\ Achieved\ (kN)}{Encapsulation\ Length\ (mm)}$$

Shear Failure Mechanism

This design methodology takes into account, where appropriate, the surcharge load (assumed to be parabolic) generated by the softened zone above the bolted horizon; refer to Canbulat (2008) for further details of the model.

The first consideration in the design of a beam failure mechanism is to determine the minimum required thickness of the bolted beam which will be stable from a tensile point of view. The maximum tensile stress must be smaller than the tensile strength of the upper layer of the bolted beam, with an appropriate Factor of Safety (FoS).

The maximum tensile stress in a bolted beam with a parabolic surcharge load can be calculated as:

$$\sigma_{xx}\left(\pm\frac{L}{2}\right)=\frac{2}{5}\frac{\rho g L^2}{h^2}(h+h_1)$$

The tensile stress in the lower surface at the mid-span of the bolted beam is calculated as:

$$\sigma_{xx}(0)=\frac{9}{40}\frac{\rho g L^2}{h^2}(h+h_1)$$

The majority of 1.8m roof bolts used in the industry when used in the above calculation, indicate relatively low tensile strengths are required for the 1.8m steel bolts.

Typically bolted beams are subjected to transverse loads which generate both bending moments M(x) and shear forces V(x) along the span of the roof. The bending moments can result in horizontal stress, σ_{xx}, to arise through the thickness of the beam, and shear forces cause transverse shear-stress distributions, $\tau_{xy} = \tau_{yx}$, through the beams cross section, as illustrated in Figure 1.

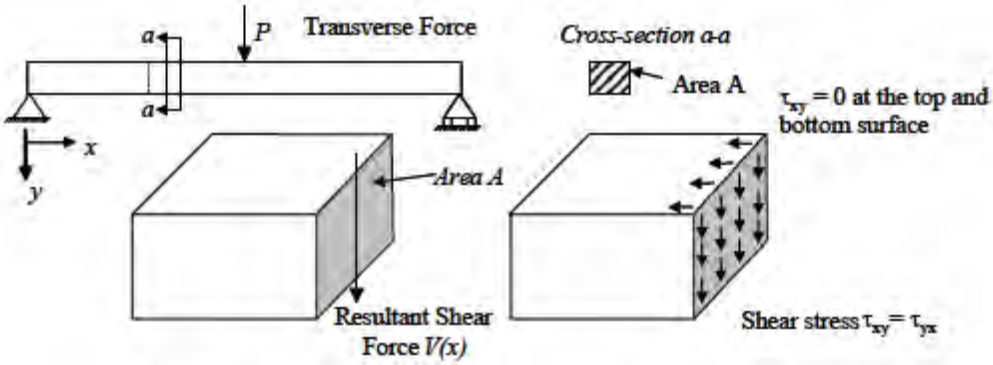

Figure 1: Schematic illustration of shear force generation in a bolted beam.

When using beam theory, it is important to consider the top and bottom surfaces of the beam being free of shear stress, and the shear stress distribution across the beam to be parabolic - as such the maximum shear stress is given by:

$$\tau_{\max}(x)=\frac{3V(x)}{2A}$$

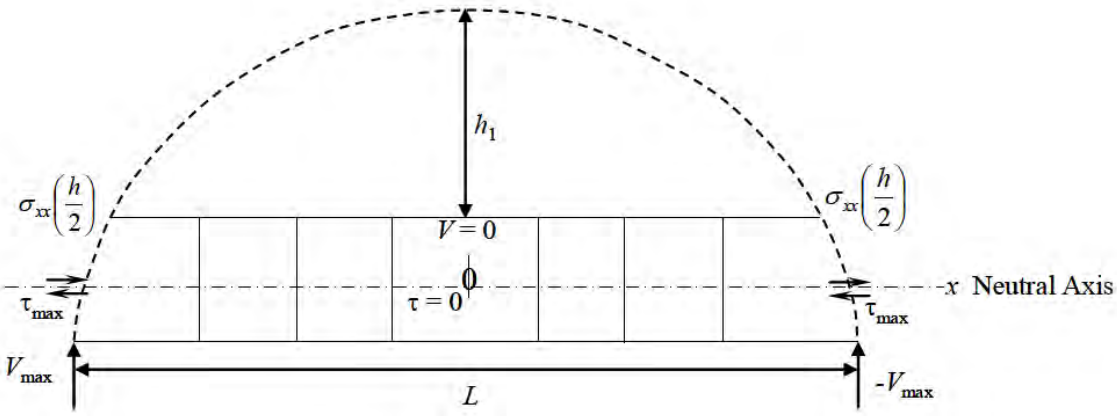

Figure 2: Illustration of the concept of transverse shear forces acting on a beam generating transverse shear stress.

The shear force distribution $V(x)$ is zero at the centre of a symmetrically loaded beam, and rises to a maximum at the ends, where it is equal to ½ of the total load. If the composite beam thickness is taken to be equal to the bolt length h, and the surcharge is parabolically distributed with a maximum height $h + h_1$ (Figure 1 and Figure 2), then:

$$V_{\max} = \frac{1}{3}\rho g(h + h_1)L$$

Which gives:

$$\tau_{\max} = \frac{1}{2}\frac{\rho g}{h}(h + h_1)L$$

Where h = built beam thickness (m)
h_1 = additional surcharge thickness (m)
L = span (m)
ρ = density of strata (kg/m^3)
g = gravitational acceleration (m/s^2)

For the built composite beam to act as a single entity, the shear stress given by the above equation should be overcome by the action of the bolts. Two types of resistance are provided:

- frictional due to bolt pre-tensioning, and
- intrinsic shear strength of the bolts.

Neglecting the inter-layer cohesion and layer deadweight, the frictional shear resistance of tensioned roof bolts can be calculated using the following well-known formula:

$$T_R = nF_p\mu$$

Where: n is number of bolts per square meter (m^2),
F_p is the pre-tension of bolt and μ is the coefficient of friction between the layers.

It is suggested that the coefficient of friction between the layers should be taken as 0.4, unless otherwise proven by laboratory testing.

The shear strength of bolts also generates shear resistance, which must be considered in the design. This can be calculated using the following formula:

$$T_B = nS_R$$

Where: S_R is shear strength of a bolt (in kN).

Based on past laboratory testing (see Canbulat, 2008), it is suggested that the shear strength of a fully encapsulated bolt is taken to be equal to approximately 90 per cent of the UTS of a bolt (based on 650 MPa strength for x-grade roof bolts, including 220 kN for M24 bolt).

The above equation then becomes:

$$T_B = 0.7nS_B$$

Where: S_B is the Ultimate Tensile Strength (UTS) of a bolt (in kN).

The shear resistance of a bolting system can therefore be determined as follows:

$$T_{TOTAL} = n(F_p\mu + 0.7S_B)$$

For stability in terms of a factor of safety the shear resistance calculated above has to be greater than the maximum shear stress τ_{max}.

$$SF = \frac{T_{TOTAL}}{\tau_{max}}$$

Buckling Failure Mechanism

Beam buckling has been extensively researched and discussed in Australia. This section is mainly taken from the publication by Colwell and Frith (2007). This methodology also utilises a Safety Factor concept - this being a measure of the load applied to that structure in comparison to its ability to accommodate that load without undergoing yield or failure, which is expressed as:

$$SF = \frac{\text{load bearing ability (roof strata + roof support)}}{\text{applied load}}$$

In this instance the applied load acts horizontally across the roof and is a product of the *in situ* horizontal stress and concentration thereof, as a result of the mining process. Therefore the resolution of equation 5 is across the roof, which necessitates that the load bearing ability roof strata and the load bearing ability roof support is also resolved accordingly.

Colwell and Frith (2007) suggested (based on industry research/experience) that for small vertical roof displacements (up to around 50mm and possibly to 100mm), slender beam behaviour or buckling is typically the dominant behavioural mechanism occurring within the immediate coal mine roof measures.

Uncontrolled roof behaviour of this type may then lead to other failure mechanisms occurring, in particular to large-scale roof displacements or roof falls. By understanding slender beam behaviour, it allows for the most pragmatic way of evaluating the initial load bearing ability of the strata (P_{roof}) and subsequently determining the lateral resistance offered by the roof support ($P_{support}$). In terms of the use and application of the analytical model there are three basic components:

1. Evaluation of horizontal stress acting across the roof within individual roof units (typically at various key points in the mining process).

2. Determination of the material properties (including Modulus, UCS and "beam" thickness & length) associated with the immediate roof units, that are required both in terms of Point 1 above and in evaluating the load bearing capacity of the strata.

3. Utilising a load-balance approach (which incorporates well established load-bearing characteristics of slender beam behaviour and mechanical advantage) where a FoS is calculated. Engineering judgement needs to be applied in selecting a suitable FoS for design purposes, as this is a risk-based consideration which is always discussed with mine management as part of finalising design outcomes.

As previously discussed, roadway roof behaviour and associated instability is primarily based around the uncontrolled buckling of slender horizontal beams under the action of horizontal stress. Early theoretical models for this simply used the concepts of Euler Buckling. However more recent developments by Colwell and Frith (2007) have included other structural concepts that allow a complete range of possible behaviours to be considered, according to beam geometry - with Euler Buckling representing a relatively small proportion of the full range.

Behaviour outside the Euler range can be defined by a number of different structural concepts. For the purpose of this model, use will be made of what is termed as the Johnson formula (see http://physics.uwstout.edu/statstr/statics/ for more general information on this topic). Utilising these concepts of beam behaviour under axial load, in conjunction with the roof's material & physical properties, an estimate of its load bearing ability (Proof) can be deduced.

In terms of buckling; beams (or columns) have typically been divided into three general types:

(i) Short Beams

(ii) Intermediate Beams, and

(iii) Long Beams.

A short beam will not fail due to buckling, as the ratio of the beam length to the effective cross sectional area is too small. Rather a short, 'thick' beam, axially loaded, will fail in simple compressive failure; that is when the load/area of the beam exceeds the allowable stress, the beam will fail in compression. The critical or allowable stress associated with long beams/columns is governed by the Euler Formula.

$$\sigma_{crit} = \frac{\pi^2 E}{12(L_{eff} / d)^2}$$

Where: E is Young's Modulus, L_{eff} is the effective beam length and d is beam thickness.

The above formula only applies while the material is in the elastic region and therefore the maximum allowable stress is limited by the yield strength (σ_y) of the material. It is suggested that 70% UCS should be considered in the design as the yielding strength.

There are a number of semi-empirical formulas for buckling in beams/columns in the intermediate length (and short) range. One of these is the J.B. Johnson Formula. The J.B. Johnson formula is the equation of a parabola with the following characteristics: for a graph of stress versus slenderness ratio, the parabola has its vertex at the value of the yield stress on the y axis. Additionally, the parabola is tangent to the Euler curve at a value of the slenderness ratio, such that the corresponding stress is one-half of the yield stress. For further information please see http://physics.uwstout.edu /StatStr/statics/Columns/cols62.htm.

The Johnson equation for the allowable stress is as follows:

$$\sigma_{crit} = 1 - \frac{(L_{eff} / r')^2}{2C^2}\sigma_y$$

Where: r' is the beams Radius of Gyration and
C is the beams Critical Slenderness Ratio

$$r' = I/A \text{ and } C = (2\pi^2 E/\sigma_y)^{0.5}$$

Where: I is the beams moment of inertia and equals db3/12 and
A is the cross section of the beam.

Essentially when the beam's Slenderness Ratio (L_{eff} /ŕ) is greater than the beam's Critical Slenderness Ratio (C) then the Euler equation is used to calculate the beam's load bearing capacity. When the beam's Slenderness Ratio is less than C, then Johnson's equation is invoked.

Rib Bolt Analysis

For proposed 2 x 1.8m steel bolts per 1.2m support pattern:

RBOLT (Capacity per m^2 of ribline)

$$\text{RBOLT} = \frac{L_{rb} \times N_{rb} \times Sh^{1/2}}{S_{rb} \times h}$$

$$= \frac{\text{Length of rib bolt} \times \text{No. bolts per vertical row} \times \text{shear strength of bolt}^{1/2}}{\text{Spacing between rows} \times \text{Development height}}$$

$$= \frac{1.8 \times 2 \times 225^{1/2}}{1.2 \times 3.5}$$

= 12.86 for 3.5m maximum height

FPLATE (Confinement offered by face plate)

FPLATE = [(Area of face plate) / (Area of standard butterfly plate)]$^{1/2}$

= [(0.28 x 0.3) / (0.28 x 0.3)]$^{1/2}$

= 1

CF (Confinement factor for a liner)

CF = 1 + (constant x % Surface area covered / 100) Constant = 3

= 1 + 3 x 0 / 100

= 0

0% area covered assumes no rib mesh to be installed

Therefore RIBSUP

= FPLATE x RBOLT = 12.86 Where no rib mesh assumed

ADRS Analysis & Design of Rib Support

Place change drivage to be undertaken at 300m depth of cover

Angle between major cleat direction and roadway orientation (α) = 50 Roadway orientation 060 and cleat orientations 010 and 090. Face and butt cleats are of similar nature (i.e. neither is dominant) therefore the smaller cleat orientation difference is used as per ADRS =30

Coal UCS is ~7MPA

<u>300m depth</u>

Probability of rib instability during development:

Coal UCS ≤ 15 MPa so PROB1 (%) = 0.428 H Cos α - 42.803

= 0.428 x 300 x 0.86 – 42.803

= 16.1%

According to ADRS, PROB1 of <25% means that rib support may not be required. However, this is essentially ignored and step 2) completed regardless.

PROB1 > 25% & coal UCS ≤ 15MPa so use the following for design boundaries:

$RIBSUP_{upper}$ = 0.332 PROB1 = 5.342

$RIBSUP_{lower}$ = 0.174 PROB1 = 2.80

The above results indicate that the proposed rib bolt support system would be sufficient for the place change units to a depth of approximately 300m. The RIBSUP calculation at 12.86 sits above both the upper and lower boundary recommendations as per the ADRS calculations.

APPENDIX I REHABILITATION MANAGEMENT PLAN (2019)

Rehabilitation Management Plan

September 2019

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1 Introduction

Stanmore IP Coal Pty Ltd (Stanmore) submitted a Rehabilitation Management Plan (RMP) to the Department of Environment and Science (DES) in accordance with Conditions F7 and F8 of the Isaac Plains Environmental Authority (EA) (EPML0093213) on 29 June 2018. Condition F8 was subsequently amended to require the re-submission of the RMP on 01 October 2019.

The RMP submitted on 29 June 2018 was prepared by C&R Consulting Pty Ltd (C&R). This RMP has been prepared by Stanmore and includes elements of the RMP submitted on 29 June 2018.

This RMP incorporates all mining areas at the Isaac Plains Mining Complex (IPC). The IPC includes the operational areas of Isaac Plains Mine (IPM) on mining lease (ML) 70342 and the operational areas on the Isaac Plains East (IPE) ML 700016, ML 700017, ML 700018 and ML 700019, including the extension of the mining areas for the Isaac Plains East Extension (IPEE). The report has been prepared in accordance with Condition F7 of the Isaac Plains Environmental Authority (EA) (EPML0093213).

1.1 Mineral and Energy Resources (Financial Provisioning) Act 2018

The *Mineral and Energy Resources (Financial Provisioning) Act 2018* (MERFP Act) was assented to on the 30 November 2018 and the financial provisioning components commenced on 1 April 2019. The MERFP Act resulted in amendments to the *Environmental Protection Act 1994* (EP Act) pertaining to requirements for progressive rehabilitation and closure plans (PRCPs) and PRCP schedules. The MERFP Act introduced transitional arrangement into the EP Act, relating to the transition of existing EA conditions into a PRCP schedule, timing from when PRCP requirements would apply and recognition of existing approvals as they relate to rehabilitation. EA applications made before PRCP start date (on or before 1 November 2019) do not require a PRCP, however on grant of the EA amendment, the EA will be transitioned into a PRCP schedule. This RMP is a land outcome document (LOD) under Section 750 of the EP Act, whilst recognising that the current EA is the primary LOD. This RMP relates to the management of residual voids. This RMP considers potential future PRCP requirements, whilst continuing to meet the requirements of the existing EA.

1.2 Scope

1.2.1 EA Requirements

The main objectives of this RMP are to clearly outline rehabilitation requirements, objectives and criteria for each mining area as well as detailing monitoring and reporting requirements. This is achieved by dividing the mine into areas known as domains. Rehabilitation objectives, indicators and completion criteria are nominated for each domain to ensure that rehabilitation and closure are measurable and manageable by Site Management and the regulatory authorities.

The completion of the RMP is in accordance with Condition F7 within the IPC EA. The RMP includes:

A. A map of existing areas of rehabilitation including classification and status of rehabilitation;

B. A strategy and schedule for the progressive rehabilitation of all disturbance during the life of mine;

C. A strategy for successfully achieving rehabilitation requirements of this environmental authority;

D. Details of the grazing trials that are to be undertaken on overburden emplacement areas as per Condition F11;

E. Details of the objectives and success criteria for rehabilitation of each mining domain to achieve rehabilitation outcomes listed in Appendix 2, Table 1: Rehabilitation Requirements and Table 18: Residual Void Design in the EA;

F. Details of landform design to achieve rehabilitation outcomes listed Appendix 2, Table 1: Rehabilitation Requirements in the EA including end of mine design and schematic representation of final landform inclusive of:

   i. drainage design and features;

   ii. slope designs;

   iii. cover design; and

   iv. erosion controls proposed on reformed land.

G. Details of how landform design will be consistent with surrounding topography;

H. Details of how the final land uses will align with local planning scheme requirements;

I. Specify the spoil characteristics, soil analysis and soil separation for use on rehabilitation;

J. Specify the topsoil requirements for the site and how topsoil will be managed for use in rehabilitation;

K. Details of any topsoil deficit and how any deficit will be managed for successful rehabilitation;

L. Details of rehabilitation methods to be applied to each domain;

M. Describe the monitoring of reference sites inclusive of identification of at least three (3) reference sites for each mine domain for use in rehabilitation monitoring and the completion of Table 20: Reference Sites in the EA;

N. Description of rehabilitation indicators and how these will be monitored;

O. Description of management actions to address unsuccessful rehabilitation or redesign;

P. Description of wastewater collection, reticulation and treatment systems;

Q. Description of any risks to groundwater and how these will be managed; and

R. Description of seepage and leachate management considerations, including the prevention and management of acid mine drainage.

1.2.2 Schedule of Progressive Rehabilitation and Closure

This RMP also provides a schedule of progressive rehabilitation and closure milestones and milestone criteria for all mining areas, which is intended to assist with the transition of conditions F6 to F12 into a PRCP schedule on grant of the EA. The schedule is based on the concept of 'rehabilitation areas' which may include one or more domains described in this RMP.

1.3 Rehabilitation Monitoring Program

A separate Rehabilitation Monitoring Program (RMonP) has been prepared to comply with condition F13 of the IPC EA, and submitted to DES on 29 June 2018. The RMonP remains unchanged as a result of the update to this RMP. This allows for targeted, specific, monitoring and rehabilitation methodologies for

each disturbance type, or domain, across the mine site. The RMonP has linkages with this RMP and has been cross referenced in this document where required.

2 Background Information

2.1 Location

IPC is located within the Isaac Regional Council on Freehold Land, Reserve Land and State Leasehold Land in Central Queensland, approximately 10 km to the northeast of Moranbah and 140 km south-west of Mackay (Figure 2-1). The project is situated immediately north of the Peak Downs Highway between Moranbah and Coppabella.

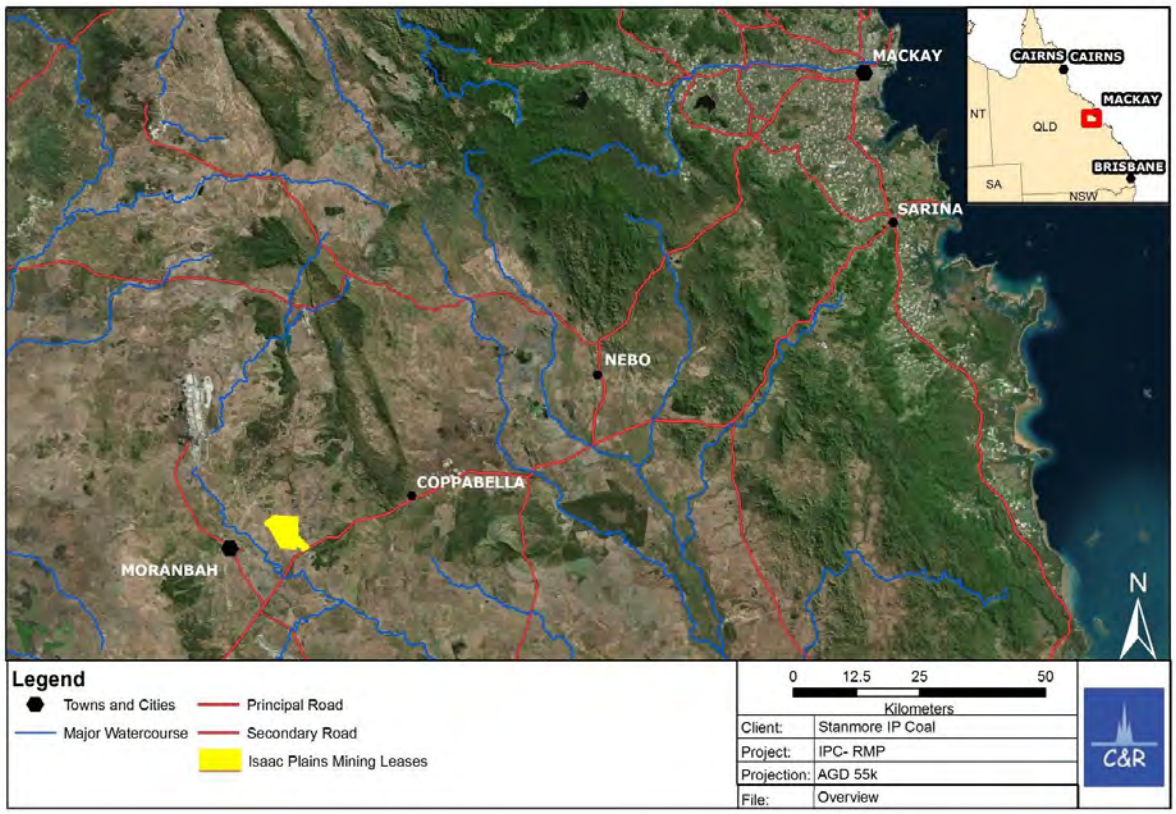

Figure 2-1 Isaac Plains Complex Location

2.2 Site Description

IPC is located in the north-western region of the Fitzroy River Catchment. There are three receiving environments associated with the site; Smoky Creek, Billy's Gully and Isaac River (Figure 2-2). While these receiving environments may be superficially similar on initial inspection (i.e. highly ephemeral, sediment laden watercourses), the land uses and sizes of the streams are considerably different.

Smoky Creek catchment drains approximately 16,000ha upstream of the IPC. The upper catchment includes the open-cut Broadlea Coal Mine as well as the Burton Coal Mine Rail Loop and Load-out

Facility. Both of these upstream users have the potential to passively release water into Smoky Creek or its tributaries upstream of IPC. A number of off-channel farm dams exist between Broadlea Coal Mine and IPC. The remainder of the catchment drains grazed lands of both 'Broadlea' and 'Wotonga' stations with runoff delivered to the stream via two main channels that converge roughly 1.7km upstream of the IPC open-cut pits.

Billy's Gully catchment is an order of magnitude smaller than Smoky Creek, draining an area of approximately 3,500ha upstream of IPC. Approximately half of this catchment area (1,600ha) is situated on the Annandale Lease of the neighbouring Carborough Downs Coal Mine (CDCM). Previously the Annandale Dam, situated on CDCM, was an in-channel dam that collected 'sediment-laden' water from infrastructure associated with CDCM. This dam partially regulated flows in Billy's Gully but was decommissioned in 2014. Billy's Gully is also diverted around the CDCM Coal Haul Processing Plant (CHPP) and flows beneath the CDCM Rail Loop through a series of culverts.

Both Smoky Creek and Billy's Gully release waters into the Isaac River approximately 5km downstream of the IPC. Isaac River has a catchment area of approximately 180,000ha upstream of the IPC. The Isaac River receives runoff from grazed lands, as well as mine-affected water releases from a number of mines upstream and downstream of the IPC. The Burton Gorge Dam, situated near the river's headwaters, serves to partially regulate flows in the system. The receiving environment for the IPC consists of the confluence of Smoky Creek and the Isaac River until just downstream of the Peak Downs Highway Bridge and Isaac River's confluence with Grosvenor Creek. However, there are also two sand extraction operations between the IPC's Isaac River upstream and downstream monitoring points.

2.3 Mine Details

IPM, on ML 70342, can be separated into five primary pits, N1, N2, S1, S2 and the S3 Pits. The N pits are north of Smoky Creek which bisects the mining lease area. The three S pits are south of this watercourse. Mining started on ML 70342 in 2006 with progressive mining occurring until 2014 when it was placed under care and maintenance. In 2015 Stanmore acquired Isaac Plains and mining resumed on site in 2016

IPE is comprised of four Mining Leases, ML 700016, ML 700017, ML 700018 and ML 700019 and is located directly east of the IPM ML 70342. Environmental approvals for IPE where granted within the first half of 2018 with operations commencing in mid-2018.

The Isaac Plains Underground (IPU) project is proposed on the existing MLs and received approval in 2019. IPU would involve the development of an underground bord and pillar mine. IPU is located to the east of the IPM open cut pits and extends beneath the northern end of the IPE open cut pits. The Leichardt Seam is faulted between the IPM and IPE open cut pits areas, with the Isaac Thrust Fault forming a fault splay between IPM and IPE. The fault dips gently to the east in the northern part of the Isaac Plains Complex. In this area, the downthrust and upthrust Leichardt Seam (located west and east of the fault, respectively) overlap. The underground mining activities will target the downthrust coal seam while the open cut mining activities in the IPE mining area (Pits 1 to 5) target the overlying upthrust coal seam. The underground will be accessed from portals on the final highwall of the S2 pit and will target the same Leichhardt coal seam as the existing IPC open cut mining operations. In addition

to the underground infrastructure there will be minor gas drainage and electricity supply infrastructure located above the underground mining area. IPU is scheduled to be mined over an 8-year period.

The combined existing operations of IPM, IPE and IPU area referred to hereafter as the Isaac Plains Complex (IPC).

Overburden is removed by a combination of drilling, blasting, dragline, dozing, excavation and haul methods. Overburden material from open cut areas is placed in out-of-pit dumps and previously exhausted pits. Once each pit has been mined, residual voids will be left in the approved final landform. Once final landform contours have been completed in overburden dumps, topsoil will be replaced and disturbed areas replanted with suitable predefined vegetation. The success of this revegetation is monitored along with the stability of the rehabilitated landscape and is documented in an annual rehabilitation inspection.

A map of the IPC mining areas is provided in Figure 2-2. Table 2-1 provides a description of the proposed activities within the different areas of IPC over the life of project activities.

Table 2-1 Description of Mining Activities by Area

Location	Ming Area Feature	Description of Activities
IPM	Infrastructure areas including CHPP, coal stockpiles, rail loop, MIA, offices, water management, power supply and access roads.	Infrastructure will continue to be used for the life of the Project and hence is not available for decommissioning and rehabilitation until all IPC operations have ceased. Some infrastructure may be retained for landowner post mine life.
IPM	N1 Pit, approved residual void under current EA	Mining has ceased. To be used for disposal of tailings and rejects within cells in the pit area over the Project life. Tailings and rejects disposal areas will remain open during the majority of Project life, with potential for some areas to become available for rehabilitation during mine life. Residual void to be used for mine water storage over the life of operations and post mining. Levee along Smoky Creek to remain during mining and be incorporated into final landform.
IPM	N2 Pit, approved residual void under current EA	Mining has ceased. Pit has been backfilled. Rehabilitation activities have commenced.
IPM	S3 Pit, approved residual void under current EA	Mining has ceased. Pit is in the process of being backfilled. Rehabilitation activities to commence following backfilling. Levee along Billy's Gully to remain during mining and be incorporated into final landform.
IPM	S2 Pit, approved residual void under current EA	Open cut mining has ceased. Pit void to remain open for IPU access off base of highwall. Ramps, haul roads and access to remain open to service IPU. Rehabilitation activities have commenced at overburden areas.
IPM	S1 Pit, approved residual void under current EA	Mining has ceased. Pit has been backfilled, some areas have been converted to a haul road connecting to IPE Rehabilitation activities have commenced.

Location	Ming Area Feature	Description of Activities
		Levee along Smoky Creek to remain during mining and be incorporated into final landform.
IPE	Infrastructure areas including water management, power supply, laydowns and access roads.	Infrastructure will continue to be used for the life of the IPE Project and hence is not available for decommissioning and rehabilitation until all IPE operations have ceased. Some infrastructure may be retained for landowner post mine life.
IPE	Pit 1, approved residual void under current EA	Approved mining disturbance area. Mining not currently scheduled, as per landholder agreement, and hence no rehabilitation activities scheduled.
IPE	Pit 2, approved residual void under current EA	Mining has commenced. Progressive rehabilitation will commence as mining areas become available. Residual void to remain, with proposed extension to the east by approximately 300 m. Levee along Billy's Gully to remain during mining and be incorporated into final landform.
IPE	Pit 3, approved residual void under current EA	Mining has commenced. Progressive rehabilitation will commence as mining areas become available. Residual void to remain, with proposed extension to the east by approximately 600 m.
IPE	Pit 4, approved residual void under current EA	Mining has commenced. Progressive rehabilitation will commence as mining areas become available. Residual void to remain, with proposed extension to the east by approximately 600 m. Levee along Smoky Creek to remain during mining and be incorporated into final landform.
IPE	Pit 5, approved residual void under current EA	Mining has not commenced. Progressive rehabilitation will commence as mining areas become available. Residual void to remain, with no proposed extension.
IPU	Infrastructure areas, primarily located within S2 pit and including access portal, conveyor, MIA and roads.	Infrastructure will be used for the life of the IPU Project and hence is not available for decommissioning and rehabilitation until all IPU operations have ceased.
IPU	Mining area	Bord and pillar mining with minimal subsidence (i.e. less than 200 mm). No landform rehabilitation expected, however this will be monitored during mining.

Figure 2-2 IPC Mining Areas

2.4 Land Use

Prior to development of the site for coal mining the area had been extensively cleared for cattle grazing. Areas in and around the IPC site are still currently used for high intensity cattle grazing. Coal mining and cattle grazing is conducted in and adjacent to the area and has been done for many years. The local planning scheme considers mining to be a valid land use in the area.

3 Site Setting

3.1 Climate

The climate in Central Queensland is seasonally arid. Rainfall in the area is notoriously unreliable in its intensity and duration, both temporally and spatially. Intense rainfall events throughout the summer months (wet season) dominate the climate cycle. The majority of these rainfall events occur in distinct, spatially separated cells across the landscape. Intense rainfall events are typically associated with tropical cyclone activity on the coast, and the remnant low pressure systems that move inland.

Far less rainfall is experienced throughout the dry season, with 35% of total rain typically falling in the winter months (May to October). Evaporation tends to exceed rainfall for almost all days of the year except during intense rainfall events. The extended dry season causes baking and crusting of surface soils. These processes lead to greatly reduced infiltration of surface soils unless suitable pre-wetting can be provided by gentle rain prior to the wet season. If pre-wetting rains have not occurred, >90% of rainfall can eventuate as runoff throughout catchments altering stage-discharge relationships within waterways.

The distribution of rainfall over the previous wet season will have a dramatic role in determining the status of rehabilitation across Bowen Basin Coal Mines. An above-average wet season can result in almost 100% groundcovers being experienced in areas where buffel grass is prevalent, and can also result in significant erosion and incision of rills. A below-average wet season can result in ground-covers reducing to below targets (i.e. below 70%) while the dry-matt cover drastically increases, and minimal erosion is expected to occur when compared to previous rehabilitation inspections.

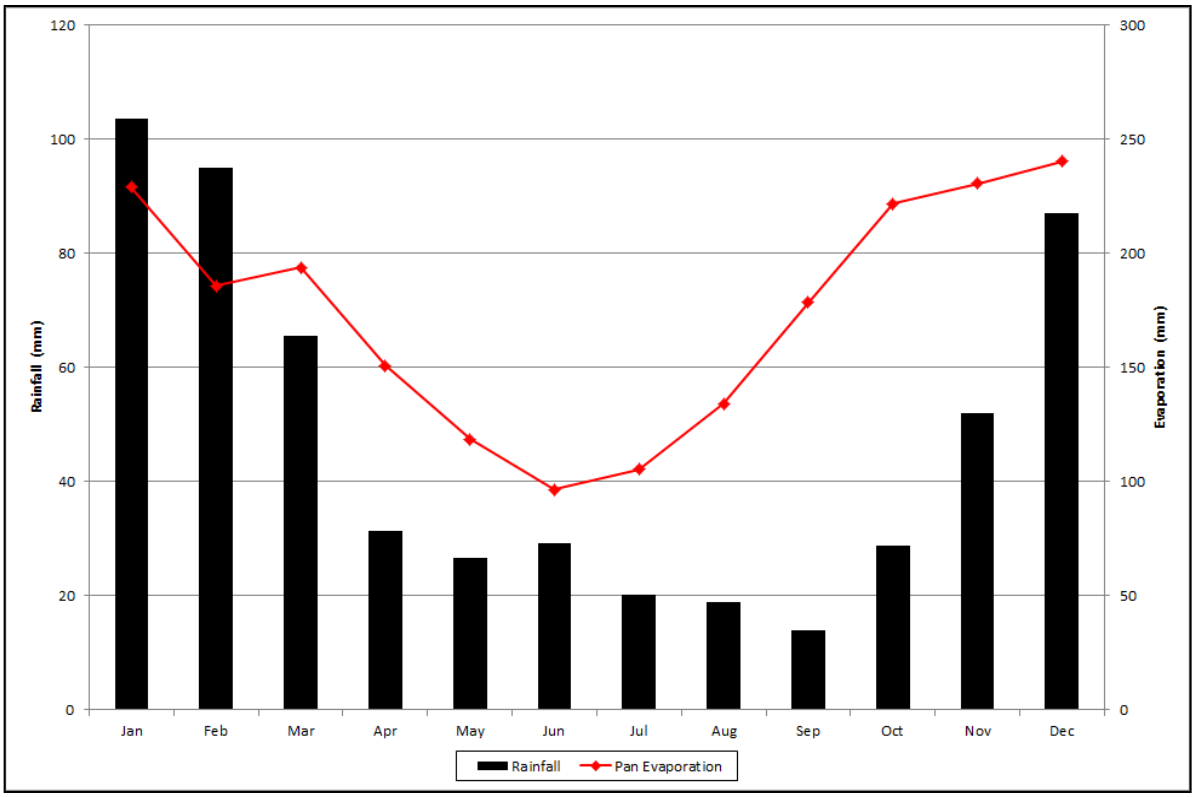

Figure 3-1 Average monthly rainfall and evaporation values for the region

3.2 Geology

The majority of the land surface is made up of deeply weathered profiles of the Permo-Triassic rock with in situ weathering and soil development and minor alluvium that, for the most part, conceal these rocks across the lease.

Tertiary-aged, poorly consolidated, sandstone forms part of an earlier thin sequence that covered much of the district. This sequence and older lithologies were eroded down to a flat surface (peneplain) that is capped with duricrust (ferricrete) or carbonate laterites. Locally the sequence has been eroded back to a table top to the north leaving behind mesas of sandstone on and around the lease.

Prior to and during this erosion period in the Tertiary, volcanic activity produced widespread basalt lava flows. At least two basalt flows have taken advantage of an earlier deep river passing down the eastern length of the lease. Remnants of the lava flows persist in mesas east of the lease and part of the northern table top while the remainder has been weathered down to the current alluvial flat developing across the site.

The coal beds exist as layers in packages of sedimentary beds called 'Coal Measures' which reflect the fact that coal seams split, thicken and thin, and are interfingered with other sediments at their time of formation. These sediments can include relatively porous sandstones conducive to groundwater flow. The coal beds themselves are frequently significant conduits to groundwater and provide local aquifer systems.

The economic coal measures at Isaac Plains are the Rangal Coal Measures which is part of the Late Permian Blackwater Group. This group of rocks extends throughout the western half of the Bowen Basin.

3.3 Soils

Several soil types are located within the Isaac Plains Complex. These are described in the Integrated Isaac Plains Project Expansion Area Soil and Land Suitability Study (Matrix Consulting 2009) and include:

1. A1 Alluvial sandy duplex soil.
2. A2 Red Duplex with thin sandy clay loam overlying hard, coarse structured brown clay.
3. B1 Uniform grey/brown clays with areas of gilgai on flat to gently undulating plains.
4. B2 Sandy uniform clay or thin red/brown duplex soils overlying weathered shale/mudstone on undulating plains. Sandy surface which is often gravelly.
5. B3 Crusting and often gravely sand clays associated with mesa scree slopes.
6. B4 Melanholed clay lowlands.
7. B5 Hard setting, gravely brown clay.
8. E1 Sandy duplex on undulating plains.
9. R1 Residual low hill of lateritised basalt.

These soil types can be grouped into the following three broad categories under the Australian Soil Classification system: Brown Sodosols, Red Chromosols and Vertisols.

3.3.1 Sodosols (A1 B5 E1)

This soil type occupies older alluvial plains associated with the Isaac River. It occurs on flat plains and is susceptible to occasional flooding. Soils are uniform silty clays and mostly cleared of vegetation. Nutrient levels are strong within the surface 30-40 cm layer. However, levels decrease below this depth. The surface structure is fine sandy clay over a silty clay profile with substantial rooting depth. The soil is not reactive, although the stratified alluvial nature of the medium is such that it should not be used for water holding structures. This soil will respond well to nitrogen application for pasture establishment and is best stripped dry. The top 30 cm may be stripped for use as topsoil with potential to take more subject to pH and EC levels. Material below 30cm with the B2 horizon may be slightly sodic and should therefore be avoided. The top 30cm within the soil profile will be useful on rehabilitation of level surfaces such as dump tops. The area currently supports strong buffel pasture and is very suitable for grazing, however no cropping potential is indicated.

3.3.2 Chromosols (A2 B2 B3)

This soil occupies mid to upper slope positions within undulating lands. The surface structure is firm and sandy with ironstone gravel common. A significant and productive grazing soil but lighter texture and reduced soil depth would reduce moisture storage and increase drying rates with onset of dry times. These soils have fairly hard structured light clay subsoils over weathered material but appear to be well drained to at least 40 cm in most instances. There are problems apparent from subsoil sodicity and salinity below 30 cm depth which is not assisted by its coarse structure. General fertility is not high although reasonable for grazing lands. The soil is well suited to grazing and pasture improvement with

favourable responses to fertiliser addition expected. The soil should preferably be stripped when dry to minimise action and structural decline. The top 20 cm may be stripped for topsoil only. The soil will be useful on rehabilitation in a variety of situations. The soil has a sandy surface and supports strong Buffel pasture.

3.3.3 Vertisols (B1 & B4)

These are productive grazing soils with desirable all round qualities on very low slopes with reduced degradation potential from erosion following dry periods. The soils are brown to grey, moderately well structured, generally non-cracking clays which support abundant Buffel pasture. Nutrient levels are quite good on the surface layers. However, saline and sodic conditions prevail immediately below 20 cm depth. Some of the area may include shallow (up to 15 cm deep) gilgai of brown sandy clay interspersed with grey clay depressions. The surface structure is sandy and firm with areas of ironstone gravel. In most instances drainage is not impeded to 40 cm. A high cation exchange capacity will facilitate favourable responses to fertiliser application for pasture improvement. Preferably, the soil should be stripped when dry to minimise compaction and structural decline. The top 20 cm may be stripped for topsoil with little potential for stripping to any deeper depths. The soil will be useful on rehabilitation in a variety of situations.

3.4 Rehabilitation History and Current Plan of Operations

Rehabilitation at IPM has been undertaken over a series of campaigns spanning several years starting in 2007 and continuing to the present day. This has resulted in a patchwork of rehabilitation of differing ages and success in different areas of the mine site. The rehabilitation objectives for the mine have been adopted from the current IPC EA which designates a grazing land use for the majority of rehabilitated land. To date rehabilitation has mainly focused on the rehabilitation of waste rock dumps. The current distribution of rehabilitation and planned rehabilitation within the plan of operations period to 30 December 2020 is shown in Figure 3-2. In the period to 30 December 2020 Stanmore plans to have rehabilitated 434 ha with vegetation established or seeded, and recontoured a further 136 ha in preparation for topsoiling and seeding.

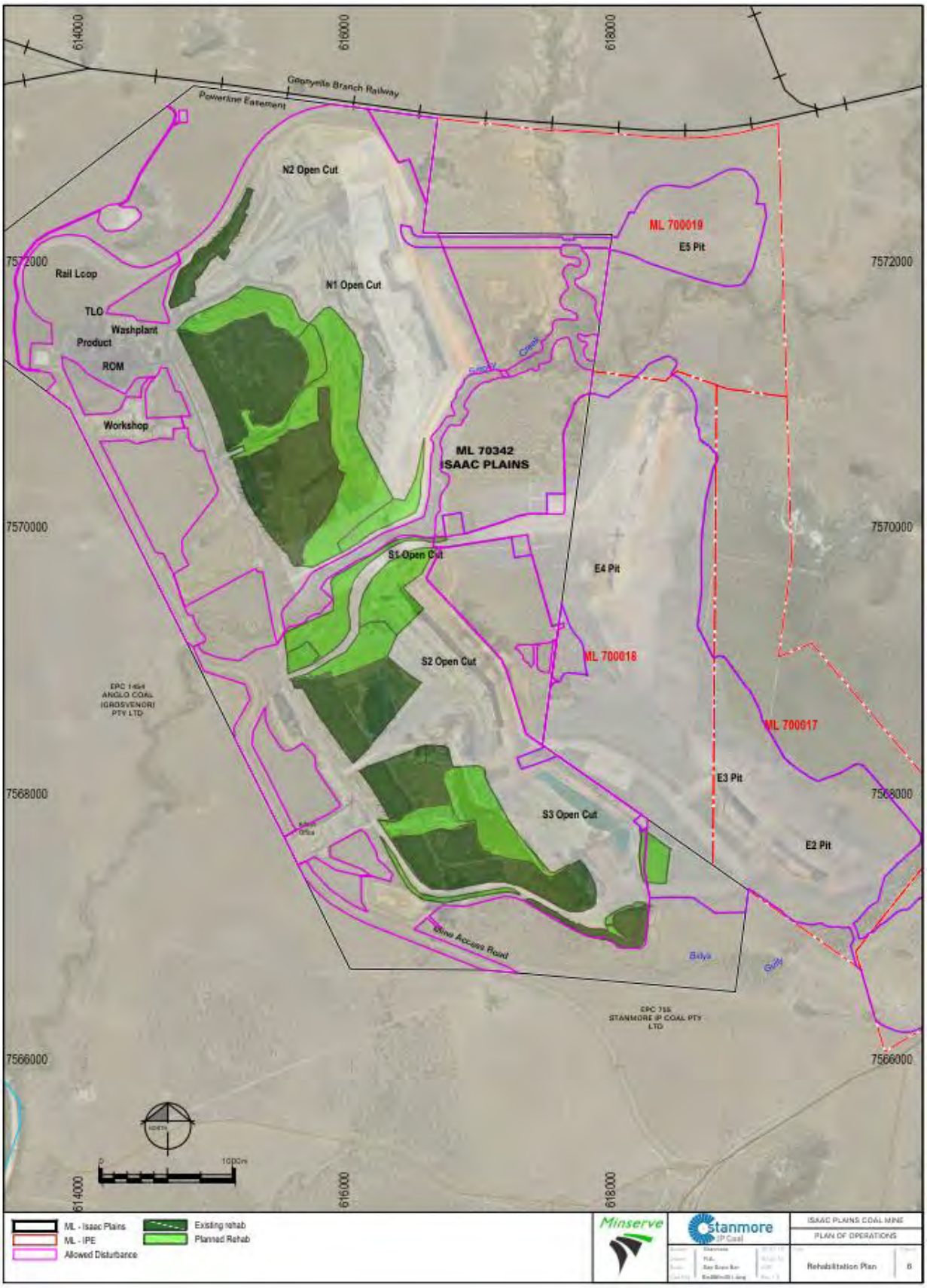

Figure 3-2 Current and Proposed Rehabilitation within the Plan of Operations Period

3.5 Current Approved Progressive Rehabilitation Schedule

Stanmore's current approved rehabilitation schedule (i.e. approved prior to any EA amendment for the IPE extension) for the life of mine of IPC is provided in Table 3-1

Table 3-1 IPC Rehabilitation Schedule (Table 19 with the IPC EA)

Time Frame	Domain	Area	Activuty
30 June 2022	Overburden emplacement areas	At least 240 ha on ML70342	Reshaped to final landform design, topsoiled and seeded.
30 June 2025	Overburden emplacement areas	At least 170 ha on ML700016, ML700017, ML700018 and ML700019. At least 210 ha on ML70342.	Reshaped to final landform design, topsoiled and seeded.
29 June 2029	All domains, other than final voids	Remaining disturbance on all tenures	Reshaped to final landform design, topsoiled and seeded.
29 June 2029	Final voids	All final voids	Reshaped to final landform design as per requirements of Table F18 of the EA.

4 Legislative Rehabilitation Requirements

Stanmore submitted a RMP to DES in accordance with Conditions F7 and F8 of the Isaac Plains Environmental Authority (EA) (EPML0093213) on 29 June 2018. Condition F8 was subsequently amended on 08 May 2019 to require the re-submission of the RMP on 01 October 2019.

A policy framework set out by DES in their guideline *Rehabilitation requirements for mining resource activities (ESR/2016/1975 formerly EM1122)* (Rehabilitation Guideline) provides requirements that must be considered in the development of a rehabilitation management plan. The Rehabilitation Guideline may be superseded by the PRCP Guidelines (currently in draft), following PRCP Start Date.

The RMP submitted on 29 June 2018 contained rehabilitation goals, objectives, indicators and completion criteria for different mine domains. This RMP continues to adopt these objectives and criteria, as required by EA Condition F7. Historical rehabilitation management plans have been produced for IPC and these documents have been considered in this RMP in recognition of their use for all previous rehabilitation on the site.

The RMP submitted on 29 June 2018 collated information from the EA, Plan of Operations at the time and previous rehabilitation management plans into the one, coherent framework, list of requirements and commitments. This RMP builds on the RMP submitted on 29 June 2018 through reference to established rehabilitation goals, objectives, indicators and completion criteria for different mine domains, and development of a progressive rehabilitation schedule.

This RMP adopts the concepts of mining domains, rehabilitation objectives, rehabilitation success criteria and post mining land uses. The concept of domains does not necessarily align with the PRCP requirements for 'rehabilitation areas' and 'improvement areas'. The concept of 'success criteria' or 'completion criteria' does not necessarily align with the PRCP requirement for 'rehabilitation milestones', 'management milestones' and 'milestone criteria'. These PRCP requirements define interim and final steps in the process of progressive rehabilitation, whilst 'completion criteria' focus on the final rehabilitation outcomes.

4.1 Domains

Table 4-1 provides the domain definitions, and the activities included within each domain, used in this RMP for the IPC.

Table 4-1 Domain Definitions

Domain	EA Domain reference	Definition
Spoil (Overburden) Dump	**Domain 2**	Waste rock from excavations or cuttings into the land surface.
Infrastructure Areas	**Domain 1**	Area of critical infrastructure, such as Mine Infrastructure Areas, Buildings, Hardstand areas, powerlines, switchyards, pipelines, the rail loop and laydown areas.
Roads (including Haul Roads)	**Domain 1**	Compacted earth / bitumen roadways for the safe travel of vehicles. These structures have been built up from, or cut into, the surrounding landscape.
Tracks	**Domain 1**	Compacted earth for the safe travel of vehicles. These areas have been cleared of vegetation and the in-situ ground material compacted to allow safe vehicle access.
Dams	**Domain 1**	Area used to store water. This can be separated into 'mine affected water' dams, 'sediment affected water' dams or 'clean water' dams.
ROM Pads and Stockpiles	**Domain 1**	Areas where Run of Mine (ROM) material has been stored and potentially contaminated the land surface.
Drill Pads	**Domain 1**	Area of cleared land that has been set aside for the manoeuvring and safe operation of drilling rigs and gas / groundwater drainage holes.
Voids	**Domain 3**	Holes created from excavations, not including dams and sumps.
Cleared Areas	**All domains**	Areas where the vegetation has been cleared, but the topsoil remains in-tact.
Rehabilitation	**All domains**	Areas which have been disturbed but vegetation re-growth and re-establishment has been encouraged or purposefully installed.
Drainage	**Domain 1**	Areas in which the drainage flow path of a creek or river has been altered to redirect its natural path.
Quarries and Borrow Pits	**Domain 1**	Areas where in-situ rock material has been extracted for general purpose use at the site. Quarries target hard, igneous rock while Borrow Pits typically target soft, sedimentary rock.

Domain	EA Domain reference	Definition
In-Pit Tailings storage facilities (TSF)	**Domain 4**	In-Pit tailings storage facilities include exhausted pits that have been used to store reject and tailings material
Underground Mining	**Domain 5**	Underground mining areas where rehabilitation of subsidence areas may be required (noting that minimal subsidence is predicted for the proposed bord and pillar mining method).

4.2 Definitions

The definitions of terms used in this RMP is provided below.

4.2.1 Rehabilitation & Certification Process

In Queensland once a rehabilitation area is considered suitable it is certified as "successful rehabilitation". prior to this it will be classified as either "recontoured land", "topsoiled", or "seeded".

The *Environmental Protection Act 1994* allows either final or progressive certification of rehabilitation to classify it as 'successful rehabilitation'. Final certification is given when all mining activities have ceased and mining lease and EA relinquishment is to occur. Progressive rehabilitation occurs during the mine life on parts of the mining lease(s).

To have rehabilitation certified as "successful rehabilitation" the following process / evidence is required:

1. Provision of a cross-reference to the RMP and conditions of the EA that are relevant to the specific domain. Typically this includes rehabilitation objective, rehabilitation indicators and completion criteria.
2. Outlined consultation processes undertaken (if any) for the development of rehabilitation objectives, indicators and completion criteria.
3. Comparison of rehabilitated areas to completion criteria as outlined in the RMP.
4. Estimates of aggregate costs for rehabilitating the subject area(s).
5. Analyses of the relevant monitoring data to demonstrate compliance.
6. Statements or certifications by appropriately qualified persons regarding the construction, stability, or likely future performance of structures that are components of the rehabilitation (i.e. dams, voids, diversions etc.).
7. Requirements for any ongoing maintenance, monitoring or management.
8. References to other relevant reports (such as inspections, design reports etc.).

The main purposes of this RMP are to:

1. Develop a practical set of rehabilitation completion criteria for IPC that are easily interpreted, robust and result in the achievement of rehabilitation objectives as outlined by the administering authority;
2. Outline processes and methods that can be used to rehabilitate areas so they meet the completion criteria as outlined in this document; and
3. Outline processes to monitor rehabilitation that will demonstrate compliance with the completion criteria, to be used for rehabilitation monitoring.
4. Develop a schedule of progressive rehabilitation with milestones, based on domains (or grouping of domains) and interim milestones necessary to achieve completion criteria.

4.2.2 The Rehabilitation Hierarchy

The rehabilitation hierarchy relates to a series of 'end points' defining successful rehabilitation across mine sites. The definitions of each level of the hierarchy are outlined in the Rehabilitation Guideline. A summary of each level of the hierarchy is outlined below.

Rehabilitation goals: These are goals prescribed by the administering authority for the rehabilitation of all mine sites. Each domain must be:

1. Safe to humans and wildlife
2. Non-polluting
3. Stable and
4. Able to sustain the agreed upon post mining land use.

Note that the terminology used in these goals is not necessarily the same as that proposed for PRCPs. In the context above:

- Stable is taken to mean "Resistant to change in landform, pollution generation or land use potential to an extent that is similar to unmined land in the locality. The acceptable rates of change of specified parameters or the maximum risk of specified environmental harm may be set in an environmental authority." This is different to the definition of 'stable' under the MERFP Act changes, which includes land being able to sustain a post mine land use.
- An 'agreed post mining land use' includes areas where no use is proposed (e.g. 'unused void with low risk'). This is different to concept of 'post mining land use' under the MERFP Act changes.

Rehabilitation objectives: Rehabilitation objectives are more specific targets that vary between each mine domain (e.g. polluted water is contained and/or treated on-site).

Rehabilitation indicators: These define the parameters that have been measured and clarifies how the measurements were established. The outcome is compliance with the rehabilitation objective(s) and can include specific measurements (e.g. pH), groupings (e.g. water quality), a process under a recognised standard or protocol and used to gauge changes to a system.

Completion criteria: Generally quantitative or semi-quantitative and used to determine whether indicators, and therefore objectives, are being met.

4.3 Post Mining Land Uses

Appendix 2 of the EA describes the 'sustainable land use' across all mine domains, noting that a 'sustainable land use' is not proposed for the final voids domain the post mining land uses within each domain across the IPC. Table 4-1 summarises the post mine land capability and land use for each domain within the IPC. The post mining land use or 'sustainable land use' for all domains, other than voids, is agricultural cattle grazing, which is the pre-mining and current land use for the property on which mining is located.

The rehabilitation objectives for the closure of IPC are adopted from the EA. Consequently, the majority of areas to be rehabilitated support a "grazing" post mine land use.

To quantify the post-mining land uses, the rehabilitation objectives for vegetation and land-use are described as:

- Water Storage: The level of water storage and retention must be defined based on the environmental impacts of overflow to downstream waterways. The water storage must not detrimentally affect downstream ecosystems or surrounding groundwater systems.
- Grazing on Native & Improved Pasture: Rehabilitation must establish a thick pasture capable of self-regeneration over successive seasons with minimal inputs outside that required for the management of pastures in surrounding, off-lease areas by landowners.

The land capability classifications applicable to various areas across the site as outlined in Regional Land Suitability Frameworks for Queensland (2013) are:

- Class 3: Suitable land with moderate limitations which either further lower production or require more than those management practices of Class 2 land to maintain economic production.
- Class 4: Marginal land which is presently considered unsuitable due to severe limitations. The long term significance of these limitations on the proposed land use is unknown or not quantified. The use of this land is dependent upon undertaking additional studies to determine whether the effect of the limitation(s) can be reduced to achieve sustained economic production.
- Class 5: Unsuitable land with extreme limitations that preclude its use for the proposed purpose.

Generally 'Grazing' land uses are coupled with 'Class 3' lands. This aligns with soil and sub-soil profiles that will sustain a land use with higher requirements from the soil than other areas. The overburden emplacement areas and in-pit tailings storage facility must be restored to 'Class 4' lands while voids have not been allocated a class.

4.4 Classification of Post-Mining Land Uses

A more thorough definition of the above land uses is required in order to develop a 'target' for acceptable rehabilitation and is outlined below for each post-mining land use.

4.4.1 Grazing

Buffel grass (*Cenchrus ciliaris*) is the dominant pasture species around the Moranbah region (Grigg et. al. 2001) including the areas surrounding the IPC. The presence of buffel grass exerts control on the

diversity of grass pastures, most often out-competing other exotic and native species. Pasture diversity in plots containing buffel grass is often at its greatest when buffel grass comprises less than 50% of the ground cover (Grigg et. al. 2001). Buffel grass has the ability to rapidly establish and out-compete other species. This results in the percentage of ground cover within a plot increasing, but the overall species diversity decreasing with time.

Griggs et. al. (2001) demonstrated in a survey of Bowen Basin Coal Mines that the percentage of buffel grass in rehabilitated pastures increases with the age of rehabilitation. Pastures surrounding the IPC are dominated by buffel grass and it is recommended that this species comprises the dominant species in the 'grazing' rehabilitation mix. However, the native and improved pastures mix should also include a mixture of native species to promote diversity.

4.5 Control Strategies & Commitments

There are a number of site-specific commitments and control strategies in previous documents that outline the rehabilitation requirements for previous rehabilitation that has taken place on the site that are applicable to the site in addition to what is required under the EA, including:

- Topsoil will be spread evenly over the surface of disturbed land. The final depth will depend on the quantity available. An average depth of 15 centimetres will be applied as estimated from the financial assurance calculations.
- As required and depending on circumstances, shallow or deep ripping may be undertaken to break up compacted surface layers or to key in the topsoil to the underlying spoil.
- Pending soil chemistry analysis, suitable types and rates of fertiliser may be applied to assist vegetation establishment.
- Seeds of selected pasture grasses and legumes, appropriate to the desired post mine land use will be sown, generally in the October to February period depending on seasonal conditions and operational requirements with native and exotic pastures being the preferred ground cover for the area as an erosion control measure.
- Weed management will be undertaken in accordance with the landholders' protocols and Local and State Government guidelines.
- Revegetation areas will be monitored annually to ensure that the performance objective of 70% groundcover by non-declared weed species for three consecutive years of monitoring are met.

5 Review of Rehabilitation Methods

The number of active coal mines currently undergoing progressive rehabilitation is large compared to areas that have been successfully rehabilitated and maintain a self-sustaining vegetation community. Typically there is a large uncertainty associated with the long-term success of rehabilitation practices because of a lack of long-term observational datasets. This uncertainty leads to a large variety of rehabilitation practices being implemented.

Each approach can be seen to meet a set of relatively arbitrary 'rehabilitation success criteria' (which sometimes relate back to the performance of specific reference sites) over several years, but the

performance of these in the long-term is unknown. These success criteria generally apply to only one or two domains at mine sites, most notably the spoil domain. Other success criteria relate to the designated "Post Mining Land Use" as outlined in the mine's EA.

However, compliance with these 'rehabilitation success criteria' does not necessarily mean that an area is available for progressive or final certification in accordance with the regulators guidelines. This is because there are often other aspects that need to be addressed to make the area suitable to hand back to the landholder for management. Therefore the approach taken in this report is to provide those success criteria for each domain that will allow the area to be successfully classified as the post mining land use as outlined in the EA, as well as be progressively certified.

In addition, a review of current rehabilitation practices in the Bowen Basin has been undertaken because of the lack of any one set of guiding principles suitable to the creation of a successful vegetation community. This review sources information from ACARP studies, as well as from publicly available documents (such as Environmental Impact Statements and Central Queensland Mining Rehabilitation Group [CQMRG] Presentations) and C&R's library[1] of rehabilitation design and assessment documents gained from other mine sites. In the latter case the specific sites are kept anonymous to retain confidentiality.

Documents used in the review include:

1. Adopting novel ecosystems as suitable rehabilitation alternatives for former mine sites (Doley & Audet., 2013).
2. Completion Criteria for Pasture Based Rehabilitation in the Bowen Basin (ACARP 2001).
3. Curragh Coal Mine Rehabilitation Monitoring 2012 Assessment (McKenna & Kilgour, 2012).
4. Environmental geotechnics in spoil dump design for erosion management - a probabilistic approach (Goh et al, 1998).
5. Industry Based Rehabilitation and Closure Knowledge Management System (ACARP 2014).
6. Mine rehabilitation: A handbook for colliery managers (HannanC).
7. Opportunities and constraints of functional assessment of mined land rehabilitation (Erskine et al, 2013).
8. Sustainable Landscape Design for Coal Mine Rehabilitation (Loch 2010).
9. Reclamation management practices of waste spoil dumps in the Australian coal industry (Goh et al, 1999).
10. Rehabilitation of Open Cut Mines Using Native Pasture Species (ACARP 1997)
11. Rehabilitation of Dispersive Tertiary Spoil in the Bowen Basin (ACARP 2004)

This review has been undertaken to assist Stanmore to determine the rehabilitation practices currently used across the Bowen Basin that are most appropriate to apply at the IPC. The review has been broken down into various areas of interest (such as spoil dumps, soil quality, etc.) with a similar review for voids undertaken in Henderson Geotech 2012.

[1] C&R prepared the RMP dated June 2018. This RMP draws on information in the June 2018 RMP.

The outcomes of particular note to the rehabilitation plan and completion criteria for IPC are listed below.

Spoil Dump Design:

1. The effectiveness of benches to slow erosion processes is questionable. Relatively old rehabilitation at some mine sites has resulted in rills eroding through benches and occurring along the entire slope. However, these external slopes at other mine sites are at or near the angle of repose (typically 30°).
2. The highest erosion is associated with steep, long, uninterrupted, slope lengths.
3. Acceptable slope angles are less than 15% (or 8.5^{o}) for external spoil slopes. The external slopes at IPC have been designed to be no greater than 8.5^{o}.
4. Where possible dispersive Tertiary spoil should be covered with benign rock cover (such as Permian spoil).
5. Spoil dumps must spread water rather than concentrate water down the slope.
6. Large rocks are preferred for rock-lined channels to break up water flow and slow velocity. If large rocks are not available, the channel width must be increased.
7. Contour ripping is standard. Areas where contour ripping does not occur are very rare and often seen as 'sub-standard'.

Vegetation and Erosion:

- Vegetation establishment improves rainfall infiltration, assisting with soil moisture during dry periods.
- Direct seed spreading methods (as opposed to aerial seeding) generates much higher success rates.
- If buffel grass can be established during wet periods, it has a high survival rate during dry periods. Therefore it is important to ensure a ground-cover establishment during wetter years.
- Breakdown of rocky spoil material into sand-sized particles (via weathering and mechanical assistance) has allowed for the establishment of vegetation and recruitment from surrounding areas without topsoil placement at some mines.
- It has been found that 70% groundcover minimises erosion.
- Raindrop impacts have a significant effect on erosion. This highlights the importance of vegetation and topsoil cover to prevent raindrop impacts on exposed spoil.

Soil Quality:

1. Crusted spoil generally results in poor vegetation establishment and increases the proportion of runoff.
2. Catchments 'self-ameliorate' (i.e. topsoil quality improves) once erosion processes have been reduced to negligible levels.
3. If Vertisols are to be used (such as B1 or B4 as outlined above) in rehabilitation, place it on top of spoil dumps rather than on side slopes.
4. Application of manure, fertilizer and hay can result in very quick and thick establishment of a ground cover.

6 Landform Design

6.1 Slope Angles

Stanmore IP Coal uses conventional rehabilitation methods for the progressive rehabilitation of overburden emplacements at the existing Isaac Plains Mine.

Overburden emplacement rehabilitation includes 15% (or 8.5^{o}) maximum external dump slopes, contour drainage, topsoiling, and reseeding with grass and trees. Landform design criteria, final land use and rehabilitation monitoring are specified in the sections below.

The open cut mine final voids and ramps will be left in a geotechnical stable form and at slopes that comply with the relevant Isaac Plains Mine EA landform criteria as outlined in Table 18 of the EA.

Progressive rehabilitation will include outer slopes being reshaped to a landform of 8.5 degrees (15%) and internally draining spoil dumps to 17 degrees (30%).

The conceptual design for all pits within IPC is shown in Figure 6-1. This design is consistent with current EA requirements and the local topography which is includes a landscape modified by historical mining activities, and gently sloping hills and outcrops.

6.2 Landholder Consultation

All mining activities occur on mining leases subject to existing compensation agreements with landholders for all mining activities on the land, including any residual voids. Stanmore has consulted the landholders on whose land the proposed IPE Extension will occur. Landholder's are satisfied that their existing compensation agreements allow for an extension of the pit areas and associated residual voids.

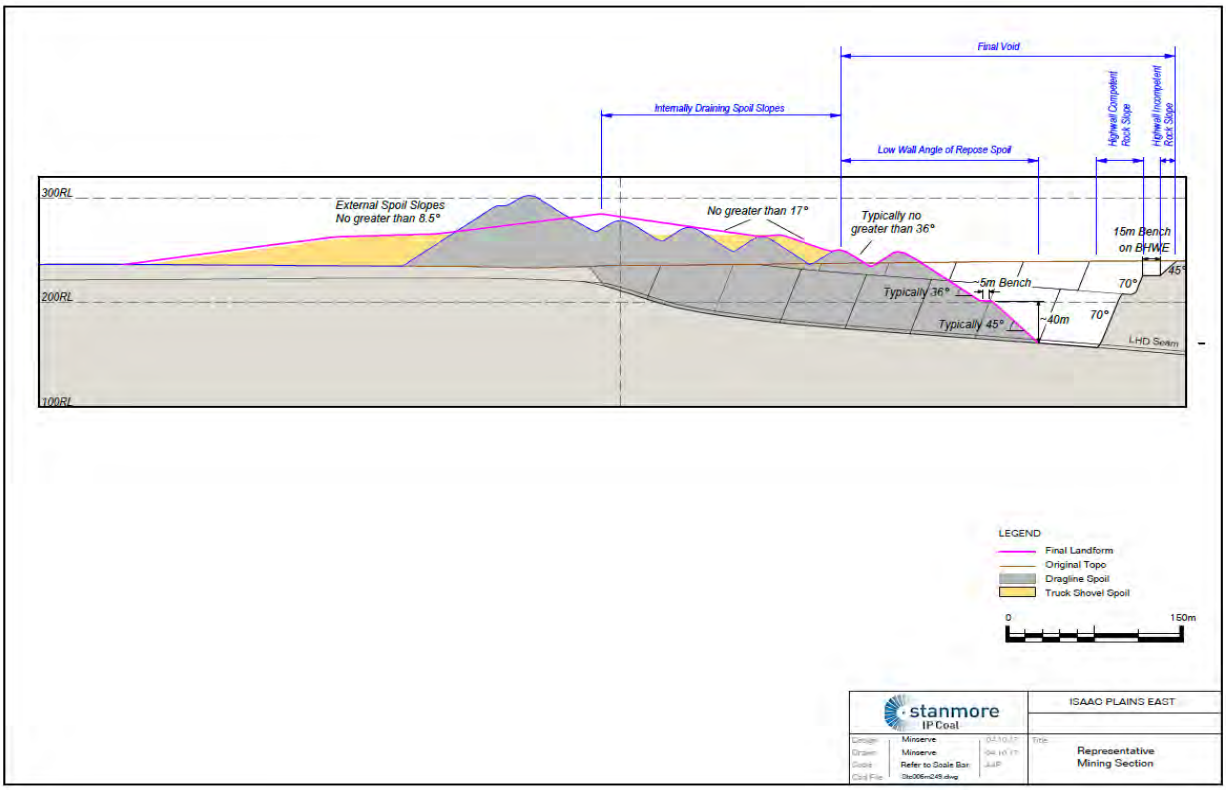

Figure 6-1 Final Landform Design at IPC

6.3 Final Void Water Balance

The catchment area of the final voids will be limited by drains and the externally draining overburden emplacement areas.

Modelling of the water balance of the final voids has undertaken for the IPE Extension Project, and includes all voids in the IPC at the end of mine life (WRM, 2019). This modelling indicates that lakes will form in the final voids. Modelling indicates N1 lake will reach a level approximately 25 m below the spill point (and 15m below the groundwater recharge level) and that all other residual void lakes will reach a level between approximately 45 m and 60 m below the spill point (and 35 to 50 m below the groundwater recharge level) of the final voids. Overflow from the final voids is therefore not predicted to occur during even the most extreme climatic conditions. The predicted lake levels are also below the groundwater source / sink level. Therefore, the final voids will continue to act as a groundwater sink and water from the void lakes will not migrate away from the voids and potentially contaminate groundwater.

6.4 Final Voids and Flood Levels

A hydraulic model was developed for the Isaac Plains East Extension (IPEE) project (WRM, 2019) which demonstrated that all residual voids at IPE would be located outside of the 0.1% annual exceedance probabaility (AEP) flood event (also referred to as the 1:1000 year flood event).

The residual voids at IPM that are not proposed to be backfilled (i.e. N1 and S2) are approved under the existing EA conditions. These voids have been subject to historical flood studies incorporating the approved final landform design along Smoky Creek and Billy's Gully. The final landform design prevents flooding from a 1:1000 year flood event. Outer slopes are less than 15%, rehabilitated (i.e. topoil, seeding and revegetation) and have armour rock lining wherever the flood studies showed a water velocity greater than 1 m/sec. RPEQ certification has been achieved based on seepage criteria which shows a stable long term landform.

Hence all residual voids at the IPC are located outside of the 1:1000 year flood event.

7 Domain Objectives, Completion Criteria, Monitoring & Rehabilitation Methods

The following Sections outline the rehabilitation goals, rehabilitation objectives, indicators, completion criteria, monitoring requirements and rehabilitation methods for each domain, in accordance with current EA conditions. In addition, for each completion criteria, additional information is provided on how evidence of achieving the completion criteria can be demonstrated. This evidence can take the form of the following:

- Final Rehabilitation Report or Progressive Rehabilitation Report – A Final Rehabilitation Report or Progressive Rehabilitation Report is required to determine whether the completion criteria have been met. This is similar to a Rehabilitation Inspection but must assess all of the completion criteria for the relevant area, and can refer to previous rehabilitation inspections. The Final Rehabilitation Report or the Progressive Rehabilitation Report must be audited. Other requirements of these reports are outlined in the Rehabilitation Guidelines.
- Certification Report – A report by an appropriately qualified third party outlining that the completion criteria has been met and the relevant infrastructure / works are fit for purpose.
- Inspection by Appropriately Qualified Person – A report undertaken by someone who is qualified and has demonstrated experience investigating the relevant issue.

A summary of the completion criteria for each domain is provided in Table 7-1.

Table 7-1 Summary of Completion Criteria for Each Domain.

Domain	Summary of Criteria
Domain 2 Overburden Emplacement areas.	The majority of completion criteria for overburden emplacement areas focus on: • establishing a stable non-polluting landform that has a self-sustaining ground cover able to support grazing activities, • minimising erosion, and • maintaining water quality/runoff.
Domain 3 Residual Voids	The completion criteria for residual voids focus on leaving the landscape stable and non-polluting while preventing access by stock and humans.

Domain	Summary of Criteria
Domain 1 Infrastructure, Roads, Tracks, ROM Pads & Stockpiles, Laydown Areas	These areas are provided with relatively standard completion criteria. However, emphasis is placed on ensuring that potentially contaminated material is remediated or removed (such as ROM Pads) and that erosion is controlled. The majority of completion criteria for infrastructure focus on establishing a stable, non-polluting landform that has a self-sustaining ground cover that can support grazing activities, minimising erosion and maintaining water quality /runoff
Domain 1 Dams	Two sets of completion criteria are provided for dams: (i). Providing the landholder with infrastructure that is useable and will not contaminate water supplies, and (ii) Dam decommissioning.
Domain 4 In-Pit Tailings Storage Facility	The completion criteria from the EA for in-Pit TSF areas are similar to the spoil dump criteria focusing on: • establishing a self-sustaining ground cover, • minimising erosion and • maintaining water quality. The current completion criteria outlines that these areas should be designated as a grazing land use.
Domain 5 – Potential underground subsidence areas	The completion criteria focus on determining whether there has been a subsidence impact requiring rehabilitation, and that the landform is safe, stable and non-polluting and continues to support cattle grazing.

The following Sections are structured as follows for each domain:

- Table containing rehabilitation objectives, indicators, completion criteria and evidence that should be supplied to demonstrate compliance with the criteria.
- Rehabilitation monitoring: Indicates how inspections should be undertaken to gather the data required for compliance with completion criteria.
- Rehabilitation methods: Outlines how rehabilitation can be undertaken to maximise the probability of compliance with completion criteria. This is a guide only and does not prohibit the application of other rehabilitation methods to meet the completion criteria.

8 Overburden Emplacement Areas.

8.1 Rehabilitation Completion Criteria

Table 8-1 Overburden Emplacement Areas Completion Criteria

Overburden emplacement areas Rehabilitation Goal	Overburden emplacement areas Rehabilitation Objective	Overburden emplacement areas Indicators	Overburden emplacement areas Completion Criteria	Evidence Required for Completion Criteria
Long-term Safety	Structurally safe with no hazardous materials	Safety assessment of landform stability (geotechnical issues)	Certification by an appropriately qualified person, that the land is safe for the post-mining land use via a geotechnical assessment to determine stability.	Suitably qualified geotechnical expert to certify that externally draining slopes will be suitable for human and/or animal trafficking and internally draining slopes are geotechnical stable. Certification will be documented in rehabilitation report that slopes are safe and there is minimal risk of future failure.
		Exposure to, and availability of heavy metals and other toxic materials	Evidence (certified by an appropriately qualified person) which confirms the absence of potential for acid mine drainage from the rehabilitated landform.	It is unlikely that any acid mine drainage will occur as a result of this mining operation. A risk assessment for PAF and NAF of overburden material will be conducted by a suitably qualified geochemist, with evidence presented in the Final Rehabilitation Report.
			Evidence, which has been certified by an appropriately qualified person that residual soil contamination on the mining leases has been removed, neutralized or isolated.	A risk assessment of potentially contaminated material in voids will be undertaken. If the risk assessment identified potential for contamination at receptors, a soil survey and quality analyses will be carried out in accordance with AS4482.1 (Guide to the investigation and sampling of sites with potentially contaminated soil). If contamination is found as a result of this survey a contaminated land investigation will be conducted this will determine if:

Overburden emplacement areas Rehabilitation Goal	Overburden emplacement areas Rehabilitation Objective	Overburden emplacement areas Indicators	Overburden emplacement areas Completion Criteria	Evidence Required for Completion Criteria
				• the contamination needs to be remediated, in which case a validation report must be prepared following remediation to confirm that the remediation process was successful; and/or • the contamination is best managed under the conditions of a site management plan, in which case a draft site management plan must be prepared and submitted for approval. Evidence of management or remediation will be provided in the Final / Progressive Rehabilitation Report.
Non-Polluting	No contamination of surface water and groundwater resources	Downstream surface water quality .	Evidence (certified by an appropriately qualified person) that surface water monitoring demonstrates the quality of water in the receiving environment meets the following, as a minimum, water quality objectives: • pH 6.5-8.5 pH units • EC ≤720µS/cm • TSS ≤55mg/L • Turbidity ≤50NTU • Sulphate ≤25mg/L	Testing of downstream waters will be carried out throughout the mine life in accordance with the receiving environment monitoring programme as conditioned under C22-C24 of the EA. The historic results of this testing and any management actions resulting from this testing will be presented in the final rehabilitation management inspection. The quality of water generated from the area will be assessed against the baseline range for the receiving environment (i.e. Smoky Creek and Billy's Gully) or ANZECC (2000) 95% Species Protection Levels for aquatic ecosystem.

Overburden emplacement areas Rehabilitation Goal	Overburden emplacement areas Rehabilitation Objective	Overburden emplacement areas Indicators	Overburden emplacement areas Completion Criteria	Evidence Required for Completion Criteria
		Groundwater quality.	Evidence which has been certified by an appropriately qualified person, that groundwater monitoring demonstrates that the groundwater quality is within 5% of the results of baseline monitoring results, or when baseline is not available, reference bores which have not impacted by mining activities.	Testing of groundwater will be carried out in accordance with the Groundwater Management and Monitoring Programme as conditioned under C43-C49 of the EA. The historic results of this testing and any management actions resulting from this testing will be presented in the final rehabilitation management inspection.
Stable	Erosion rates are appropriate for landform design	Safety assessment of landform stability (geotechnical issues)	Evidence (certified by an appropriately qualified person) that: • All external draining slopes are ≤15%(8.5°); • All internal draining slopes, other than void low wall and void high wall are ≤30% (17°); • All rehabilitated areas are geo-technically stable for the intended post mining grazing land use.	Initial evidence will be provided within rehabilitation inspection reports assessing the landform by analysing detailed topographic data (LiDAR) and creating cross section of the created landform. Evidence will be provided in the Final / Progressive Rehabilitation Report.
		Erosion control and rates.	Evidence (certified by an appropriately qualified person) that erosion rates of rehabilitated areas are suitable for the post mining grazing land use..	Erosion ratings will be carried out in accordance with Section 15.1 with erosion rating less than or equal to 2 as per Table 15-1. Erosion rates, will also be measured or modelled (using suitable modelling methods such as RUSLE, CAESAR, SIBERIA, MINErosion, etc.) This will be provided in certification report comparing erosion losses (measured or modelled) from overburden areas to surrounding grazing lands.

Overburden emplacement areas Rehabilitation Goal	Overburden emplacement areas Rehabilitation Objective	Overburden emplacement areas Indicators	Overburden emplacement areas Completion Criteria	Evidence Required for Completion Criteria
				In addition, while progressive rehabilitation is occurring. the following criteria will be adhered to: • Areas where washouts occur do not exceed 5% of the total rehabilitation area for the site. • Each individual washout does not exceed 100m^2. • No slumping or slips occur • Topsoil has been keyed into the spoil below; to hold the topsoil to the underlying spoil material.
	Appropriate Vegetation cover	Vegetation type and density.	Evidence (certified by an appropriately qualified person) that the vegetation type and density of species in rehabilitated areas are suited to the soil composition, slope, aspect, climate and post mining grazing land use.	Suitable grazing reference sites have been established and monitored over several rehabilitation inspections. Within these inspections the vegetation composition and soil type has been assessed. Additionally the vegetation and soil at rehabilitated overburden emplacement areas has been monitored and compared to these reference sites. All rehabilitated overburden emplacement areas will be inspected as they are progressively rehabilitated with the results presented in an annual rehabilitation inspection. All rehabilitated areas will be compared to reference sites on an annual basis with their suitability for a grazing land use
			Evidence (certified by an appropriately qualified person) that the variety of vegetation species and their density in rehabilitated areas is comparable to reference sites.	

Overburden emplacement areas Rehabilitation Goal	Overburden emplacement areas Rehabilitation Objective	Overburden emplacement areas Indicators	Overburden emplacement areas Completion Criteria	Evidence Required for Completion Criteria
		Foliage cover	Evidence which has been certified by an appropriately qualified person that: • foliage and ground cover is comparable to reference sites; • minimum of 70% ground cover is present (or 50% if rocks, logs or other features of cover are present); and • no bare surfaces >20 m2 in any area or >10 m in length down any slope ≥3.	assessed against reference site. Factors that will be compared will include: • vegetation type and density • soil composition and • landform The on-ground Inspection carried out at reference site and monitoring sites is documented in Section 14. Evidence will be presented in the Final / Progressive Rehabilitation Report.

Overburden emplacement areas Rehabilitation Goal	Overburden emplacement areas Rehabilitation Objective	Overburden emplacement areas Indicators	Overburden emplacement areas Completion Criteria	Evidence Required for Completion Criteria
Sustainable Land Use	Soil properties support the nominated post mining grazing land use	Topsoil and subsoil support the proposed vegetation and land use	Evidence (certified by an appropriately qualified person) that soil properties (e.g. pH, salinity, nutrient content, sodium content) and soil characteristics (e.g. surface roughness, infiltration capacity) support the post mining grazing land use.	Suitable grazing reference sites have been established and monitored over several rehabilitation inspections. Additionally, rehabilitated overburden emplacement areas have been monitored and compared to these reference sites. All rehabilitated overburden emplacement areas will be inspected as progressive rehabilitation takes place. The results will be presented in an Annual Rehabilitation Inspection Report. All rehabilitated areas will be compared to reference sites on an annual basis with their suitability for grazing land use assessed against a reference site. The on-ground Inspection carried out at reference and monitoring sites is documented in Section 15.1, with evidence presented in the Final / Progressive Rehabilitation Report. The following soil chemical criteria have been adopted for the site based on several years of reference site monitoring: pH(1:5) range of soil is between 6 – 9.2 to at least 0.45m. Cation Exchange Capacity greater than 9meq/100g. Root zone salinity is less than 0.6dS/m (in a 1:5 soil water mixture). ESP values are less than 6 % Evidence of nutrient and organic matter cycling is occurring (this can be provided by continued sampling for organic carbon and nitrogen in the soil profile for a period of 3 years).

Overburden emplacement areas Rehabilitation Goal	Overburden emplacement areas Rehabilitation Objective	Overburden emplacement areas Indicators	Overburden emplacement areas Completion Criteria	Evidence Required for Completion Criteria
				An on-ground Inspection with a soil survey carried out in accordance with Section 15.2 will be conducted for the site.

Overburden emplacement areas Rehabilitation Goal	Overburden emplacement areas Rehabilitation Objective	Overburden emplacement areas Indicators	Overburden emplacement areas Completion Criteria	Evidence Required for Completion Criteria
			Evidence which has been certified by an appropriately qualified person that topsoil has been respread to a suitable depth in rehabilitated areas to sustain the post mining grazing land use.	Topsoil is to be >150mm thick across all vegetated areas; OR chemical analyses indicate spoil is suitable to support long-term vegetation cover and meet the required land suitability classification. with evidence presented in the Final / Progressive Rehabilitation Report.
	Vegetation is suitable for the post-mining land use by establishing self-sustaining grazing vegetation	Plant regeneration	Evidence which has been certified by an appropriately qualified person, that species in rehabilitated areas show evidence of flowering, viable seed setting, germination and emergence, and will continue to do so for the foreseeable future.	Suitable grazing reference sites have been established and monitored over several rehabilitation inspections. Additionally rehabilitated overburden emplacement areas have been monitored and compared to these reference sites. All rehabilitated overburden emplacement areas will be inspected as they are progressively rehabilitated with the results presented in an annual rehabilitation inspection. All rehabilitated areas will be compared to reference sites on an annual basis with their suitability for a grazing land use assessed against reference site The results of these inspections will be presented in the Final/Progressive Rehabilitation Report, with vegetation surveys carried out in accordance with Section 15.3 and weed management in accordance with Section 19.
		Presence of key plant species	Evidence (certified by an appropriately qualified person) that the vegetation in rehabilitated areas includes the presence of species suitable and complimentary to the post-mining land use, and are at a density and composition comparable to reference sites.	
		Density of key plant species		

Overburden emplacement areas Rehabilitation Goal	Overburden emplacement areas Rehabilitation Objective	Overburden emplacement areas Indicators	Overburden emplacement areas Completion Criteria	Evidence Required for Completion Criteria
				For grazing land uses, a suitable grazing floristic assemblage will be established that is self-sustaining as evidenced by secondary establishment of grass species. Weed prevalence and occurrence will be no greater than reference sites. A pest management plan will document how pest animals are to be controlled on site. Stanmore will implement the recommendations of the pest management plan to ensure that pest animals are adequately controlled on the site
		Composition of key plant species		
		Abundance of declared plants (weeds) identified through inspection	Evidence (certified by an appropriately qualified person) that abundance of declared weeds are no greater than reference sites and are adequately controlled on the site.	
		Actions taken to eradicate plants declared under local or State legislation	Evidence which has been certified by an appropriately qualified person, that pest animals are adequately controlled on the site.	
	Agricultural Cattle Grazing	Land is suitable for ongoing sustained cattle grazing	Evidence (certified by an appropriately qualified person) that rehabilitated areas meet the following percentage breakdown of the land suitability classification for cattle grazing as defined by the Guideline for Agricultural Land Evaluation in Queensland (State Department of Queensland 2013), or any subsequent version, and will continue to sustain these suitability classifications for the foreseeable future: Class 4 = 100%.	A grazing trial report will outline species diversity, ground cover, health and erosion undertaken prior to and after grazing on the overburden emplacement areas. The grazing trial will be carried out in accordance with section 15.5 of this report. These results will be outlined in the Final Rehabilitation Report. Additionally all water sources in rehabilitation areas will be tested to assess the suitability for stock consumption. If the water is not suitable for stock

Overburden emplacement areas Rehabilitation Goal	Overburden emplacement areas Rehabilitation Objective	Overburden emplacement areas Indicators	Overburden emplacement areas Completion Criteria	Evidence Required for Completion Criteria
		Grazing Function	The areas have demonstrated an ability to recover from significant disturbance (e.g. slashing, grazing, fire) by re-establishing target covers.	consumption mitigation measures will be provided in a water management plan.
		Stock access to water	Certification by an appropriately qualified person that all water sources in the rehabilitated areas provide water suitable for stock and have an EC ≤7800µS/cm	

8.2 Rehabilitation Methods

The final land use for overburden emplacement areas is grazing purposes at the completion of rehabilitation. The general methods for overburden emplacement area rehabilitation are:

- Re-grade external spoil slopes to a slope of no greater than 15%;
- Re-grade internally draining slopes to a slope of no greater than 30%;
- Spread topsoil over the surface to the required cover thickness (minimum of 15 cm and deeper if suitable topsoil available);
- Rip the topsoil and install contour banks (where necessary); and
- Seed and monitor.

9 Open Cut Final Voids (Domain 3)

9.1 Rehabilitation Completion Criteria

Table 9-1 Residual Void Completion Criteria

Residual Void Rehabilitation Goal	Residual Void Rehabilitation Objective	Residual Void Indicators	Residual Void Completion Criteria	Evidence Required for Completion Criteria
Long-term Safety	Structurally safe with no hazardous materials	Safety assessment of landform stability (geotechnical issues)	• Certification by an appropriately qualified and experienced person, that final voids are stable, including: • Certification that slopes are as per Table 18: Residual Void Design and are geotechnical stable for the foreseeable future; • Certification that drainage measures and structures have been appropriately established and are directing overland flow away from the highwall edge; and • Certification that erosion and sediment control measures have been installed and are operating as designed.	Before the voids are surrendered a Geotechnical inspection and certification will be required to assess the residual voids to ensure stability with a low probability of rock fall, land slip or slumping. An "as constructed" survey of the final landforms will verify the residual voids design as per Table 9-2. This will be carried out via Lidar survey of the area. Geotechnical testing and reporting will analyse the data and determine stability of the open cut final voids. Drainage, soil erosion, and sediment control measures will be assessed. All sample results, analyses and interpretation will be carried out by a suitably qualified geotechnical engineer, with evidence provided in a Final Rehabilitation Report
		Exposure to, and availability of heavy metals and other toxic materials	Evidence (certified by an appropriately qualified person) and based on the results of progressive sampling and geochemical characterisation, together with site water quality monitoring as required by the EA, will be assessed for confirmation of the absence of acid mine drainage potential from the rehabilitated landform. Evidence (certified by an appropriately qualified person) will be required to verify that residual soil contamination on the mining leases has been removed, neutralised or isolated.	It is unlikely that any acid mine drainage will occur as a result of this mining operation, and will impact a receptor. However, • Testing of downstream waters will be carried out in accordance with the Receiving Environment Monitoring Programme as conditioned under C22-C24 of the EA. • Testing of groundwater will be carried out in accordance with the Groundwater Management and Monitoring Programme as conditioned under C43-C49 of the EA. • A risk assessment of potentially contaminated material in voids will be undertaken. If the risk assessment identified potential for contamination at receptors, a soil survey and quality analyses will be carried out in accordance with AS4482.1 (Guide to the investigation and sampling of sites with potentially contaminated soil). If contamination is found as a result of this survey a contaminated land investigation will be conducted this will determine if:

Residual Void Rehabilitation Goal	Residual Void Rehabilitation Objective	Residual Void Indicators	Residual Void Completion Criteria	Evidence Required for Completion Criteria
				• the contamination needs to be remediated, in which case a validation report must be prepared following remediation to confirm that the remediation process was successful; and/or • the contamination is best managed under the conditions of site management plan, in which case a draft site management plan must be prepared and submitted for approval. Evidence of management or remediation will be provided in the Final / Progressive Rehabilitation Report. • The historic results of all testing, and any management actions resulting from this testing, will be presented in the Final Rehabilitation Management Inspection
	Residual void remains safe for humans and wildlife	Risk to life	Evidence which has been certified by an appropriately qualified and experienced person that the risk of harm to humans, livestock and wildlife has been minimized appropriate safety measures including but not limited to bunds, fencing and any other necessary measures have been installed.	• Signage will be erected advising of steep slopes, potential for geotechnical failure or slumping, and uneven ground at the perimeter of the voids safety area. • Safety barriers will be installed in accordance with Technical Guidelines for Environmental Management of Exploration and Mining in Queensland (1995) and certified by an RPEQ. • An audit against relevant standards detailing appropriate safety barrier installation will be carried out prior to final rehabilitation. Evidence will be provided in the Final/Progressive Rehabilitation Report.
Non-Polluting	No contamination of surface water and groundwater resources	Downstream surface water quality	Evidence (certified by an appropriately qualified person), based on up to date groundwater modelling that any final void lakes will not overflow, nor potentially contaminate, any other surface water bodies.	Evidence of suitable water management will be documented in the water management plan as conditioned under C31-C35 of the EA. This will include a risk assessment to show there is little risk of the residual voids spilling into the surrounding environment. The final water management plan will investigate and provide evidence that final void lakes will not overflow or discharge to any receiving waters.
			Evidence (certified by an appropriately qualified person) that voids do not discharge	

Residual Void Rehabilitation Goal	Residual Void Rehabilitation Objective	Residual Void Indicators	Residual Void Completion Criteria	Evidence Required for Completion Criteria
			to any receiving waters, including surface water and groundwater.	Any management actions resulting from this investigation will be presented in the Final Rehabilitation Management Inspection Report.
		Groundwater quality	Evidence (certified by an appropriately qualified person) that groundwater monitoring demonstrates that the groundwater quality is within 5% of the baseline monitoring results, or when baseline is not available, reference bores which have not been impacted by mining activities.	Testing of groundwater will be carried out in accordance with the Groundwater Management and Monitoring Program as conditioned under C43-C49 of the EA. The historic results of this testing, and any management actions resulting from this testing, will be presented in the Final Rehabilitation Management Inspection Report.
Stable	Erosion rates are appropriate for landform design	Safety assessment of landform stability (geotechnical issues)	Certification by an appropriately qualified and experienced person that the final voids are stable in the foreseeable future and have been constructed in accordance with RPEQ designs.	Before the voids are surrendered a Geotechnical inspection and certification will be required to assess the residual voids to ensure that it is stable and has a low probability of rock fall, land slip or slumping. An “as constructed” survey of the final landform will verify the residual void design. This will be carried out via a detailed survey (LiDAR) of the area. Geotechnical testing and reporting will analyse if the open cut final voids are stable. Drainage, and soil erosion and sediment control measures, will be assessed. All sample results, analyses and interpretation will be carried out by a suitably qualified geotechnical engineer, with evidence provided in a Final Rehabilitation Report

9.2 Rehabilitation Monitoring

Routine rehabilitation monitoring should include documenting the condition of the voids, including observations of wall stability. These observations should be included in the rehabilitation inspection reports. The majority of residual void/s inspections are not required to occur until closure of the voids are being considered. Once a residual void is permanently out of operation, a geotechnical investigation will determine if the final landform is stable.

9.3 Rehabilitation Methods

All voids are proposed to be bunded, fenced and left in a stable condition. The proposed final landform for all operational pit areas is described Table 2-1. The high wall and low wall slope angles proposed for all voids in consistent with current EA conditions. The current, approved EA residual void design criteria are provided in Table 9-2. The proposed EA residual void design criteria, based on the final landform described in Table 2-1, are provided in Table 9-3. In comparing the current and proposed residual void design criteria:

- S1, S3 and N2 pits will be backfilled, and hence are no longer listed in the table
- S2 and N1 void remains the same. Rehabilitation of in-pit rejects disposal areas within the N1 pit area is described in Section 12. S2 pit high wall will be used as an underground entry.
- Pit 1 (E1) void remains the same
- Pit 2, 3 and 4 (E2 / E3 / E4) voids have similar surface areas, but larger volumes as depths increase with the eastward, downdip pit extension of approximately 300 m to 600 m.
- Pit 5 (E5) remains unchanged.

Overall the total area of residual voids has decreased by 26 ha from 344 ha to 318 ha. This is a result of using overburden material at IPE to backfill voids at IPM.

Final voids have not been located within a floodplain as defined by the 1:1000 year flood event (refer to Section 6.4). final void water levels will remain well below the groundwater recharge level and the spill level (refer to Section 6.3).

The eastward extension of the Pit 2, 3 and 4 has not resulted in an increase in the environmental risk associated with these voids. Environmental risks associated with residual voids have been minimised by locating voids outside of floodplains and through the proposed rehabilitation completion criteria for voids. The area of land and the outcome for the land is substantially the same as the outcome for the land under the current approved EA.

Table 9-2 Current EA Residual Void Design

Void identification	Void wall – competent rock slope	Void low wall – incompetent rock slope	Void low wall	Void low wall – incompetent rock slope	Void maximum surface area (ha)	Void maximum depth (m)	Void volume (Mm3) (+/- 2.5%)
N1/N2	275% (70°)	n/a	n/a	73% (36°)	91	110	41
S1	275% (70°)	n/a	n/a	73% (36°)	6	80	3
S2	275% (70°)	n/a	n/a	73% (36°)	54	90	20
S3	275% (70°)	n/a	n/a	73% (36°)	46	90	18
E1	275% (70°)	100% (45°)	73% (36°) - 100% (45°)	n/a	20	80	7
E2/E3/E4	275% (70°)	100% (45°)	73% (36°) - 100% (45°)	n/a	107	90	38
E5	275% (70°)	100% (45°)	73% (36°) - 100% (45°)	n/a	20	80	8

Table 9-3 Proposed EA Residual Void Design (Table 18 of the EA)

Void identification	Void wall – competent rock slope	Void low wall – incompetent rock slope	Void low wall	Void low wall – incompetent rock slope	Void maximum surface area (ha)	Void maximum depth (m)	Void volume (Mm3) (+/- 2.5%)
N1	275% (70°)	n/a	n/a	73% (36°)	99	110	41
S2	275% (70°)	n/a	n/a	73% (36°)	42	90	20
E1	275% (70°)	100% (45°)	73% (36°) - 100% (45°)	n/a	20	80	7
E2/E3/E4	275% (70°)	100% (45°)	73% (36°) - 100% (45°)	n/a	133	140	90
E5	275% (70°)	100% (45°)	73% (36°) - 100% (45°)	n/a	24	80	8

10 Infrastructure

10.1 Rehabilitation Completion Criteria

Table 10-1 Completion Criteria for Infrastructure Areas

Infrastructure Rehabilitation Goal	Infrastructure Rehabilitation Objective	Infrastructure Indicators	Infrastructure Completion Criteria	Evidence Required for Completion Criteria
Long-term Safety	Infrastructure has been retained in a safe and operable manner; or is decommissioned and removed	Certification that residual infrastructure is safe and fit for purpose	**Infrastructure areas only:** Final inspection by suitably qualified person confirming that residual infrastructure is fit for purpose and suitable for adoption by the post-mine landholder.	Evidence that any infrastructure left on-site is safe to use and is operable, as provided by maintenance logs or inspections.
	Rehabilitation of exploration drill holes and groundwater monitoring bores	All exploration drill holes and all monitoring bores established on the Mining Leases have been rehabilitated	Certification of the following by an appropriately qualified person: • All exploration drill holes and monitoring bores have been rehabilitated in accordance with the applicable Australian Standard or guideline. • All aquifers have been isolated where exploration drill holes or monitoring bores have intersected more than one water bearing strata, in accordance with the "Minimum Construction Requirements for Water Bores in Australia" (Australian Government, February 2012) or latest edition.	A plug or concrete has been used to seal drill holes below ground level, and the hole is backfilled with benign material to ground level. If relevant, the casing has been cut off below ground level, the hole capped or plugged, and the hole backfilled with benign material to ground level. Written evidence of drill hole sealing will be provided in the final rehabilitation report.
	Site is safe for humans and animals	Appropriate decommissioning of infrastructure	A risk assessment is to be undertaken by an appropriately qualified person prior to the surrender of the Environmental Authority to ensure the site is safe and all infrastructure has been decommissioned appropriately and in accordance with the conditions of the Environmental Authority and any applicable Australian Standard or Guideline. Roads and dams may be left in place to support the post mining grazing land use, in accordance with **Condition F5**.	Evidence of appropriate decommissioning will be provided in the final Rehabilitation Inspection Report. Additionally, an audit confirming that any areas left to the landholder after mining, are in compliance with the relevant standards.

Infrastructure Rehabilitation Goal	Infrastructure Rehabilitation Objective	Infrastructure Indicators	Infrastructure Completion Criteria	Evidence Required for Completion Criteria
		Remediate contaminated land	Evidence(certified by an appropriately qualified person) that residual soil contamination on the mining leases has been removed, neutralized or isolated.	Contaminated Land Assessment undertaken in accordance with AS1940:2004 and certified as meeting these standards. Contamination land assessment (in accordance with the *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland*) determines that contaminated material has been removed, neutralised or chemically and hydrologically isolated. Leaching tests of exposed material meet specified guideline values (using standard protocols such as US EPA Toxic Characteristic Leaching Procedure). Suitably qualified geotechnical expert to certify that the land is safe and will be suitable for human and/or animal trafficking all and infrastructure areas are geotechnical stable. Certification will be documented in rehabilitation report that infrastructure areas are safe and there is minimal risk of future failure.
		Safety assessment of landform stability (geotechnical issues)	Certification by an appropriately qualified person, that the land is safe for the post-mining land use.	
Non-Polluting	No contamination of surface water and groundwater resources	Downstream surface water quality	Evidence(certified by an appropriately qualified person) that surface water monitoring demonstrates the quality of water in the receiving environment meets the following, as a minimum, water quality objectives: • pH 6.5-8.5 pH units • EC ≤720µS/cm • TSS ≤55mg/L • Turbidity ≤50NTU • Sulphate ≤25mg/L	• The quality of water generated from the area is within the baseline range for the receiving environment (i.e. Smoky Creek and Billy's Gully) or ANZECC (2000) 95% Species Protection Levels for aquatic ecosystem. • Testing of downstream waters will be carried out in accordance with the Receiving Environment Monitoring Programme as conditioned under C22-C24 of the EA. The historic results of this testing and any management actions resulting from this testing will be presented in the final rehabilitation management inspection.

Infrastructure Rehabilitation Goal	Infrastructure Rehabilitation Objective	Infrastructure Indicators	Infrastructure Completion Criteria	Evidence Required for Completion Criteria
		Groundwater quality	Evidence(certified by an appropriately qualified person) that groundwater monitoring demonstrates that the groundwater quality is within 5% of the results of baseline monitoring, or when baseline is not available, reference bores which have not been impacted by mining activities.	Testing of groundwaters have been carried out in accordance with the Groundwater Management and Monitoring Programme as conditioned under C43-C49 of the EA. The historic results of this testing and any management actions resulting from this testing will be presented in the final rehabilitation management inspection.
Stable	Erosion rates are appropriate for the landform design	Slope angle and length	Evidence, which has been certified by an appropriately qualified person, that rehabilitated areas are geotechnical stable.	The gradient of rehabilitated land will generally be <10%. Initial evidence will be provided within Rehabilitation Inspection Reports assessing the landform by analysing detailed topographic data (LiDAR) and creating cross sections of the landform. This will be certified with evidence provided in the Final Rehabilitation Report.
		Erosion control	Evidence(certified by an appropriately qualified person) that erosion rates of rehabilitated areas are suitable to sustain the intended post-mining grazing land-use.	Evidence will be provided in the Final / Progressive Rehabilitation Report that sediment loss from the batter slopes is similar to soil loss rates from surrounding grazing lands. Evidence must be in the form of measured sediment loss (through measured accumulation in dams servicing the catchment, time-series of topographic surveys, or estimates from time series of rill development) or calibrated modelling (i.e. CAESAR / SIBERIA, etc. modelling that has been calibrated with a low estimate of error for the site). This will be provided in certification report comparing erosion losses (measured or modelled) from infrastructure areas to surrounding grazing lands.

Infrastructure Rehabilitation Goal	Infrastructure Rehabilitation Objective	Infrastructure Indicators	Infrastructure Completion Criteria	Evidence Required for Completion Criteria
Stable	Appropriate vegetation cover	Vegetation type and density	Evidence (certified by an appropriately qualified person) that the vegetation type and density of species in rehabilitated areas are suited to the soil composition, slope, aspect, climate and post mining grazing land use. Evidence (certified by an appropriately qualified person) that the variety of vegetation species and their density in rehabilitated areas is comparable to reference sites, and are suited to the post mining grazing land use	Suitable grazing reference sites have been established and monitored over several rehabilitation inspections. During these inspections the vegetation composition and soil type has been assessed. The vegetation and soil at rehabilitated infrastructure areas will be monitored and compared to these reference sites. All rehabilitated infrastructure areas will be inspected as they are progressively rehabilitated with the results presented in an annual rehabilitation inspection. All rehabilitated areas will be compared to reference sites on an annual basis with their suitability as a grazing land use assessed against reference site. Factors that will be compared will include: • vegetation type and density • soil composition and • landform The on-ground Inspection carried out at reference site and monitoring sites is documented in Section 14. Evidence will be presented in the Final / Progressive Rehabilitation Report.
		Foliage and ground cover	Evidence(certified by an appropriately qualified person) that: • foliage and ground cover is comparable to reference sites;	On-ground Rehabilitation Inspections will be carried out in accordance with Section 14, with evidence provided in the Final / Progressive Rehabilitation Report.

Infrastructure Rehabilitation Goal	Infrastructure Rehabilitation Objective	Infrastructure Indicators	Infrastructure Completion Criteria	Evidence Required for Completion Criteria
			• minimum of 70% ground cover is present (or 50% if rocks, logs or other features of cover are present); and • no bare surfaces >20 m2 in any rehabilitated area or >10 m in length down any rehabilitated slope ≥3.	
Sustainable Land Use	Soil properties support the nominated post mining grazing land use	Topsoil and subsoil support the proposed vegetation and land use	Evidence(certified by an appropriately qualified person) that soil properties (e.g. pH, salinity, nutrient content, sodium content) and soil characteristics (e.g. surface roughness, infiltration capacity) support the post mining grazing land use.	• Suitable grazing reference sites have been established and monitored over several rehabilitation inspections. • Rehabilitated infrastructure areas have been monitored and compared to these reference sites. • All rehabilitated infrastructure areas will be inspected as they are progressively rehabilitated with the results presented in an annual rehabilitation inspection. • All rehabilitated areas will be compared to reference sites on an annual basis with their suitability for a grazing land use assessed against reference site. • The on-ground Inspection carried out at reference site and monitoring sites is documented in Section 14 and evidence will be presented in the Final / Progressive Rehabilitation Report. The following soil chemical criteria have been adopted for the site based on several years of monitoring at grazing reference sites. • pH(1:5) range of soil is between 6 and 9.2 to a minimum depth of 0.45m. • Cation Exchange Capacity greater than 9meq/100g. • Root zone salinity is less than 0.6dS/m (in a 1:5 soil water mixture). • ESP values are less than 6 % • Evidence of nutrient and organic matter cycling is occurring (this can be provided by continued sampling for organic carbon and nitrogen in the soil profile for a period of 3yrs)

Infrastructure Rehabilitation Goal	Infrastructure Rehabilitation Objective	Infrastructure Indicators	Infrastructure Completion Criteria	Evidence Required for Completion Criteria
Sustainable Land Use			Evidence (certified by an appropriately qualified person) that topsoil has been respread to a suitable depth in rehabilitated areas to sustain the post mining grazing land use.	An on-ground site inspection, including a soil survey, will be conducted in accordance with Section 14. Topsoil is to be >150mm thick across all vegetated areas; OR chemical analyses indicating the area is suitable to supporting long-term vegetation cover and meeting the required land suitability classification.
		Plant regeneration	Evidence (certified by an appropriately qualified person) that species in rehabilitated areas show evidence of flowering, viable seed setting, germination and emergence, and will continue to do so for the foreseeable future. For grazing land uses, a suitable grass species has established and is self-sustaining as evidenced by secondary establishment of grass species future.	Suitable grazing reference sites have been established and monitored over several rehabilitation inspections. All rehabilitated infrastructure areas will be inspected as they are progressively rehabilitated with the results presented in an annual rehabilitation inspection. All rehabilitated areas will be compared to reference sites on an annual basis with their suitability for a grazing land use assessed against reference site The results of these inspections will be presented in the Final/Progressive Rehabilitation Report, with vegetation surveys carried out in accordance with section 15.3 and weed management in accordance with Section 19. For grazing land uses, a suitable grazing floristic assemblage will be established that is self-sustaining
		Presence of key plant species	Evidence (certified by an appropriately qualified person) that the vegetation in rehabilitated areas includes the presence of species suitable and complimentary to the post-mining land use, and are at a density and composition comparable to reference sites. Evidence (certified by an appropriately qualified person) that the abundance of declared weeds is no greater than reference sites and is adequately controlled on the site.	
		Density of key plant species		
		Composition of key plant species		

Infrastructure Rehabilitation Goal	Infrastructure Rehabilitation Objective	Infrastructure Indicators	Infrastructure Completion Criteria	Evidence Required for Completion Criteria
		Abundance of declared plants (weeds) identified through inspection	Evidence (as certified by an appropriately qualified person) that pest animals are adequately controlled on the site	as evidenced by secondary establishment of grass species. Weed prevalence and occurrence will be no greater than reference sites. A pest management plan will document how pest animals are to be controlled on site. Stanmore will implement the recommendations of the pest management plan to ensure that pest animals are adequately controlled on the site
		Actions taken to eradicate plants declared under local or State legislation		
	Agricultural Cattle Grazing	Land is suitable for ongoing sustained cattle grazing	Evidence (certified by an appropriately qualified person) that rehabilitated areas meet the following percentage breakdown of the land suitability classification for cattle grazing as defined by the Guideline for Agricultural Land Evaluation in Queensland (State Department of Queensland 2013), or any subsequent version, and will continue to sustain these suitability classifications for the foreseeable future: • Class 3 = 100%.	Rehabilitated infrastructure areas will be assessed against the land suitability framework for the Inland Fitzroy and Southern Burdekin area which is outlined in the Regional Land Suitability Frameworks for Queensland (2013) The results of these investigation will be outlined in the Final/Progressive Rehabilitation Report
		Grazing Function	The areas have demonstrated an ability to recover from significant disturbance (e.g. slashing, grazing, fire) by re-establishing target covers.	A grazing trial report will outline species diversity, ground cover, health and erosion undertaken prior to and after grazing on the infrastructure areas. The grazing trial will be carried out in accordance with section 15.5 of this report. These results will be outlined in the Final Rehabilitation Report.
		Stock access to water	Certification by an appropriately qualified person that all water sources in the rehabilitated areas	All onsite water sources will be routinely monitored with evidence of water quality provided in Water

Infrastructure Rehabilitation Goal	Infrastructure Rehabilitation Objective	Infrastructure Indicators	Infrastructure Completion Criteria	Evidence Required for Completion Criteria
			provide water suitable for stock and have an EC ≤7800µS/cm.	Management Plans. These results will be outlined in the Final Rehabilitation Report.

10.2 Rehabilitation Methods

10.2.1 ROM, Product Coal and Rejects Pads

ROM pads, reject pads and areas that have stored coal are usually constructed out of compacted raw material extracted from general mine operations. During mining operation these areas are covered with mining materials including raw, washed or rejected coal. After mining operations have ceased the construction material may contain contaminants and may be saline.

Where possible these layers are to be removed and buried as backfill in the in-pit tailings storage facility. A contaminated land assessment would then be performed to determine the presence or otherwise of residual contamination on the pads. If residual contamination is present the contaminated material must be removed off-site or disposed to the in-pit tailings storage facility. Evidence must be provided that the areas have been remediated, topsoiled and seeded to suit the designated final land use (grazing). This broadly correlates with the criteria outlined in the National Environment Protection Measures HIL- C, Recreational. However, an unaffected, nearby, area may be more appropriate as a guideline level.

Alternatively, these areas can be capped with benign material, topsoiled and seeded with a suitable species composition. Capping must be at least 1m thick to provide a suitable growth medium. The land is then considered suitable for assessment as non-polluting and for grazing purposes.

10.2.2 Infrastructure

Decommissioning the mine infrastructure area (MIA) including the offices, CHPP, rail loop, powerlines and laydown areas will require the removal of significant infrastructure unless a written agreement with the landholder exists for infrastructure to be kept on site. Removable infrastructure includes:

- Demountable buildings;
- Sheds;
- Chemical and fuel storage areas; and
- Laydown area

A contaminated land assessment would be performed to determine the presence or otherwise of residual contamination. If residual contamination is present the contaminated material must be removed off-site or disposed to the in-pit tailings storage facility. Evidence must be provided that the areas have been remediated, topsoiled and seeded to suit the designated final land use (grazing). This broadly correlates with the criteria outlined in the National Environment Protection Measures HIL- C, Recreational. However, an unaffected, nearby, area may be more appropriate as a guideline level.

10.2.3 Roads

Roads will require decommissioning unless a written agreement with the landholder exists for roads to be kept on site. Roads refer to trafficable access paths that have been overlain with a material or bitumen surface. Hard, or contaminated materials (such as bitumen or mine spoil), must be removed and buried in an hydraulically secured location (e.g. within the in-pit tailings storage facility). Once this

material has been removed, roads must be moulded into the surrounding landscape (if elevated) to minimise water concentration and erosion

Roads running perpendicular to a drainage feature would be breached in accordance with the 50 year flooding extent. Breaching would be designed to prevent the road from acting as an earthen embankment and to allow the free passage of waters from the road surface.

Roads running parallel to the direction of flow will require the construction of small mounds perpendicular to the road. The mounds will be designed to (a) reduce flow velocity, (b) redirect flows to the surrounding landscape, (c) reduce erosion along the road corridor by disrupting flow, and (d) reduce the use of the road corridor as a 'preferred flow path'.

Once these actions have been completed the area will be ripped, topsoiled and seeded with appropriate species.

10.2.4 Tracks

Generally, tracks consist of lightly compacted topsoil for vehicle access and are not built up or cut into the surrounding landscape. Thus, the rehabilitation of tracks does not require a large amount of work.

The ability of local vegetation to naturally re-establish would be assessed along each track. If the degree of compaction is not suitable for vegetation (i.e. buffel grass) to re-establish, the track would be ripped and lightly seeded to promote vegetation re-establishment.

10.2.5 Drill Pads

In many cases the drill pads are also associated with a sump to house water extracted from the hole during drilling. These sumps are typically rectangular depressions in the ground with sharp edges.

Rehabilitation of the drill pads must be undertaken to ensure the area is safe for humans and wildlife. This can be accomplished as follows:

- Seal the drill hole with a plug made of durable material (i.e. PVC, steel, concrete, bentonite) below ground level.
- Backfill sumps.
- Fill the space above the plug with rock, soil or drill cuttings to above ground level to allow for the subsidence and settlement of loose material.
- If topsoil is available, re-spread topsoil across the drill pad.
- Rip the area making sure that the residual hole / cap / seal is not damaged during ripping.
- Seed with a suitable species mix.

This methodology is commonly applied to drill pads across Queensland and is generally consistent with the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME) 1995.

11 Dams

11.1 Rehabilitation Completion Criteria

Two sets of rehabilitation completion criteria have been developed for dams. The first set of rehabilitation completion criteria (Table 11-1) is applicable if a dam is able to be remediated and left for use as a storage for clean water (i.e. as a water supply for cattle, etc.). The landholder on whose properties the dams are located, has provided written agreement to retention of dams on those properties. Condition F5 of the EA states "The environmental authority holder may only retain items of infrastructure which are beneficial to the post-mining land use, when there is written agreement between the environmental authority holder and the post-mining landowner/holder. Where the post-mining landowner/holder, is also the environmental authority holder, infrastructure cannot remain without the administering authority's agreement". All infrastructure that is to remain on site will adhere to condition F5. The second set of completion criteria should be adopted if the dam is to be formally decommissioned (Table 11-2), and is presented in this RMP as a contingency measure in case any future dams are not retained.

Table 11-1 Completion Criteria for Dams Retained for Clean-Water Use

Dams Rehabilitation Goal	Dams Rehabilitation Objective	Dams Indicators	Dams Completion Criteria	Evidence Required for Completion Criteria
Long-term Safety	Dam walls are fit for purpose and do not show signs of probable failure	Erosion	Dam walls are fit-for purpose and have been inspected by a suitably qualified person.	Dam inspection as outlined by the latest copy of the *Queensland Dams Manual*.
Non-Polluting	Water quality in the dam is suitable for the landholder's uses	Water quality	Water quality complies with ANZECC (2000) Guidelines for Primary Industries; OR the receiving water baseline.	Long-term water quality monitoring record and interpretation will be presented in the Final / Progressive Rehabilitation Report.
		Sediment quality	Saline and contaminated material have been removed from the base of dam. Sediment at the base of the dam complies with the levels outlined in the *Draft Guidelines for the Assessment and Remediation of Contaminated Sites in Queensland (2013)* or any later guideline.	Water will be removed from all dams and transferred to a void. The sediment will then be tested and compared to the relevant guidelines. If sediment is considered to be contaminated as a result of the assessment the sediment will then be removed and runoff from rehabilitated or undisturbed areas allowed to refill dams. Evidenced of this process will be presented in the Final / Progressive Rehabilitation Report.
Stable	The spillway of any dam is fit for purpose and not subject to large-scale erosion	Erosion indicators	The spillway of all dams to be left for the landholder must be inspected and certified by a suitably qualified person.	Dam inspections will be carried out in accordance with the latest copy of the *Queensland Dams Manual*.
			Discharge of water from the dam does not cause significant erosion to the bed and banks of the receiving environment.	Assessment / demonstration of erosion potential of discharges from dam's spillway.
Sustainable Land Use	As outlined in the Completion Criteria for "Non-Polluting".			

Table 11-2 Completion Criteria for Dams to be Decommissioned.

Dams Rehabilitation Goal	Dams Rehabilitation Objective	Dams Indicators	Dams Completion Criteria	Evidence to be supplied of compliance with Completion Criteria
Long-term Safety	Residual embankment walls (if any) do not pose a safety hazard to humans or wildlife	Stability	Any dam walls or embankments that are not removed are not prone to instability or slumping as certified by a suitably qualified person.	Dam inspections will be carried out in accordance with the latest copy of the *Queensland Dams Manual*.
Non-Polluting	The dam has been decommissioned and is non-polluting	Water quality	Minimal water is permitted to pool at the site of the former dam	Topographic assessment showing that water is unlikely to pool in the area.
		Sediment quality	Saline and contaminated material have been removed from the base of dam. Sediment at the base of dam complies with the levels outlined in the *Draft Guidelines for the Assessment and Remediation of Contaminated Sites in Queensland(2013)* or any later guideline.	Sediment analyses from the base of dam indicates compliance with relevant guidelines, evidence will be presented in the Final / Progressive Rehabilitation Report.
Stable	Erosion is not enhanced by the residual landform	Residual landform	The residual landform is safe, not conducive to erosion and will support the post-mining land use.	Dam inspections will be carried out in accordance with the latest version of the *Queensland Dams Manual*.
			Adequate mitigation measures have been provided to reduce the level of erosion of any reaming dam features left after decommissioning.	Assessment / demonstration of erosion potential of any remaining structures.
Sustainable Land Use	The residual landform is suitable for the surrounding environment	Soil quality	Soil $pH_{1:5}$ is 5.5 – 9.	Soils inspections will be carried out in accordance with Section 15.2 with evidence presented in the Final / Progressive Rehabilitation Report.
			Root zone salinity is less than 0.6dS/m.	
			Soil Cation Exchange Capacity is >10.	
Sustainable Land Use (continued)	The residual landform is suitable for the surrounding environment	Soil quality	Nutrient cycling / microbial processes are occurring in the soil profile.	Soils inspections will be carried out in accordance with Section 15.2 with evidence presented in Final / Progressive Rehabilitation Report.

Dams Rehabilitation Goal	Dams Rehabilitation Objective	Dams Indicators	Dams Completion Criteria	Evidence to be supplied of compliance with Completion Criteria
		Vegetation parameters	Groundcover in areas not subject to periodic inundation >70%.	Vegetation inspections will be carried out in accordance with Section 15.3 with evidence presented in Final / Progressive Rehabilitation Report.
			Groundcover has demonstrated the ability to recover from disturbance (whether by fire or grazing) by re-establishing target covers.	

11.2 Domain Specific Rehabilitation Monitoring

11.2.1 Residual Clean-Water Dams

Rehabilitation monitoring for dams to be handed back to the landholder must be undertaken once the dam has been drained of mine-affected or sediment affected water. Monitoring must include:

- Soil sampling for contaminated and saline materials to identify if they must be removed. Sampling must be completed in accordance with the Contaminated Land Assessment Guideline, Department of Environment and Heritage Protection (July 2014), The Australian Soil and Land Survey Field Handbook (Mcdonald et al. 1998), or any later guideline;
- Water quality sampling to assess water quality for comparison with local baselines and relevant standards, including ANZECC (2000) Guidelines for Primary Industries;
- An inspection of dam walls / embankment crests, and the spillway undertaken by a suitably qualified person; and
- A general inspection to ensure that the dam is fit for purpose.

11.2.2 Decommissioned Dams

Rehabilitation monitoring for decommissioned dams must include the following:

- Soil sampling for contaminated and saline materials to identify if they must be removed. Sampling must be completed in accordance with the Contaminated Land Assessment Guideline (Department of Environment and Heritage Protection, July 2014), The Australian Soil and Land Survey Field Handbook (Mcdonald et al. 1998), or any later guideline;
- Water quality sampling, if any residual water remains, to assess water quality and compare against local baselines and relevant standards including ANZECC (2000) 95% Species Protection Level Guidelines for Aquatic Ecosystems and ANZECC (2000) Guidelines for Primary Industries;
- An inspection of the residual landform undertaken by a suitably qualified person;
- Soil inspection to ensure that the area is conducive to vegetation establishment; and
- Vegetation inspection to ensure that the area is regenerating appropriately.

12 In-Pit Tailings Storage Facilities

12.1 Rehabilitation Completion Criteria

The following table outlines the requirements for the rehabilitation of the in-pit tailings storage facility, where it is not part of the final void domain. Stanmore has prepared an in-pit tailings storage facility management plan in accordance with EA condition E6, and which is based on the criteria in the table below.

Table 12-1 Rehabilitation Completion Criteria for In-Pit Tailings Storage Facilities

In-Pit TSF Goal	In-Pit TSF Objective	In-Pit TSF Indicators	In-Pit TSF Completion Criteria	Evidence Required for Completion Criteria
Long-term Safety	Structurally safe with no hazardous materials	Safety assessment of landform stability (geotechnical issues)	Certification by an appropriately qualified person that: • The land is safe for the post-mining land use. • In-pit tailings storage areas are geotechnically stable and capped with overburden material, and in accordance with mine waste management plan in Condition E6.	Suitably qualified geotechnical expert to assess that in-pit tailings storage facility are geotechnical stable, capped with overburden material and suitable for the post mine land use. Certification will be documented in rehabilitation report that slopes are safe and there is minimal risk of future failure.
		Exposure to, and availability of heavy metals and other toxic materials	Evidence (certified by an appropriately qualified person) which confirms the absence of potential for acid mine drainage from the rehabilitated landform.	It is unlikely that any acid mine drainage will occur as a result of this mining operation. Nevertheless, a risk assessment for PAF and NAF material placed within the in-pit TSF area will be conducted by a suitably qualified geochemist with evidence presented in the Final Rehabilitation Report. A risk assessment of potentially contaminated material in voids will be undertaken. If the risk assessment identified potential for contamination at receptors, soil survey and quality analyses will be carried out in accordance with Section 15.2. Testing of downstream waters will be carried out in accordance with the Receiving Environment Monitoring Programme as conditioned under C22-C24 of the EA. Testing of groundwater will be carried out in accordance with the Groundwater Management and Monitoring Programme as conditioned under C43-C49 of the EA. The historic results of this testing and any management actions resulting from this testing will be presented in the final rehabilitation management inspection.

In-Pit TSF Goal	In-Pit TSF Objective	In-Pit TSF Indicators	In-Pit TSF Completion Criteria	Evidence Required for Completion Criteria
Non-Polluting	No contamination of surface water and groundwater resources	Downstream surface water quality	Evidence (certified by an appropriately qualified person) that surface water monitoring demonstrates the quality of water in the receiving environment meets the following, as a minimum, water quality objectives: • pH 6.5-8.5 pH units • EC ≤720µS/cm • TSS ≤55mg/L • Turbidity ≤50NTU • Sulphate ≤25mg/L	Modelling will be conducted to demonstrate that there are no contaminants of potential concern from in-pit tailings to surface waters. Testing of downstream waters will be carried out in accordance with the Receiving Environment Monitoring Programme as conditioned under C22-C24 of the EA. The historic results of this testing and any management actions resulting from this testing will be presented in the Final Rehabilitation Management Inspection. Analytical results from the sampling must comply with the long-term baseline of the receiving water, be within the water quality range of long-term predictions for water quality in any residual void within the catchment, or / Queensland Water Quality / NEPC Contaminated Lands guidelines.
		Groundwater quality	Evidence which has been certified by an appropriately qualified person, that groundwater monitoring demonstrates that the groundwater quality is within 5% of the results of baseline monitoring results, or when baseline is not available, reference bores which have not been impacted by mining activities.	Modelling will be conducted to demonstrate that there are no contaminants of potential concern from in-pit tailings to potential groundwater receptors. Testing of groundwater will be carried out in accordance with the Groundwater Management and Monitoring Programme as conditioned under C43-C49 of the EA. The historic results of this testing and any management actions resulting from this testing will be presented in the final rehabilitation management inspection.

In-Pit TSF Goal	In-Pit TSF Objective	In-Pit TSF Indicators	In-Pit TSF Completion Criteria	Evidence Required for Completion Criteria
Stable	Erosion rates are appropriate for landform design	Safety assessment of landform stability (geotechnical issues)	Evidence (certified by an appropriately qualified person) that rehabilitated areas are geotechnical stable.	Geotechnical testing will analyse if the In-pit tailings storage areas is geotechnical stable. Testing will also assess if the capping material is suitable for the designated post mine land use.
		Erosion Control	Evidence (certified by an appropriately qualified person) that erosion rates of rehabilitated areas are suitable for the post mining grazing land use.	Where possible erosion ratings will be carried out in accordance with Section 15.1 with erosion rating less than or equal to 2 as per Table 15-1. Erosion rates as measured or modelled using suitable modelling methods such as RUSLE, CAESAR, SIBERIA, MINErosion, etc This information will be provided in a certification report comparing erosion losses (measured or modelled) from the vegetated in-pit tailings storage area to surrounding grazing lands. In addition, while progressive rehabilitation is being undertaken, the following criteria will be adhered to: • Areas where washouts occur do not exceed 5% of the total rehabilitation area for the site. • Each individual washout does not exceed 100m2. • No slumping or slips occur.
	Appropriate vegetation cover	Vegetation type and density	Evidence (certified by an appropriately qualified person) that the vegetation type and density of species in rehabilitated areas are suited to the soil composition, slope, aspect, climate and post mining grazing land use.	Suitable grazing reference sites have been established and monitored over several rehabilitation inspections. Within these inspections the vegetation composition and soil type has been assessed. The vegetation and soil within the vegetated in-pit tailings storage facility will be monitored

In-Pit TSF Goal	In-Pit TSF Objective	In-Pit TSF Indicators	In-Pit TSF Completion Criteria	Evidence Required for Completion Criteria
			Evidence, which has been certified by an appropriately qualified person, that the variety of vegetation species and their density in rehabilitated areas is comparable to reference sites.	and compared to these reference sites. All rehabilitated tailings storage facility areas will be inspected as they are progressively rehabilitated with the results presented in an annual rehabilitation inspection. All vegetated rehabilitated areas will be compared to reference sites on an annual basis with their suitability as a grazing land use assessed against reference site. Factors that will be compared will include: • vegetation type and density • soil composition and • landform The on-ground Inspection carried out at reference site and monitoring sites is documented in Section 14. Evidence will be presented in the Final / Progressive Rehabilitation Report. On-ground Rehabilitation Inspections will be carried out in accordance with Section 14, with evidence provided in the Final / Progressive Rehabilitation Report.
	Appropriate vegetation cover	Vegetation type and density	Evidence (certified by an appropriately qualified person) that the variety of vegetation species and their density in rehabilitated areas is comparable to reference sites.	
		Foliage cover	Evidence (certified by an appropriately qualified person) that: • Foliage and ground cover is comparable to reference sites; • Minimum of 70% ground cover is present (or 50% if rocks, logs or other features of cover are present); and • No bare surfaces >20 m2 in any area or >10 m in length down any slope ≥3.	
Sustainable Land Use	Soil properties support the nominated post mining grazing land use	Topsoil and subsoil support the proposed vegetation and land use	Evidence (certified by an appropriately qualified person) that soil properties (e.g. pH, salinity, nutrient content, sodium content) and soil characteristics (e.g. surface roughness, infiltration capacity) support the post mining grazing land use.	Suitable grazing reference sites have been established and monitored over several rehabilitation inspections. In-pit tailings storage facility vegetated areas will be monitored and compared to these reference sites.

In-Pit TSF Goal	In-Pit TSF Objective	In-Pit TSF Indicators	In-Pit TSF Completion Criteria	Evidence Required for Completion Criteria
				Rehabilitated in-pit TSF vegetated areas will be inspected as they are progressively rehabilitated with the results presented in an annual rehabilitation inspection. Rehabilitated in-pit TSF vegetated areas will be compared to reference sites on an annual basis with their suitability for a grazing land use assessed against reference site. The on-ground inspection carried out at reference site and monitoring sites is documented in Section 15.1, with evidence presented in the Final / Progressive Rehabilitation Report. The following soil chemical criteria have been adopted for the in-pit TSF vegetated areas based on several years of reference site monitoring • pH (1:5) range of soil is between 6 and 9.2 to a minimum depth of 0.45m. • Cation Exchange Capacity is greater than 9meq/100g. • Root zone salinity is less than 0.6dS/m (in a 1:5 soil water mixture). • ESP values are less than 6%. • Evidence of nutrient and organic matter cycling is occurring (this can be provided by continued sampling for organic carbon and nitrogen in the soil profile for a period of 3 years).
			Evidence (certified by an appropriately qualified person) that topsoil has been respread to a suitable depth in rehabilitated areas to sustain post-mining grazing land use.	An on-ground inspection and soil survey will be carried out on the site in accordance with Section 14. Topsoil is to be >150mm thick across vegetated areas; OR chemical analyses must indicate the vegetated area is suitable to support long-term vegetation cover and meet the required land suitability classification.

In-Pit TSF Goal	In-Pit TSF Objective	In-Pit TSF Indicators	In-Pit TSF Completion Criteria	Evidence Required for Completion Criteria
Sustainable Land Use	Establish self-sustaining grazing vegetation	Plant regeneration	Evidence (certified by an appropriately qualified person) that species in rehabilitated areas show evidence of flowering, setting viable seed, germination and emergence, and will continue to do so for the foreseeable future. For grazing land uses, a suitable grass species has established and is self-sustaining as evidenced by secondary establishment of grass species	Suitable grazing reference sites have been established and monitored over several rehabilitation inspections. In-pit tailings storage vegetated areas will be monitored and compared to these reference sites. Rehabilitated in-pit TSF vegetated areas will be inspected as they are progressively rehabilitated with the results presented in an annual rehabilitation inspection. Rehabilitated in-pit TSF vegetated areas will be compared to reference sites on an annual basis with their suitability for use as grazing land assessed against a reference site. The results of these inspections will be presented in the Final/Progressive Rehabilitation Report with vegetation survey carried out in accordance with Section 15.3 and weed management in accordance with Section 19. For grazing land uses, a suitable grazing floristic assemblage will be established and that is self-sustaining as evidenced by secondary establishment of grass species. Weed prevalence and occurrence will be no greater than reference sites. A pest management plan will document how pest animals are to be controlled on site. Stanmore will implement the recommendations of the pest management plan to ensure that pest animals are adequately controlled on the site.
		Presence of key plant species	Evidence (certified by an appropriately qualified person) that the vegetation in rehabilitated areas includes the presence of species suitable and complimentary to the post-mining land use, and are at a density and composition comparable to reference sites.	
		Density of key plant species		
		Composition of key plant species		
		Abundance of declared plants (weeds) identified through inspection. Actions taken to	Evidence, which has been certified by an appropriately qualified person, that abundance of declared weeds are no greater than reference sites and are adequately controlled on the site.	

In-Pit TSF Goal	In-Pit TSF Objective	In-Pit TSF Indicators	In-Pit TSF Completion Criteria	Evidence Required for Completion Criteria
		eradicate plants declared under State legislation.	Evidence which has been certified by an appropriately qualified person, that pest animals are adequately controlled on the site.	
	Agricultural Cattle Grazing	Land is suitable for ongoing sustained cattle grazing	Evidence, which has been certified by an appropriately qualified person, that rehabilitated areas meet the following percentage breakdown of the land suitability classification for cattle grazing as defined by the Guideline for Agricultural Land Evaluation in Queensland (State Department of Queensland 2013), or any subsequent version, and will continue to sustain these suitability classifications for the foreseeable future: • Class 4 = 100%.	A grazing trial report will outline species diversity, ground cover, health and erosion undertaken prior to and after grazing on the tailings storage facility. The grazing trial will be carried out in accordance with section 15.5 of this report These results should will be outlined in the Final Rehabilitation Report. Additionally any water sources in rehabilitation areas, that will be used for pastoral purposes, will be tested to assess the suitability for stock consumption. If the water is not suitable for stock consumption mitigation measures will be provided in a water management plan The results of these investigations will be presented in the Final/Progressive Rehabilitation Report
		Grazing Function	The areas has demonstrated an ability to recover from significant disturbance (e.g. slashing, grazing, fire) by re-establishing target covers	
		Stock access to water	Certification by an appropriately qualified person that all water sources in the rehabilitated areas provide water suitable for stock and have an EC ≤7800µS/cm.	

13 Underground

13.1 Rehabilitation Completion Criteria

Table 13-1 Rehabilitation Completion Criteria for Underground

Underground Goal	Underground Objective	Underground Indicators	Underground Completion Criteria	Evidence Required for Completion Criteria
Long-term safety	Ensure site is safe for humans and animals	Rehabilitation of subsidence impacts	Evidence in the Rehabilitation Report, certified by an appropriately qualified person, that subsidence is safe, stable, non-polluting and sustainable.	Suitably qualified expert to assess amount of subsidence and whether subsidence is safe, stable, non-polluting and sustainable.
Non-polluting	No contamination of surface water and groundwater resources	Downstream surface water quality	Evidence in the Rehabilitation Report, certified by an appropriately qualified person, that surface water monitoring demonstrates the quality of water in the receiving environment meets relevant water quality objectives.	• The quality of water generated from the area is within the baseline range for the receiving environment (i.e. Smoky Creek and Billy's Gully) or ANZECC (2000) 95% Species Protection Levels for aquatic ecosystem. • Testing of downstream waters will be carried out in accordance with the Receiving Environment Monitoring Programme as conditioned under C22-C24 of the EA. The historic results of this testing and any management actions resulting from this testing will be presented in the final rehabilitation management inspection.
		Groundwater quality	Evidence in the Rehabilitation Report, certified by an appropriately qualified person, that groundwater monitoring demonstrates that the groundwater quality is within the contaminant trigger levels specified in the EA.	Testing of groundwaters have been carried out in accordance with the Groundwater Management and Monitoring Programme as conditioned under C43-C49 of the EA. The historic results of this testing and any management actions resulting from this testing will be presented in the final rehabilitation management inspection.
Stable landform	Surface water drainage	Stabilise subsided drainage lines	Evidence in the Rehabilitation Report, certified by an appropriately qualified person that subsided sections of drainage lines will be maintained in a stable condition post-subsidence.	Suitably qualified geotechnical expert to assess amount of subsidence and whether ant areas of subsidence are stable. Suitable grazing reference sites have been established and monitored over several rehabilitation inspections. Within

Underground Goal	Underground Objective	Underground Indicators	Underground Completion Criteria	Evidence Required for Completion Criteria
	Landform achieves appropriate erosion rates	Rehabilitation of subsidence area	Evidence in the Rehabilitation Report, certified by an appropriately qualified person, that subsidence areas have been successfully revegetated (where required), by comparison to reference sites.	these inspections the vegetation composition and soil type has been assessed. The vegetation and soil at rehabilitated areas will be monitored and compared to these reference sites. All rehabilitated areas will be inspected as they are progressively rehabilitated with the results presented in an annual rehabilitation inspection. All rehabilitated areas will be compared to reference sites on an annual basis with their suitability as a grazing land use assessed against reference site. Factors that will be compared will include: • vegetation type and density • soil composition and • landform The on-ground Inspection carried out at reference site and monitoring sites is documented in Section 14. Evidence will be presented in the Final / Progressive Rehabilitation Report.
	Appropriate vegetation cover	Vegetation type and density	Evidence in the Rehabilitation Report, certified by an appropriately qualified person, that the vegetation type and density of species in rehabilitated areas are suited to the soil composition, slope, aspect, climate and agreed post mining land use.	
		Foliage Cover	Evidence in the Rehabilitation Report, certified by an appropriately qualified person, that: • Minimum of 70% ground cover is present (or 50% if rocks, logs or other features of cover are present). • No bare surfaces >20 m^2 in area or >10 m in length down slope. Foliage and ground cover is comparable to reference sites.	On-ground Rehabilitation Inspections will be carried out in accordance with Section 14, with evidence provided in the Final / Progressive Rehabilitation Report.
	Soil properties support the desired land use	Topsoil and subsoil support the proposed vegetation and land use	Evidence in the Rehabilitation Report, certified by an appropriately qualified person, that: • Soil properties (e.g. pH, salinity, nutrient content, sodium content) reflect the soil properties prior to subsidence.	• Suitable grazing reference sites have been established and monitored over several rehabilitation inspections. • Rehabilitated infrastructure areas have been monitored and compared to these reference sites. • All rehabilitated infrastructure areas will be inspected as they are progressively rehabilitated with the results presented in an annual rehabilitation inspection.

Underground Goal	Underground Objective	Underground Indicators	Underground Completion Criteria	Evidence Required for Completion Criteria
				• All rehabilitated areas will be compared to reference sites on an annual basis with their suitability for a grazing land use assessed against reference site. • The on-ground Inspection carried out at reference site and monitoring sites is documented in Section 14 and evidence will be presented in the Final / Progressive Rehabilitation Report. The following soil chemical criteria have been adopted for the site based on several years of monitoring at grazing reference sites. • pH(1:5) range of soil is between 6 and 9.2 to a minimum depth of 0.45m. • Cation Exchange Capacity greater than 9meq/100g. • Root zone salinity is less than 0.6dS/m (in a 1:5 soil water mixture). • ESP values are less than 6 % Evidence of nutrient and organic matter cycling is occurring (this can be provided by continued sampling for organic carbon and nitrogen in the soil profile for a period of 3yrs).
	Agricultural cattle grazing	Land is suitable for cattle grazing	Evidence in the Rehabilitation Report, certified by an appropriately qualified person, that rehabilitated areas, at a minimum, meet the comparable reference sites suitability classification for cattle grazing as defined by the Guideline for Agricultural Land Evaluation in Queensland (State Department of Queensland 2013), or any subsequent version, and will continue to sustain the suitability classification for the foreseeable future.	Rehabilitated infrastructure areas will be assessed against the land suitability framework for the Inland Fitzroy and Southern Burdekin area which is outlined in the Regional Land Suitability Frameworks for Queensland (2013) The results of these investigation will be outlined in the Final/Progressive Rehabilitation Report
		Plant regeneration		A grazing trial report will outline species diversity, ground cover, health and erosion undertaken prior to and after grazing on the infrastructure areas. The grazing trial will be carried out in accordance with section 15.5 of this report. These results will be outlined in the Final Rehabilitation Report.

Underground Goal	Underground Objective	Underground Indicators	Underground Completion Criteria	Evidence Required for Completion Criteria
		Presence of key grazing species		For grazing land uses, a suitable grazing floristic assemblage will be established that is self-sustaining as evidenced by secondary establishment of grass species.
		Composition of key grazing species		
		Actions taken to eradicate plants declared under local or state legislation		Weed prevalence and occurrence will be no greater than reference sites. A pest management plan will document how pest animals are to be controlled on site. Stanmore will implement the recommendations of the pest management plan to ensure that pest animals are adequately controlled on the site
		Landform stable when grazed	Evidence in the Rehabilitation Report, certified by an appropriately qualified person, that land maintenance requirements are comparable to reference sites.	A grazing trial report will outline species diversity, ground cover, health and erosion undertaken prior to and after grazing on the infrastructure areas. The grazing trial will be carried out in accordance with section 15.5 of this report. These results will be outlined in the Final Rehabilitation Report.

14 Progressive Rehabilitation and Closure Schedule

A schedule of progressive rehabilitation and closure, based on the expected requirements of a PRCP Schedule has been prepared for IPC. This schedule provides a schedule of rehabilitation milestones for areas where a post mine land use is proposed, and a schedule of management milestones for areas where a non-use management area is proposed. The terminology used in this section (e.g. post mine land use and non-use management area) mirrors that in the draft PRCP Guideline; however it must be recognised that this terminology does not apply to EA amendments or land outcome documents provided before PRCP start date. IPC has been separated into the following areas for this purpose:

- Areas with a post mining land use associated with historical mining activities on ML 70342.
- Areas with a post mining land use associated with mining on the IPE MLs, including infrastructure linkages on ML 70342.
- Non-use management areas (i.e. residual voids) associated with mining on ML 70342.
- Non-use management areas (i.e. residual voids) associated with mining on IPE MLs.

Underground mining is predicted to result in minimal subsidence (due to the bord and pillar mining method) and hence there is not predicted to be any change in the land use of areas above underground mine workings. All infrastructure associated with underground mining is within the footprint of open cut mining and is therefore included in the progressive rehabilitation schedule for those areas. Therefore a separate progressive rehabilitation schedule for underground mining is not required.

A series of figures illustrating proposed progressive rehabilitation and closure at different stages of mining is provided below for:

- 2020, which aligns with the current plan of operations
- 2024, with active mining operations on the IPE MLs, and progressive rehabilitation in progress
- 2028, at the end of life of open cut mining operations
- 2033, with progressive rehabilitation active in all open cut mining areas on IPE MLs, underground mining active, and IPE open cut residual voids at final landform
- 2038, following final rehabilitation in all open cut areas, except active infrastructure, tailings management and water management areas on IPM, and underground mining activities having ceased
- 2043, following final decommissioning and rehabilitation of all infrastructure and tailings management areas, and IPM open cut residual voids at final landform.

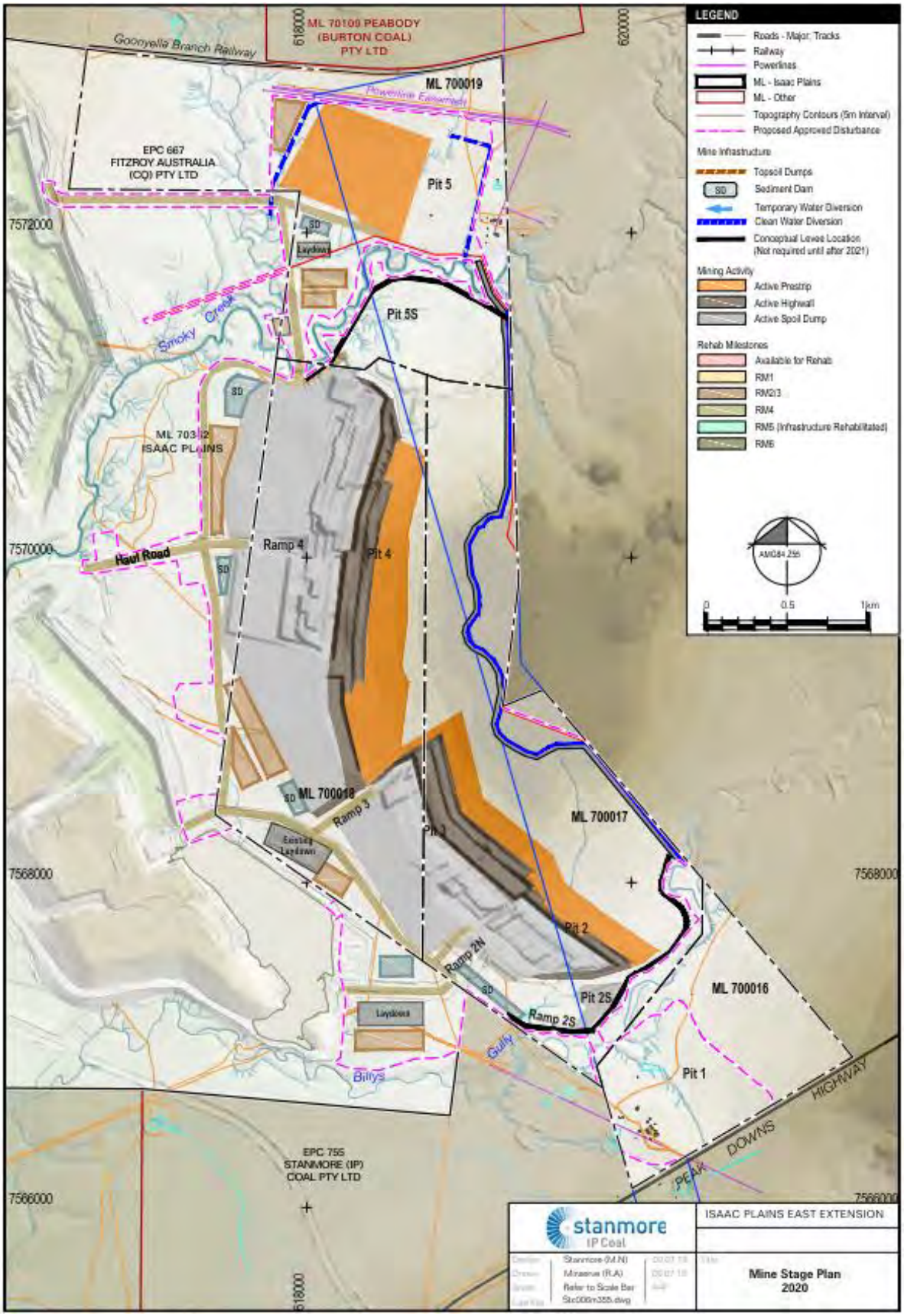

Figure 14-1 IPE MLs Rehabilitation 2020

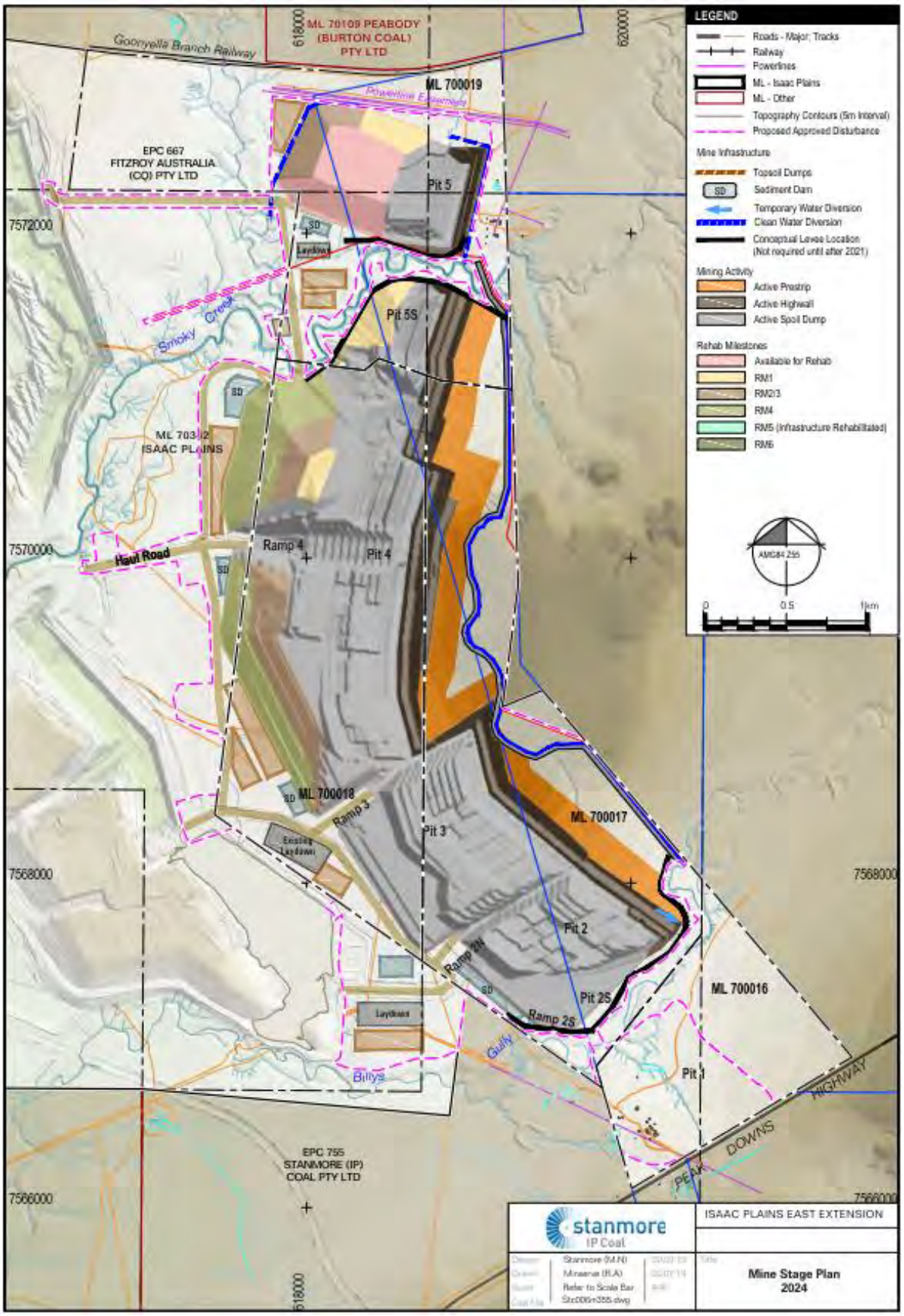

Figure 14-2 IPE MLs Rehabilitation 2024

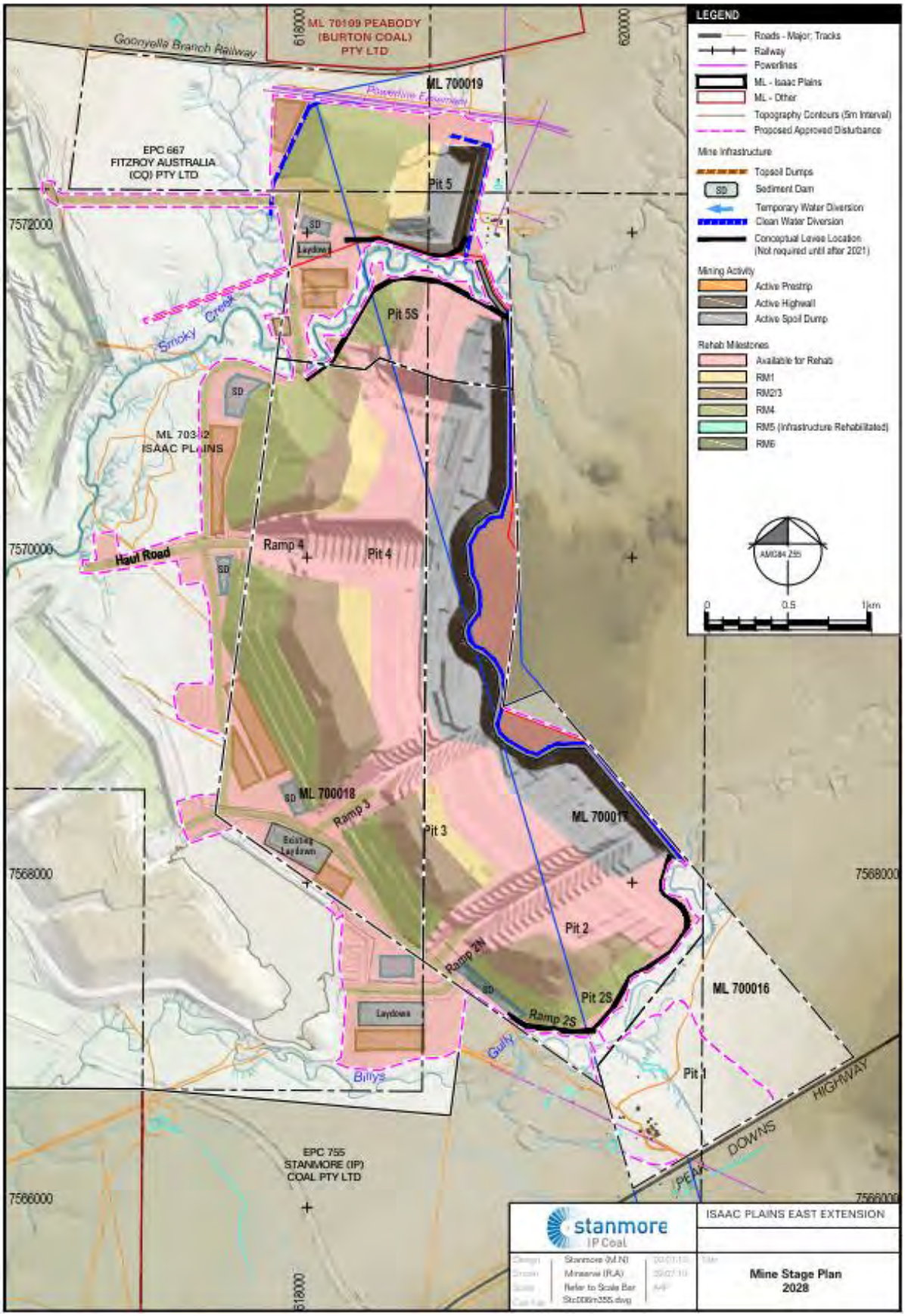

Figure 14-3 IPE MLs Rehabilitation 2028

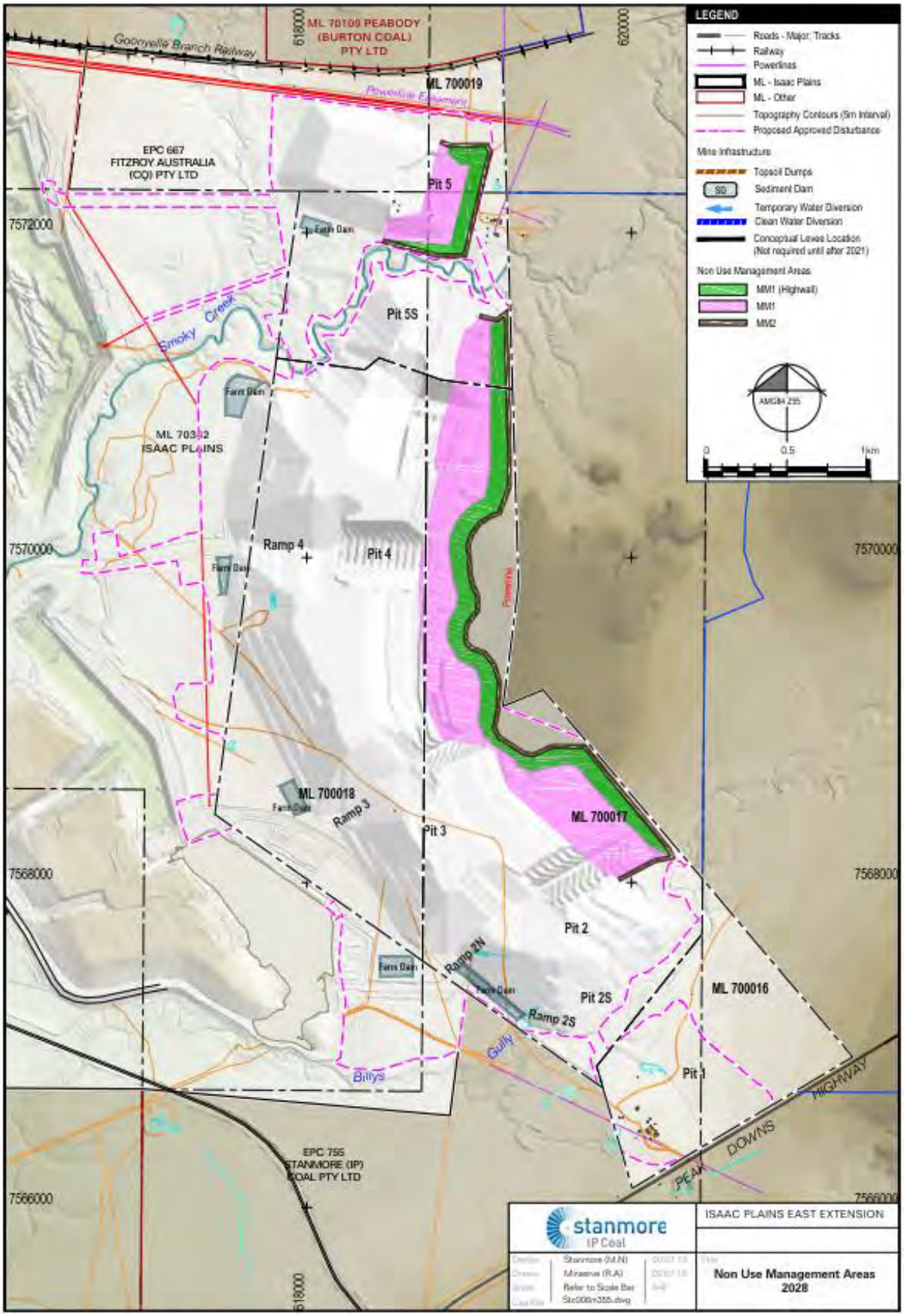

Figure 14-4 IPE MLs Non-Use Areas 2028

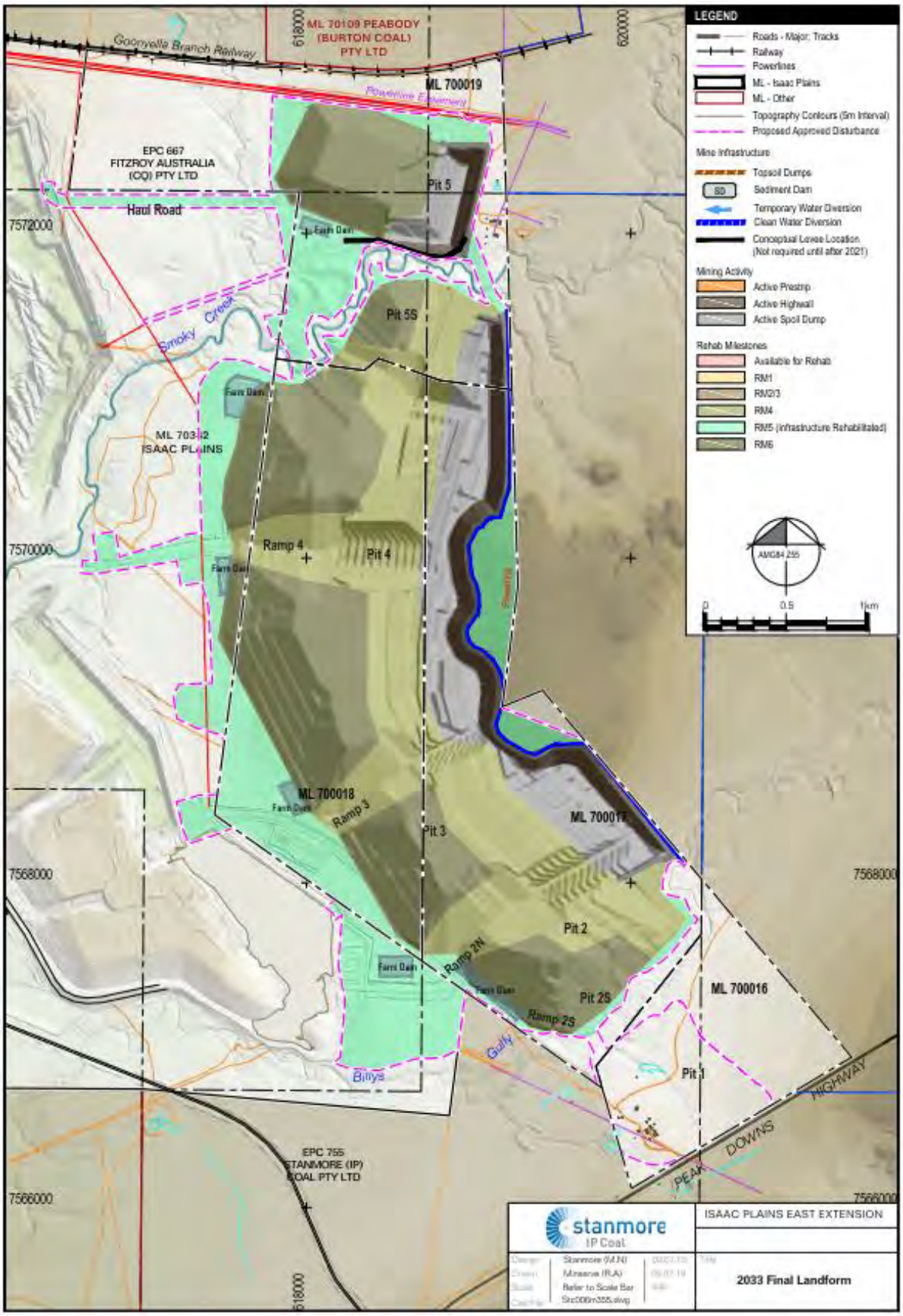

Figure 14-5 IPE MLs Rehabilitation 2033

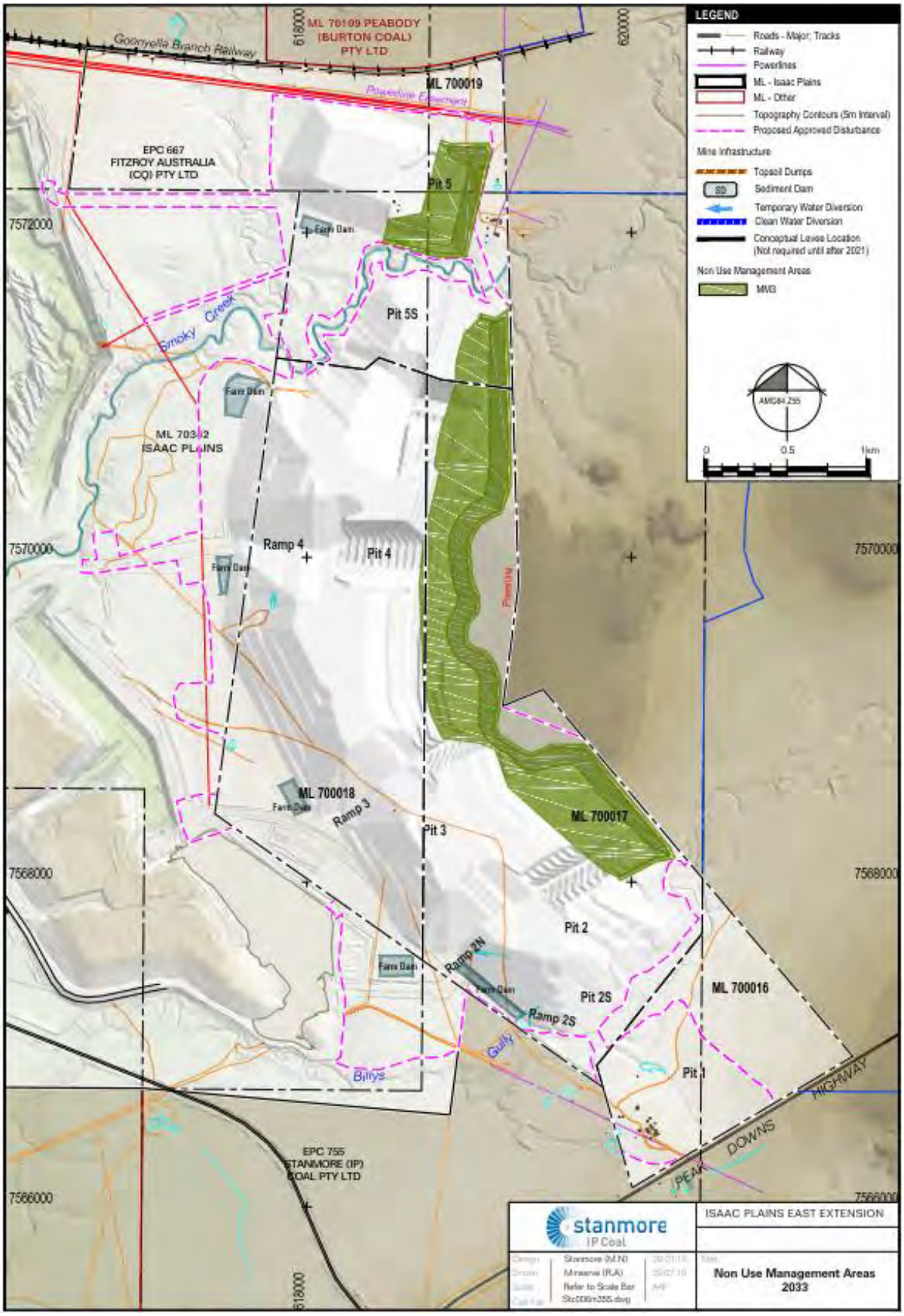

Figure 14-6 IPE MLs Non-Use Areas 2033

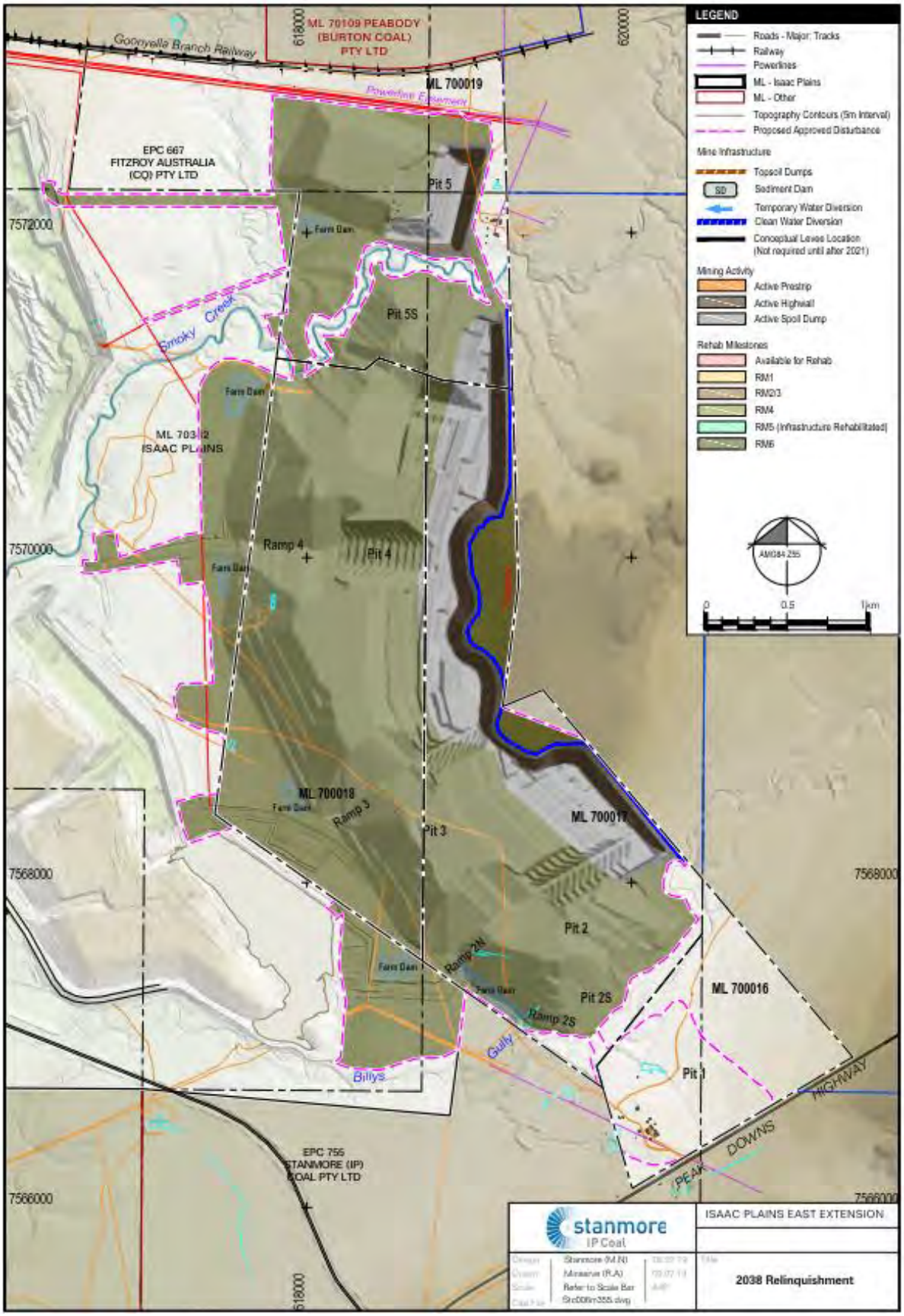

Figure 14-7 IPE MLs Rehabilitation 2038

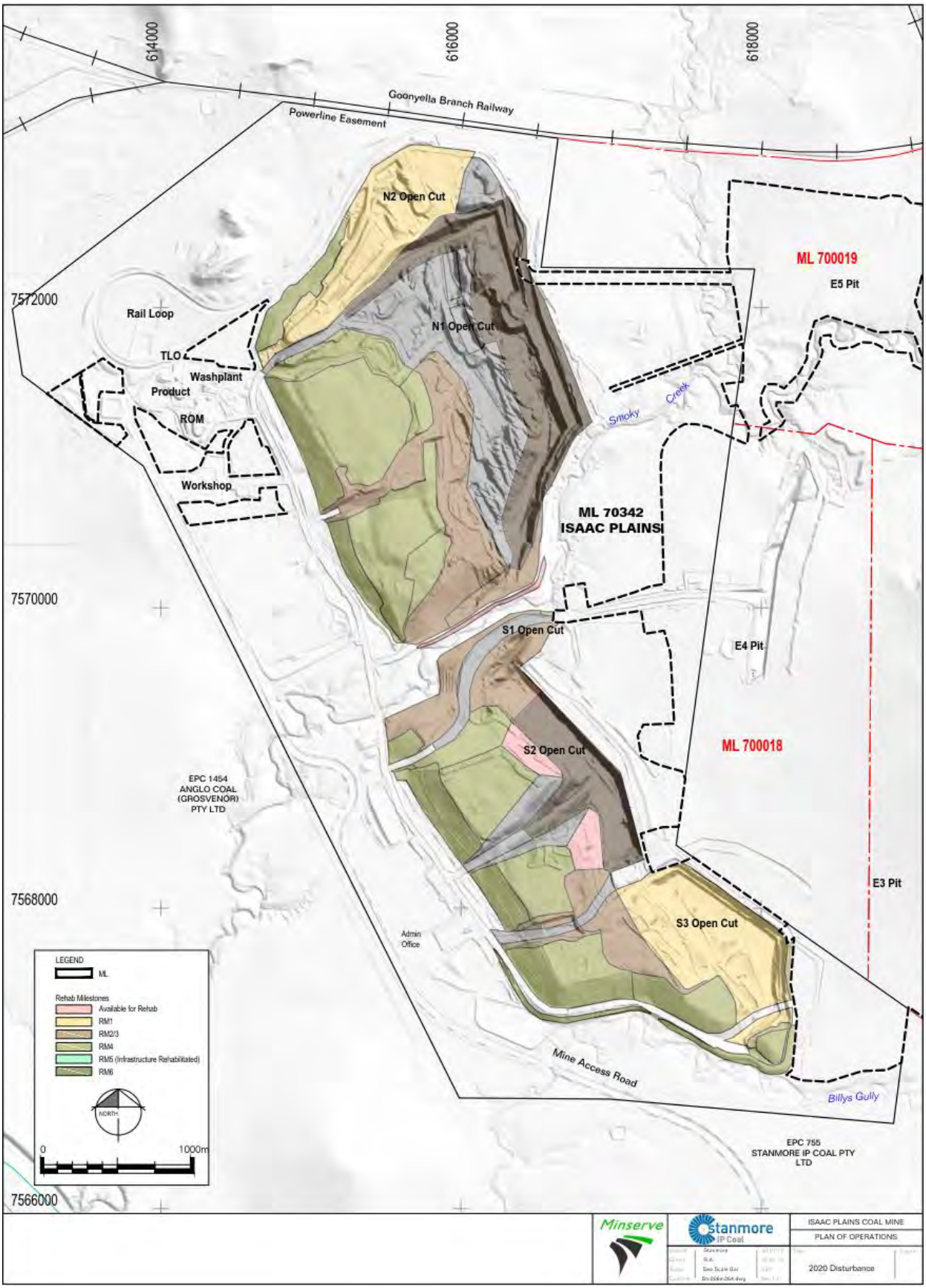

Figure 14-8 ML 70342 Rehabilitation 2020

Figure 14-9 ML 70342 Rehabilitation 2024

Figure 14-10 ML 70342 Rehabilitation 2028

Figure 14-11 ML 70342 Rehabilitation 2033

Figure 14-12 ML 70342 Rehabilitation 2038

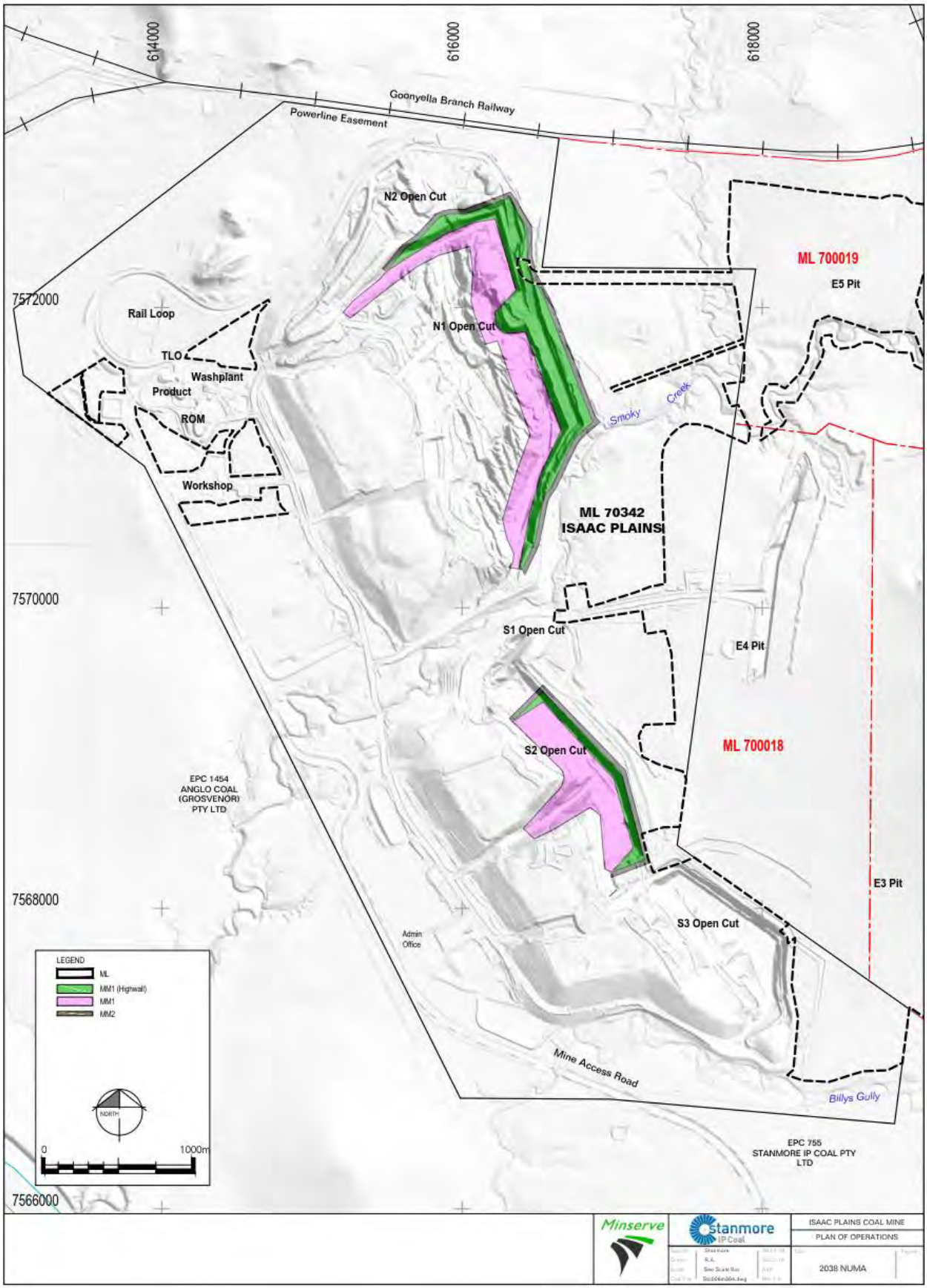

Figure 14-13 ML 70342 Non-Use Areas 2038

Figure 14-14 ML 70342 Rehabilitation 2043

Figure 14-15 ML 70342 Non-Use Area 2043

A schedule of progressive rehabilitation, based on the expected requirements of a PRCP Schedule is provided in:

- Table 14-1 for mining activities on ML 70342 with a post mining land use
- Table 14-2 for non-use management areas on ML 70342
- Table 14-3 for mining activities on IPE MLs with a post mining land use
- Table 14-4 for non-use management areas on IPE MLs

Rehabilitation milestones, applicable to all rehabilitation areas with a post mine land use are provided in Table 14-5. Management milestones, applicable to all improvement areas are provided in Table 14-6.

Table 14-1 ML 70342 Post Mine Land Use

Rehabilitation area				RA 1 - IPM				
Disturbance type				Open cut mine and associated infrastructure				
Reference map				Figures in Section 14 of RMP				
Total size (ha)								1070.6
Commencement of first milestone								02-Jan-20
Area available	02-Jan-20	02-Jan-24	02-Jan-28	01-Jan-33	01-Jan-38	01-Jan-43		
Cumulative size (ha)	570.5	570.6	581.1	581.1	707.2	1070.6		
Milestone reference	**Cumulative size rehabilitated (ha)**							
Milestone completed	31-Dec-20	31-Dec-24	31-Dec-28	31-Dec-33	31-Dec-38	31-Dec-43		
PMLU			Grazing					
Description of PMLU (optional)			Pasture					
PMLU size (ha)								1070.6
RM1	554.7	567.8	570.5	581.1	591.8	1070.6		
RM2	422.4	537.3	570.5	581.1	591.8	1070.6		
RM3	422.4	537.3	570.5	581.1	591.8	1070.6		
RM4	282.9	488.9	570.5	581.1	591.8	1070.6		
RM5	0	0	0	0	363.4	1070.6		
RM6	0	281.5	524.2	570.5	591.8	1070.6		
Total area of rehabilitation commenced	554.7	567.8	570.5	581.1	591.8	1070.6		

Table 14-2 ML 70342 Non-use Management Areas

Improvement area				IA1						
Disturbance type				Pits N1, S2						
Reference map				Figures in Section 14 of RMP						
Total size (ha)										141.5
Commencement of first milestone										31-Dec-37
Area available	01-Jan-38	01-Jan-43								
Cumulative size (ha)	73									
Milestone reference	**Cumulative size rehabilitated (ha)**									
Milestone completed	31-Dec-38	31-Dec-43								
NUMA	Residual void									
NUMA size (ha)										141.5
MM1	55.8									
MM2	17.2									
MM3		141.5								

Table 14-3 IPE Post Mine Land Use

Rehabilitation area				RA 1 - IPE						
Disturbance type				Open cut mine and associated infrastructure						
Reference map				Figures in Section 14 of RMP						
Total size (ha)										905.1
Commencement of first milestone										02-Jan-20
Area available	02-Jan-20	02-Jan-24	02-Jan-28	01-Jan-33	01-Jan-38					
Cumulative size (ha)	0	148.4	906.2	601.5	905.1					
Milestone reference	**Cumulative size rehabilitated (ha)**									
Milestone completed	31-Dec-20	31-Dec-24	31-Dec-28	31-Dec-33	31-Dec-38					
PMLU			Grazing							
Description of PMLU (optional)			Pasture							
PMLU size (ha)										905.1
RM1	0	117.6	337.8	601.5	905.1					
RM2	0	98	284.2	601.5	905.1					
RM3	0	98	284.2	601.5	905.1					
RM4	0	52.6	175.1	601.5	905.1					
RM5	0	0	0	303.6	905.1					
RM6	0	0	0	337.9	905.1					
PMLU										
Total area of rehabilitation commenced	0	117.6	337.8	601.5	905.1					

Table 14-4 IPE Non-use Management Areas

Improvement area			IA1							
Disturbance type			Pits 2, 3, 4, 5							
Reference map			Figures in Section 14 of RMP							
Total size (ha)										156.5
Commencement of first milestone										31-Dec-28
Area available	02-Jan-28	01-Jan-33	01-Jan-38							
Cumulative size (ha)	63.7	156.5	156.5							
Milestone reference	**Cumulative size rehabilitated (ha)**									
Milestone completed	31-Dec-28	31-Dec-33	31-Dec-38							
NUMA	Residual void									
NUMA size (ha)										156.5
MM1	47.9									
MM2	15.8									
MM3		156.5	156.5							

Table 14-5 Rehabilitation Milestones

Milestone reference	Rehabilitation milestone	Milestone criteria
RM1	Landform development and re-shaping/re-profiling	Engineered dump design plans prepared in accordance with approvals requirements and any internal design standards (e.g. geotechnical stability)
		Bulk earthworks completed to achieve design in engineered design plans
		Landform surveyed to asses compliance with engineered design plan
RM2	Surface preparation / topsoiling	Placement of >150 mm of topsoil.
		Addition of any soil ameliorants, as required.
		An assessment of soil health and suitability has been completed by an appropriately qualified person to confirm soil is suitable for target vegetation establishment.
RM3		Seeding requirements identified through revegetation plan.

	Revegetation / seeding (grazing)	Completed seeding of target species for grazing at a kg/ha rate defined in revegetation plan.
RM4	Achievement of surface requirements (grazing)	Revegetation growth, including biomass and species composition, to be defined in revegetation plan.
		Groundcover biomass % defined in revegetation plan for consecutive years
		Revegetation % comparable to analogue grazing site defined in Rehabilitation Monitoring Plan
		Weeds are a maximum % of groundcover, as defined in revegetation plan
		No active areas of rill or gully erosion and drainage follows appropriate drainage paths
		Resilience to fire can be demonstrated
RM5	Infrastructure decommissioning and rehabilitation	Disconnect and terminate infrastructure services, unless agreed with landholder to retain
		Decommission dams, including removal and in-pit disposal of any water and contaminated sediment, unless agreed with landholder to retain
		Demolish and remove buildings
		Remove bitumen, blue metal, aggregate on roads and laydown areas
		Undertake contaminated land investigations as per the NEPM
		Removal / or onsite-treatment of contaminated water i.e. affected by hydrocarbons, mine affected water
		Removal and appropriate disposal of contaminated materials of contaminated soil and/or on-site remediation of hydrocarbon contaminated soils
		Conduct validation testing to confirm that contaminated soils have been removed/remediated
		Landform modifications to achieve stable landform
		Surface preparation and topsoiling (as per RM2)
		Revegetation and seeding (as per RM3)
		Achievement of surface requirements (grazing) (as per RM4)
RM6	Achievement of final land use (grazing)	As per Table 8-1, Table 10-1, Table 11-1, Table 11-2, Table 12-1, and Table 13-1 of this RMP

Table 14-6 Management Milestones

Milestone reference	Milestone description	Milestone criteria
MM1	High wall treatment	High walls battered to a maximum slope as defined in RMP.
MM2	Fencing, bunding and signage	Fencing to erected around the perimeter of the high wall / end wall
		Warning signage posted around the perimeter of the high wall / end wall
		Safety bund constructed in accordance with engineering requirements for height, based and crest width
MM3	Sufficient improvement of the area	As per Table 9-1 of this RMP

15 General Monitoring

15.1 Land Survey

Rehabilitation areas will be inspected for erosion rills, erosion gullies, signs of slumping or failure and topsoil depth to determine their erosion rating (Table 15-1). These observations must be made along transects based on the following protocols:

- Two 50m transects along the contour are required for every 25ha of rehabilitated area. Discretion should be used in determining the number of transects required for smaller areas.
- Where relevant transects should be made at the mid-slope on steep lands if possible.
- A minimum overlap of 15m along the slope is acceptable for transects in any one small rehabilitation area.

Table 15-1 Erosion Rating System

Erosion Rating	Rills per transect	Average depth of rills	Topsoil depth	General observations
0	0 - 3	<10cm	>90% of original depth	Generally little erosion. The majority of rills are <10cm depth.
1	2 - 6	<20cm	>75% of original depth	Minimal instances of sheet-wash and gully erosion.
2	3 - 8	<50cm	>50% of original depth	Minimal-moderate erosion occurring but limited to localised areas.
3	4+	>50cm	>40% of original depth	Moderate erosion occurring.
4	4+	any >80cm depth	>30% of original depth	Heavy erosion occurring.

A generalised inspection of each rehabilitated area for surface cracks, rills >1m depth and areas of bare spoil (washouts) should be undertaken in addition to the transects. This can be accomplished by a walkover of the rehabilitated areas or if possible drones could be used. The purpose of the inspection is to document significant erosion that may not be present inside the transect (i.e. major gullies). Where a washout is encountered, an estimate must be made of its area. If multiple washouts are encountered, an estimate of the percentage of the rehabilitation area disturbed by washouts must be made (i.e. 5%). Within the Annual Rehabilitation Report the results of each transect must be presented with additional areas of significant erosion documented.

During the land survey, factors for suitable erosion modelling should also be gathered (such as RUSLE modelling). Measurement of soil loss must also occur. There are several methods to measure soil loss from spoil dumps, including:

- Establish survey pegs at regular intervals in receiving sediment dams, drains or benches. The top of the survey pegs, and the intersection with the ground is then surveyed and recorded with a RTK GPS to accurately determine the elevation of the top of the peg. The distance from the top of the peg to its intersection with the sediment at its base will provide a volume estimate of the amount of sediment in the bench / drain / dam. Repeating measurements at each inspection will enable the volume of sediment lost over time to be quantified.
- Undertake high-resolution topographic surveys along the contour during rehabilitation inspections. These surveys must be able to detect changes in rill dimensions (i.e. depth and width) over successive years. Rill dimensions must not change by large degrees (i.e. mm scale) year to year. Therefore, the survey method must be able to detect these changes, especially in areas of high grass cover.
- Excavate small pits at the base of the slope and install survey pegs as outlined in Suggestion 1. Measure after each rainfall event.
- Install flumes in areas of concentrated runoff and measure water levels via an automatic water level sensor.

15.2 Soil Survey

For each rehabilitation area requiring monitoring, soil analyses are required to confirm factors outlined in the completion criteria. Soil sampling would include:

- One soil sampling site per 25ha inspected. If numerous <25ha areas are inspected, one soil sampling site for each area inspected is required.
- At each site the depth of the soil profile should be noted with samples collected from 0cm, 10cm, 20cm and 50cm depth.
- Soil samples should be analysed at a NATA accredited laboratory for the following:
    - pH & EC;
    - Total soluble salts;
    - Nutrients (ammonia, total nitrogen, and total phosphorous);
    - Metals (aluminium, arsenic, barium, boron cadmium, chromium [Cr total], copper, iron, lead, manganese, nickel, uranium & zinc);
    - Exchangeable sodium percentage;
    - Cation exchange capacity and exchangeable cations / anions;
    - Sodium adsorption ratio;
    - Dispersivity (such as Emerson ratings);
    - Total Organic Matter and Total Organic Carbon; and
    - Carbon : Nitrogen Ratio.

While all of the above parameters are not required under the completion criteria, they are useful to determine soil health and ability of the soil to support plant growth. The consistent collection and analysis of soil samples over several years develops a useful time-series outlining the processes occurring in, and interactions between, soil and vegetation.

The ratio of carbon (total organic carbon) to nitrogen (total nitrogen, percentage by weight) is useful to determine the capacity of the soil to support microbial populations. Comparison to reference site data will determine when conditions are suitable and meet the surrounding areas. This is a requirement under the completion criteria.

Soil analyses of nominated soil reference sites must also be undertaken. Analysis results from rehabilitated lands are compared to the results from rehabilitation reference sites to identify areas of deficiency. Comparison of soil quality data between rehabilitation sites and reference sites can then be used to assess soil processes.

15.3 Vegetation Survey

For each designated rehabilitation area a 50m by 10m belt transect must be sighted. Each belt transect must be surveyed as follows:

- Ten random quadrats (1m2) analysing overall vegetation cover, percentage dry matter cover, percentage vegetation cover, percentage soil cover, and ground cover species composition.
- Trees / bushes, if any, identified to a species level.

This information is required to assess the completion criteria predominantly the amount, type and composition of cover present. Some of the completion criteria will have to be extrapolated from these selected data or high-resolution aerial photographs. Any signs of adverse health conditions should be noted. Fauna use of the rehabilitation areas should also be noted. All vegetation surveys should be completed in accordance with the Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland (Neldner et al. 2012).

Where an area will be, or has been, subject to grazing trials, the same methodology should be used to inspect the area pre-grazing and post-grazing to ensure information is comparable. This relates to the location of transects, number of surveys and survey effort.

15.4 Water Survey

Samples should be taken of seepage zones (soil samples) and / or residual pools (water samples) observed during inspection at the top of spoil dumps or within benches. The soil and / or water samples should be analysed for the parameters outlined in Table 15-2.

Table 15-2 Analytical Parameters for Seepage Zones

Parameter / Analyte	Water	Soil	Both
Physical parameters	Suspended solids and turbidity	Total soluble salts	pH & EC
Major Cations and anions	-	-	Alkalinity as $CaCO_3$, chloride, sulphate as SO_4^{2-}, calcium, magnesium, sodium and potassium
Metals	Dissolved and total parameters outlined in 'both'	-	Aluminium, arsenic, barium, beryllium, cadmium, cobalt, chromium, copper, manganese,

Parameter / Analyte	Water	Soil	Both
			nickel, lead, vanadium, zinc, molybdenum, selenium, silver, uranium, boron, iron, fluoride and mercury
Nutrients	-	-	Ammonia as N, nitrite as N, nitrate as N, Total N and Total P
Organics	-	Total Organic Carbon and Total Organic Matter	-

15.5 Grazing Trial

As part of this RMP a grazing trial in accordance with EA condition F11 is proposed. Condition F11 states: Grazing trials must be conducted on ML70342 to inform the final rehabilitation outcomes for overburden emplacement areas to achieve a safe, stable and a non-polluting landform with a sustainable final land use of grazing.

The exact details of the grazing trial cannot be finalised at this stage as current mining operations and rehabilitation activities will impede, or render unsafe, the trial in the immediate future. The overburden emplacement areas associated with N1, N2 and S3 are in close proximity to the designated haul road to the CHPP. In addition, trials should be conducted in areas that are close to achieving their designated rehabilitation goals. The designated overburden emplacement area land use is grazing. Before grazing trials can begin an assessment of the overburden emplacement area against the current rehabilitation criteria will be conducted. Grazing trials can commence in areas where rehabilitation objectives have been met and here mining operations do not impact access or safety.

Additionally to the EA F11 requirement, the completion criteria for all domains with a post mine land use of grazing calls for evidence that shows: The areas have demonstrated an ability to recover from significant disturbance (e.g. slashing, grazing, fire) by re-establishing target covers. The following outlines the grazing trials that will be carried out to assess the viability of grazing on all rehabilitated lands that have a designated post mine land use of grazing.

Trials will consist of comparing naturally undisturbed areas (non-mine affected, previously cleared, cattle grazing lands) with fully rehabilitated overburden emplacement areas. Prior to the trials taking place, an area that has been rehabilitated should be designated with the size of the area dependent on the amount of rehabilitation area available, but should be between 10-20 ha. Previous investigation as a result of annual rehabilitation have shown that the estimated standing pasture yield on the rehabilitated sites are higher than the reference sites. This has been assessed using the grass check estimated staning pasture yield method. To make a valid comparison the amount of available pasture for grazing should be comparable at both sites. Therefore, an area of non-mine affected land of the same size as the trial site (i.e. between 10-20 ha) should be allocated as a control. Before the trial can begin the available pasture within both sites (the control and the rehabilitates area) must be comparable. This may mean the control site will need to be excluded from grazing until the available pasture yield is similar to that of the rehabilitation site.

The amount of available pasture should be estimated using pasture rulers or 'sticks'. Results recorded using these devices are converted to an estimate of kg green DM/ha via lookup tables. The method for estimating the kg green DM/ha is available from the Meat and Livestock Australia website (http://mbfp.mla.com.au/Pasture-growth/Tool-27-Field-based-pasture-measurements). Before grazing trials can begin both the control and rehabilitation site must have between 2000-3000 Kg/DM/Ha

In addition to the estimation of available pasture an assessment of the vegetation composition, soil and land within both the control and rehabilitation site should be conducted using the method outlined in Section 15.1.

After the initial site surveys have been conducted the stocking rate for the trial can be determined. The stocking rate will be calculated using the Meat and Livestock Australia stocking rate calculator https://www.mla.com.au/extension-training-and-tools/tools-calculators/stocking-rate-calculator/. The stocking rate will depend on the type of grazing animal (i.e. type of cattle), the size of area allocated to the trial, and the initial Kg/DM/Ha. The time the cattle can be present within the areas will be variable as the amount of pasture present at the end of grazing will be allocated at 1200 KgDM/Ha.

As an example, if 10 ha of land is allocated with an available pasture of 3000 KgDM/Ha with an end target after 30 days of 1200 KgDM/Ha the stocking rate will be:

- Fifty 400kg live weight steers
- Seventy five 200kg live weight steers

As there is significant variability in the quantity of cattle needed, the stocking rate can only be determined when all variables are known.

On removal of the cattle a vegetation assessment must be carried out to determine if grazing rates are comparable within both plots. If the grazing rates are comparable the plots should be left ungrazed. Both plots should then be assessed after the next wet season assessing vegetation composition, soil and land, using the method outlined in Section 15.1. Comparisons can then be made between grazing on rehabilitated mining land and local unaffected pasture land. This process will need to be repeated in the same plots for at least 3 consecutive years.

The proposed grazing trial has focused on comparing rehabilitated land with nearby unaffected pasture. The results of this study should be presented in a stand-alone document but also incorporated into the Annual Rehabilitation Inspection.

It should be noted that allocation or method to assess the health of the cattle, or pasture suitability for consumption within each of the plots, has not been proposed.

16 Monitoring Sites

The existing and proposed rehabilitation reference sites and monitoring sites are described in the Rehabilitation Monitoring Program.

17 Mine Waste Characterisation and Management

Geochemical testing of the overburden materials is undertaken in accordance with the Isaac Plains Mine Waste Management Plan, prepared in accordance with the EA conditions of the time.

Condition E6 of the current EA states: A Mining Waste Management Plan must be developed and implemented by an appropriately qualified person for every stage of the mining activities. The Mining Waste Management Plan must be submitted to the administering authority by 29 June 2018 for review and comment.

A mine waste management plan for overburden and in-pit tailings storage facilities will be submitted to DES by 29 June 2018 in accordance with EA condition E6. The mine waste management plans will describe the geochemistry of overburden and tailings / rejects, potential risks from acid mine drainage (if any), potential risks to groundwater, and seepage and leachate management, as required.

Geochemical information has been obtained at various times during the mine's life and includes the findings of historical and recent geochemical analyses of overburden and rejects by Geo-Environmental Management (GEM) in 2005 and Terrenus Earth Science in 2017.

18 Soil Management

IPC has an existing Topsoil Management Plan which it is currently using. Soils stripping depths have been nominated for soils within the IPC located on ML 70342, and for the IPE MLs, which are similar based on similar soil profiles. The topsoil inventory provided in the 2019 plan of operations indicates that there is a net topsoil surplus for use in rehabilitation. The following is a summary of key points that are to be implemented across all areas of the IPC.

Measures to be adopted during stripping of topsoil include:

- Disturbance areas will be stripped progressively ahead of mining operations
- Soil stripping plans will be developed showing the depth of topsoil to be stripped to ensure that all suitable materials are salvaged and that the quality of stripped soil is not reduced through contamination with unsuitable soils. The requirements for soil to be used within rehabilitation are:
    - pH(1:5) range of soil is between 6 – 9.
    - Electrical conductivity is less than 0.6dS/m (in a 1:5 soil water mixture).
    - Exchangeable sodium percent values are less than 6 %
    - Cation Exchange Capacity greater than 9meq/100g
- Drainage will be diverted around stockpiles to prevent erosion
- Sediment control in accordance with the Erosion and Sediment Control Plan will be installed downstream of the stockpiles to collect any washed sediment
- Topsoil stockpiles will be formed in mounds up to a maximum height of approximately 3 m consistent with the storage area available

- Soil stockpiles will be clearly signposted for easy identification and to avoid any inadvertent losses
- Establishment of weeds on the stockpiles will also be monitored and controlled: and
- An inventory of available material, including soil types, will be maintained to ensure adequate materials are available for planned rehabilitation activities.

Measures to be adopted during respreading topsoil include:

- Mine rehabilitation planning will include balancing the topsoil and subsoil quantities required for rehabilitation against stored stockpile inventories. Topsoil used in rehabilitation will be applied in accordance with the specifications in the Topsoil Management Plan
- Soil material will be re-spread in even layers at a thickness appropriate for the intended land use of the area to be rehabilitated and volume of soil available, to a minimum thickness to 150 mm; and
- Soils will be selectively placed, with more erodible materials being placed on flatter areas in order to minimise erosion.

Soil loss from rehabilitated areas will be minimised through:

- Contour ripping to encourage rainfall infiltration and minimise runoff
- Reseeding soon after re-spreading to establish a vegetation cover as early as possible; and
- Installing collection drains and sediment dams to collect runoff and control suspended sediment.

The following erosion and sediment control measures will be implemented during the project to conserve the soil resources on the project site:

- Vegetation clearing will be conducted progressively so that the minimum area necessary for construction and operations is cleared at any time
- Runoff from higher areas will be directed around disturbed areas
- Runoff from bare earthworks areas will be collected in drains and directed through sediment traps and settling
- Ponds to control suspended sediment prior to discharge from the site
- Earthworks batters will be constructed to stable slopes and re-vegetated soon after construction; and
- Earthworks areas will be landscaped and re-vegetated as soon as possible after construction is completed.

19 Weed Management

Weed infestation within rehabilitated areas and areas disturbed by mining activities is low within the IPC. Minor occurrences of Parthenium (*Parthenium hysterophorus*) have been observed on rehabilitated waste rock piles with significantly greater infestation in areas that have been recently disturbed for grazing practices. Although these infestations are not a direct result of mining activities, they have the potential to impact rehabilitated areas. Harissa cactus *(Harrisia tortuosa*) and Prickly pear (*Opuntia stricta*) occur in low densities throughout the 'lowland plains' of the IPC. These are only sporadic

occurrences of isolated individuals. Proactive management of weeds across the whole site is recommended.

19.1 Weed Management Performance Objectives and Indicators

The performance targets and indicators for the control of weeds over the project site are as follows:

- To control and eliminate weed species;
- To ensure no new weed species are introduced into the project area as a result of mining activities; and
- To minimise the areas of disturbance and to rehabilitate areas that will not have future mining use as soon as possible to control the spread of weeds.

19.2 Weed Management Operational Control

Activities conducted at the site have the potential to introduce and spread weeds. Weeds can be spread through:

- The transfer of seeds via tyres and tracks via inadequate vehicle hygiene
- Use of non-designated tracks and roads, and
- Uncontrolled personnel and vehicle access to site.

To ensure that performance objectives are met the following weed management strategies have been developed for the site.

All personnel, contractors and visitors shall access the site via the main access and haul roads, unless otherwise authorized.

Only personnel, contractors and visitors authorized by the site officer shall be permitted to travel off the designated roads and tracks (e.g. light vehicle and drill rigs for exploration activities).

Weed surveys/observations shall be to identify, record and map the control/movement of declared weeds over the mine site.

All weed control methods employed shall be recorded including details of:

- date of treatment;
- extent of treatment areas;
- method(s) used;
- application rates for any herbicides used;
- reference to appropriate control guidelines; and
- monitoring for successful control methods.

All machinery and vehicles to be brought onto site from unknown areas or known infested areas shall be cleaned prior to entry to the mine site.

Inspections and vehicle wash-downs shall be conducted on machinery and vehicles involved in clearing/construction activities and those operating outside of designated roads during mine operation.

Grazing over the Mining Leases shall be suitably managed, to allow grass species to more effectively out-compete Parthenium.

Land clearing shall only be undertaken in areas that are necessary for mining activities.

Topsoil stockpiles shall be located away from mining activities and high risk weed areas where they will not be disturbed, until required for rehabilitation activities.

Areas that have no future use shall be rehabilitated as soon as practicable after mining to reduce potential for the spread of weeds.

Once rehabilitated areas have been topsoiled, selected exotic competitive species (e.g. Buffel grass) and available native species shall be applied in accordance with the rehabilitation/topsoil management plan to provide competition to the weeds.

Approval shall be obtained from the site Environmental Officer prior to accessing any restricted weed infestation areas over the project site.

Materials such as soil, sand, gravel, mulches etc shall be sourced from areas that are free of declared plants. Weed declaration documentation shall be obtained from suppliers for the product provided and documentation must be recorded.

Appropriate training of all site staff and contractors shall be provided as required.

Any neighbouring landowners shall be notified if the IPC experiences a weed infestation which may affect the neighbouring property.

19.3 Weed Infestation Control Methods

A combined range of methods to control weed infestations may be implemented as required:

- Herbicide/Chemical Control,
- Mechanical Control,
- Biological Control; and
- Revegetation.

Ongoing and/or long-term follow-up control is usually always required.

Table 16 outlines specific control methods for the primary weed species recognised at the site

Table 19-1 Control Methods for the Primary Weed Species

Weed	Method	Timing	Follow Up

Parthenium	Herbicide such as atrazine, glyphosate, metsulfuron methyl (seedlings only). Use of a knockdown herbicide should kill existing plants and a residual herbicide to control future germinations.	Best results achieved when plants are small before they set seed (i.e. at 'rosette stage'). Treat small and / or isolated infestations first.	Repeated spraying may be required within one growing season to prevent further seed production
Harrisia	Chemical control e.g. metsulfuron; spray to run-off point.	When plant is actively growing.	A follow-up treatment may be necessary.
Prickly Pear	Herbicide e.g. picloram and Triclopyr using basal bark / cut stump and/or apply as a thorough foliage spray.	When actively growing in spring and summer is best.	Follow-up treatment may be needed.

19.4 Monitoring

The following monitoring is undertaken to assist with weed management:

- Invasive plant inspections shall be conducted and site records and mapped weed areas shall be updated accordingly (on an as required basis associated with care and maintenance status);
- Annual rehabilitation inspection, including observations of any weed occurrences;
- Any observations of invasive plant species shall be documented.

19.5 Rehabilitation Monitoring & Corrective Actions

The requirements for rehabilitation monitoring at the IPC have been outlined for each domain. Rehabilitation monitoring methods are similar across the various Domains, with most areas requiring a land survey, soil survey, vegetation survey and water survey of similar extent.

Rehabilitation inspection and monitoring will take place each year across the site and include inspections of rehabilitated areas. The annual rehabilitation inspection is the first step in assessing the success of rehabilitation monitoring results for each domain, and are currently reported in separate sections of the Annual Rehabilitation Inspection Report (and this should continue for future Rehabilitation Inspections and Monitoring Reports). An annual collation and summary of all monitoring information and subsequent assessment against completion criteria, will be used to assess the trajectory of each domain towards achieving acceptable rehabilitation outcomes.

Every reasonable effort will be made to ensure that Stanmore Coal will be compliant with the rehabilitation objectives outlined within the EA and this document. If monitoring identifies that individual areas or whole domains are not progressing towards successful rehabilitation within the designated time frame as stipulated within the EA, then management actions to address issues will be formulated. These management action will be formulated on a case by case basis dependent on the

type of corrective action needed. Any corrective actions and the success of those corrective actions will be documented in subsequent rehabilitation inspections or site specific reports.

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APPENDIX J FINAL VOID GEOTECHNICAL ASSESSMENT (IPC)

STANMORE RESOURCES LIMITED

GEOTECHNICAL ASSESSMENT OF ISAAC PLAINS COMPLEX FINAL VOIDS FOR REHABILITATION PURPOSES

September 2022

GeoTek Solutions Pty Ltd
ABN 84 090 367 409

STANMORE RESOURCES LIMITED

GEOTECHNICAL ASSESSMENT OF ISAAC PLAINS COMPLEX FINAL VOIDS FOR REHABILITATION PURPOSES

September 2022

GeoTek Solutions Pty Ltd
Report Ref.: gts-ipc-220910-PRCP-geotech-v0.2
September 2022

Issue	Date	Author	Reviewed	Distribution	Comment
v0.1	30/08/22	B Smallwood	P Maconochie	Andrew Hadfield	
v0.2	10/09/22	B Smallwood	P Maconochie	Andrew Hadfield	Modify cross section N1-1 Additional analyses for N1-3 Add FOS discussion

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SUMMARY

The nominated target geotechnical factor of safety (FOS) for the final voids landforms is 1.5.

The current ground surface, including the existing voids approximates the proposed final landform proposed for relinquishment. A series of stability analyses was undertaken to check the existing FOSs of the existing voids and where the calculated FOS did not achieve 1.5 alternative scenarios were tested to achieve the target.

All of the highwalls in fresh rock achieved a FOS ≥ 1.5.

Over steepened, highly weathered and soil horizons at the top of highwalls typically have FOS values < 1.5. However, these horizons are usually just a few metres thick. They have been excavated to batter angles of around 45° and could be re-shaped or be allowed to erode back to a geotechnically stable slope of around 27° (1V in 2H).

All of the overburden dumps in which the base of the spoil is not inundated by a final void lake have critical FOS values ≥ 1.5.

All of the overburden dumps in which the base of the spoil is inundated have a critical FOS <1.5. Alternative geometries have been analysed that would achieve a critical FOS of 1.5. Any of the solutions would require extensive movement of spoil.

Although outside of original consideration, a simple numerical analysis has been undertaken on cross section IPE-2-2 and this demonstrates that while the FOS is 1.38 the amount of movement expected due to softening of the spoil due to inundation is less than a metre. It is recommended to carry out more comprehensive numerical modelling with a view to managing the internal spoils by deformation rather than by an arbitrary Factor of Safety.

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LIST OF ABBREVIATIONS

FOS	Factor of Safey
ID	Isaac Downs
IP	Isaac Plains
IPC	Isaac Plains Complex
IPE	Isaac Plains East
PRCP	Progressive Rehabilitation and Closure Plan
SRF	Strength Reduction Factor (numerical analysis analogue for FOS)
Stanmore	Stanmore Resources Ltd

1 INTRODUCTION

The Isaac Plains coal mine complex (IPC) is located approximately 170 km southwest of Mackay. It consists of the Isaac Plains (IP), Isaac Plains East (IPE) and Isaac Downs (ID) mines. IP and IPE are substantially complete and are being re-shaped to final landform designs.

This report presents the results of stability analyses of the final landforms. The work has been carried out to check for geotechnical factors of safety (FOS) and, where the calculated FOS is less than 1.5, to provide suggestions to achieve appropriate stability factors in accordance with the requirements of the Progressive Rehabilitation and Closure Plan (PRCP). From a FOS perspective, the critical landforms are spoil dumps which become submerged and saturated by final voids lakes

Twenty-three cross sections were analysed. The cross sections are located within IP pits N1, S2 and S3 and IPE pits 2 to 4. Their locations are shown in Figure 1.

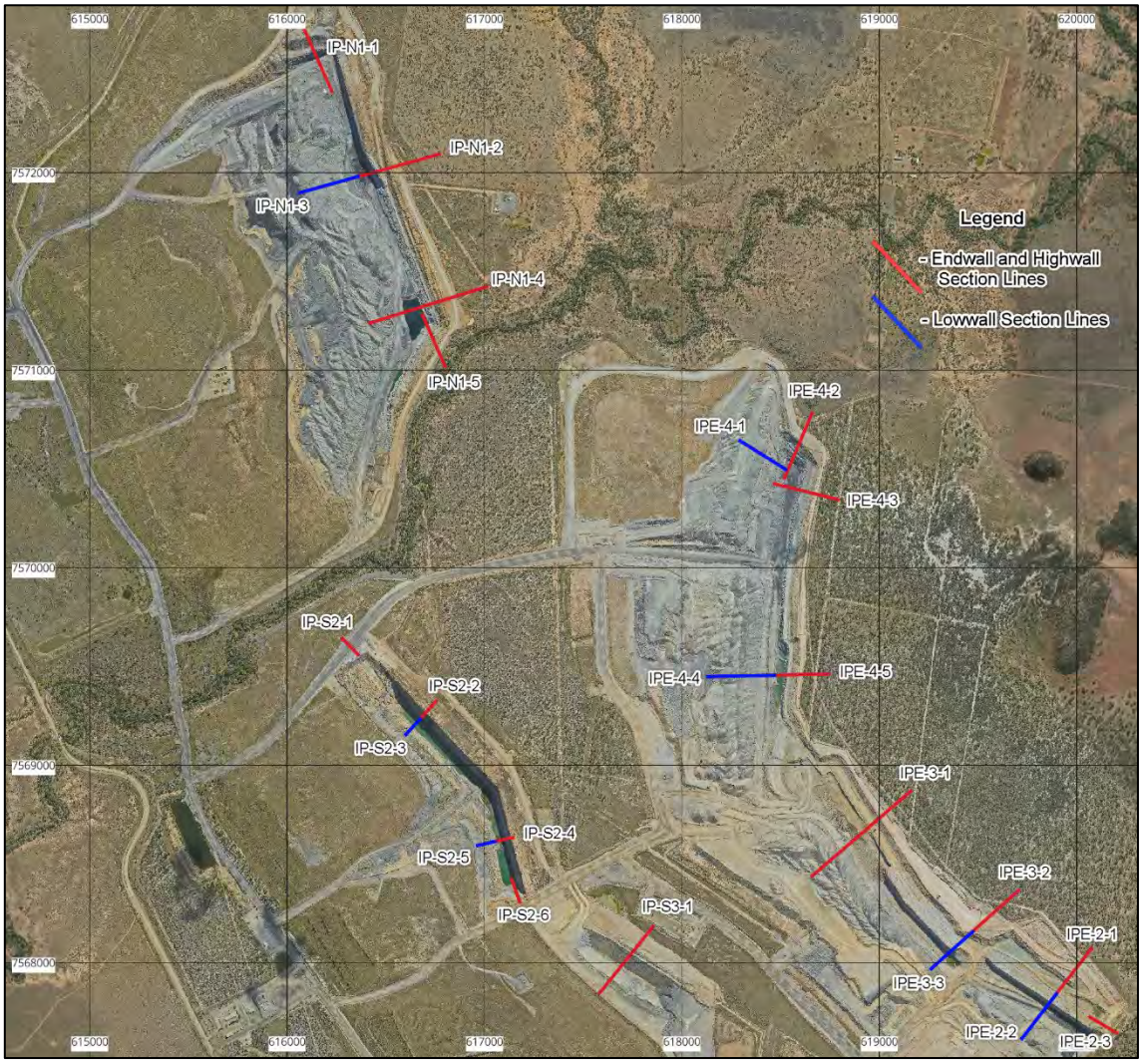


Figure 1. Plan of IP and IPE showing locations of cross sections analysed for stability (AMG84z55_24-May-2021, photo courtesy of Stanmore Resources).

2 GEOLOGY

The target coal at IP and IPE has been the Leichhardt Seam. It occurs within the upper Permian age Rangal Coal Measures. A simple stratigraphy is presented in Figure 2.

The Vermont Seam occurs at varying depths beneath the Leichhardt Seam and the Vermont Seam is divided into the Vermont Upper and Vermont Lower, separated by the Yarrabee Tuff (YT). The YT is not ubiquitous having been eroded from some areas, presumably soon after it had been deposited as an ash fall.

The Leichhardt overburden consists mainly of siltstone with interbedded sandstone. A massive claystone bed is often taken to mark the upper limit of the Permian strata and the sandstone above the claystone marker horizon is assigned to the Triassic Rewan Group.

There is a veneer of unconsolidated Cenozoic sediments. Localised Tertiary age basalt occurs, notably at the southern end of IPE Pit.

The Isaac Plains Thrust subcrops between IPCM and IPE. It is a regional east-over-west thrust fault with a throw in the order of 200 metres. It is probably an extension of the larger Burton Range Thrust. Apart from some faults, the strata dip gently towards the east at angles of around 4°: This configuration has favoured the use of a dragline for overburden removal.

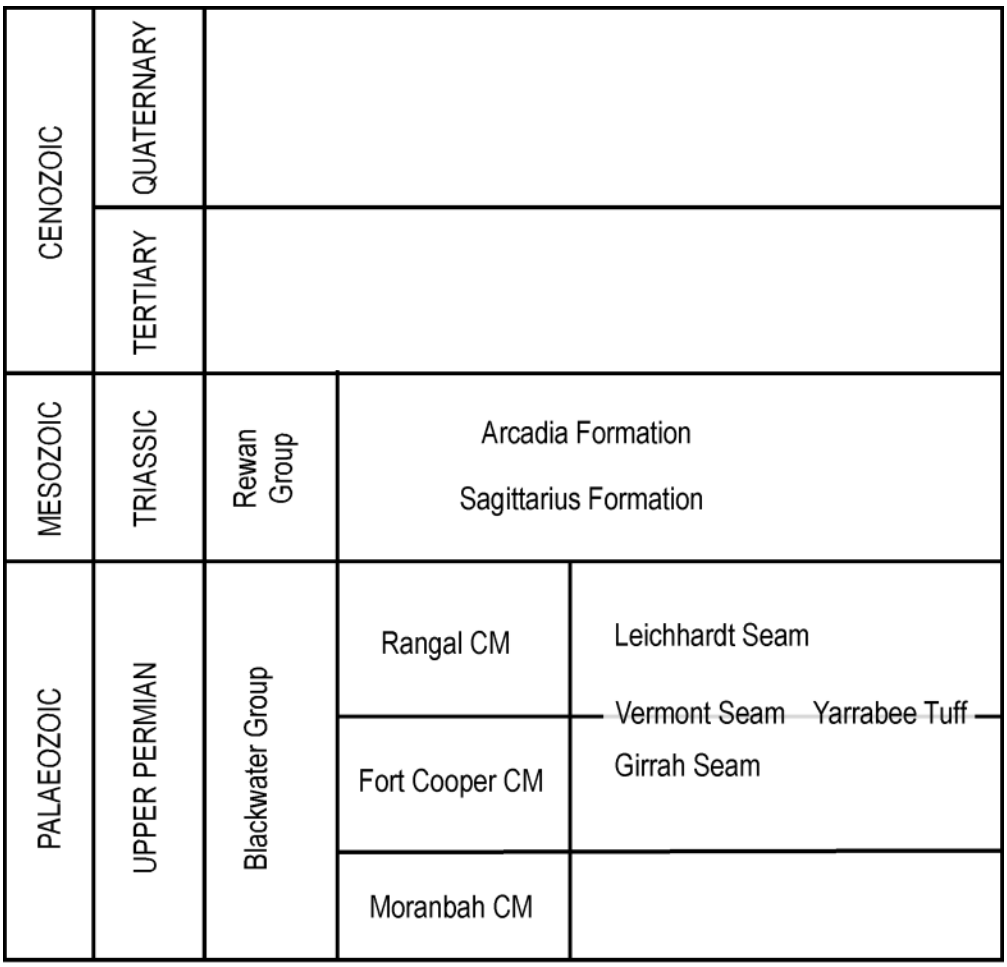


Figure 2. Generic stratigraphy for the Isaac Plains project.

3 FINAL VOIDS WATER LEVELS

WRM Water (2020) carried out a groundwater assessment for the final voids which predicted ranges of long-term water level in each of the voids. These are shown in Table 1. No analysis was provided for IP-S3, presumably because originally it was planned to backfill the void. Since that is no longer the case it has been assumed that the water level in IP-S3 will be the same as in IP-S2.

For the purposes of the stability analyses the estimated maximum water levels after 100 years have been used in the stability analyses.

Table 1. Summary of predicted long term water levels.

Pit Void	100 Years Water Level (m AHD)		
	Minimum	Mean	Maximum
IP-N1	204	207	210
IP-S2	155	162.5	170
IP-S3	155	162.5	170
IPE-2 & 3	175	182.5	190
IPE-Pit 4	155	162.5	170

All the pits were originally designed with a target FOS ≥ 1.2 for both the highwalls and lowwalls. This is standard industry practice (Wesseloo and Read, 2009).

Quarterly inspections carried out by GeoTek Solutions since 2012 have confirmed that both lowwalls and highwalls have performed to expectation.

The lowwalls have remained stable overall but have eroded where they have remained unvegetated and exposed to intense rainfall. The highwalls have remained stable overall. The finer grained strata in the Leichhardt overburden have weathered and undercut more resistant bands of sandstone resulting in some blocks of sandstone dropping out of the highwalls. This is likely to continue. The upper horizons of highly weathered rock and unconsolidated sediments have eroded causing their slope angles to retreat to longer term stable angles of around 30 to 35°.

In the absence of any major structure the fresh sedimentary strata exposed in the highwalls are considered to be stable with FOS values normally in excess of 1.5 to 1.8 because of the high strength of the strata. The finer grained lithologies exposed in the highwalls are susceptible to weathering and in the long term the weathering will undercut more resistant bands of sandstone but will not detract from overall stability. The upper strata consist of highly weathered in situ rock and/or unconsolidated sediments and are likely to be susceptible to circular modes of failure, particularly where the batters have been cut at steep angles which is common.

4 STABILITY ANALYSIS METHOD

Geological grids and topography triangulations were provided by Stanmore. The surface topography files are:

- 210330_N1_GRABEN.00t
- 160829_ips_ascon_s2_topo.00t
- 191120_ips_ascon_s3.00t
- 220717_IPE_2_3_4_UPDATE.00t

23 cross sections were created along the existing pit voids in IP and IPE as shown in Figure 1.

The cross sections were digitized and imported into the industry standard 2D limit equilibrium slope stability program Slide2 v9 (Rocscience, 2022).

Shear strength values for the various horizons are based substantially on Simmons and McManus, 2004, extensive prior experience at the Isaac Plains Complex and more broadly from across the Bowen Basin. Table 2 shows the material properties used in the stability analyses.

Table 2. Material properties used in the stability analyses.

Material Name	Colour	Unit Weight (kN/m^3)	Strength Type	Cohesion (kPa)	Friction (deg)	Water Surface	Hu Type
Cat 2.5 U Spoil		18	Mohr-Coulomb	40	29	Water Surface	Automatically Calculated
Cat 2.5 S Spoil		20	Mohr-Coulomb	17.5	24	Water Surface	Automatically Calculated
Cat 3U Spoil		18	Mohr-Coulomb	50	30	Water Surface	Automatically Calculated
Cat 3S Spoil		20	Mohr-Coulomb	20	25	Water Surface	Automatically Calculated
HW Sedimentary Rock		20	Mohr-Coulomb	30	27	Water Surface	Automatically Calculated
DW Sedimentary Rock		22	Mohr-Coulomb	100	30	Water Surface	Automatically Calculated
FR Sedimentary Rock		24	Mohr-Coulomb	450	42	Water Surface	Automatically Calculated
FR Coal		15	Mohr-Coulomb	30	35	Water Surface	Automatically Calculated
Weak Layer		20	Mohr-Coulomb	5	12	Water Surface	Automatically Calculated
DW Sedimentary Rock Blasted		22	Mohr-Coulomb	40	30	Water Surface	Automatically Calculated
FR Sedimentary Rock Blasted		22	Mohr-Coulomb	100	30	Water Surface	Automatically Calculated

U=Unsaturated; S=Saturated; FR=Fresh; DW=Distinctly Weathered; HW=Highly Weathered

Existing dumps have been characterised as comprised of Cat 2.5 spoil. Any remedial buttresses have been assigned Cat 3 spoil properties.

Spoil failures during production are most likely wedge type failure on a weak basal plane. Once the spoil becomes inundated within a final void lake, circular failure is considered the more likely mode of failure and this method of analysis has been used for the spoil.

Circular failure analysis was also used for the highwalls. It is recognised that this is imperfect but in the absence of alternative practical options is considered to be reasonable and the method has been used many times previously to provide indicative stability factors for highwalls.

The circular failure surfaces were generated using the GLE/Morgenstern-Price (GLE/M-P) method of analysis and the search for the critical surfaces was carried out using the Auto Refine search method that is embedded in Slide2. Searches were also run using the Auto Grid search method as a check for the integrity of the results and, as expected, almost identical results were obtained from both search methods in terms of identification of the critical failure surface and its FOS.

5 SUMMARY OF FOS RESULTS

The results of the stability analyses are summarised in Table 3. Results have been colour coded as:

- FOS <1.19 red
- FOS 1.20 – 1.49 orange
- FOS ≥ 1.5 green

Table 3 shows the FOS calculated for the existing geometry and where the FOS did not achieve a value of 1.5 the existing geometry was modified.

In the case of waste dumps, the existing profiles were modified by adding a buttress and/or a reducing the slope angles until a value ≥ 1.5 was achieved. It was found that adding a buttress was not sufficient to reach the desired FOS of 1.50. Consequently, combinations of regrading and buttressing were tested until a FOS ≥ 1.50 was achieved.

In the case of highwalls the issue was primarily within the over-steepened soil and highly weathered horizons. These can be remediated by flattening the horizon to 27° or by allowing sufficient space for the ground to erode to this angle. Exclusion bunds or fences would need to be set far enough back from the existing crest to allow for such crest retreat.

Selected output plots displaying the results are presented in Section 6 below.

Table 3. Summary of the critical FOS values.

Section Line	Water Level (mAHD)	Model Profile	FOS
N1			
IP-N1-1	210	Existing Endwall	1.66
IP-N1-2	210	Existing Highwall	2.37
IP-N1-3	210	Existing Lowwall	1.01
		Cat 3 Lower Buttress: 29 m High, 11 m Wide (25°) Cat 3 Upper Buttress: 20 m High, 28 m Wide (37°)	1.22
		Cat 3 Lower Buttress: 24 m High, 26 m Wide (30°) Cat 3 Middle Buttress: 29 m High, 11 m Wide (25°) Cat 3 Upper Buttress: 20 m High, 28 m Wide (37°)	1.37
		Cat 3 Buttress: 66 m High, 35 m Wide (22°)	1.50
		Regrade to 18°	1.62
IP-N1-4	210	Existing Highwall	2.28
IP-N1-5	210	Existing Endwall	2.02
S2			
IP-S2-1	170	Existing Endwall	3.22
IP-S2-2	170	Existing Highwall	1.58
IP-S2-3	170	Existing Lowwall	1.03
		Cat 3 Buttress: 11 m High, 30 m Wide (37°)	1.22
		Cat 3 Buttress: 23 m High, 20 m Wide (37°)	1.32
		Cat 3 Buttress: 18 m High, 34 m Wide (37°); with a 23° slope angle (regrade) above buttress	1.56
		Regrade to 23°	1.49
IP-S2-4	170	Existing Highwall	1.68
IP-S2-5	170	Existing Lowwall	1.21
		Cat 3 Buttress: 32 m High, 25 m Wide (36°) – Cut back existing slope face to 43°	1.20
		Cat 3 Lower Buttress: 17 m High, 15 m Wide (37°) Cat 3 Upper Buttress: 17 m High, 13 m Wide (35°) – Cut back existing slope face to 49°	1.48
		Cat 3 Lower Buttress: 17 m High, 15 m Wide (37°) Cat 3 Upper Buttress: 17 m High, 20 m Wide (39°) – Cut back existing slope face to 46° with 10 m bench in Cat 2.5 spoil immediately behind the upper buttress with a 27° batter (regrade) above the upper buttress	1.50
		Regrade to 23°	1.52
IP-S2-6	170	Existing Endwall	1.51

Section Line	Water Level (mAHD)	Model Profile	FOS
S3			
IP-S3-1	170	Highwall side: existing spoil geometry	1.22
		Highwall side: spoil level increased by 17 m to RL170m.	1.45
		Highwall side spoil level increased by 27m to RL180m.	1.45
		Lowwall side: existing spoil geometry.	1.17
		Lowwall side: spoil level increased by 17 m to RL170m.	1.51
		Lowwall side spoil level increased by 27m to RL180m.	1.64
IPE			
IPE-2-1	190	Existing Highwall	2.97
IPE-2-2	190	Existing Lowwall	1.38
		Cat 3 Buttress: 10 m High, 10 m Wide (37°)	1.45
		Cat 3 Buttress: 10 m High, 20 m Wide (37°)	1.55
		Regrade to 25°	1.57
IPE-2-3	190	Existing Endwall	2.47
IPE-3-1	190	Existing Highwall	2.27
IPE-3-2	190	Existing Highwall	2.04
IPE-3-3	190	Existing Lowwall	1.68
IPE-4-1	170	Existing Lowwall: lower level	1.62
	170	Existing Lowwall: upper level	1.74
IPE-4-2	170	Existing Endwall	2.20
IPE-4-3	170	Existing Highwall	2.59
IPE-4-4	170	Eastern spoil batter	1.54
		Eastern internal spoil batter	1.62
		Western internal spoil batter	1.68
IPE-4-5	170	Existing Highwall	2.27

6 DISCUSSION OF INDIVIDUAL RESULTS

In the following sub-sections, the results for individual pits are discussed and alternative designs presented to achieve FOS ≥ 1.5.

6.1 IP-N1-1

The existing highwall has a minimum calculated FOS = 1.66. This meets the minimum required FOS ≥ 1.5. Over time it is expected that the existing batter of approximately 41° will erode back to around 27° but without any significant consequences.

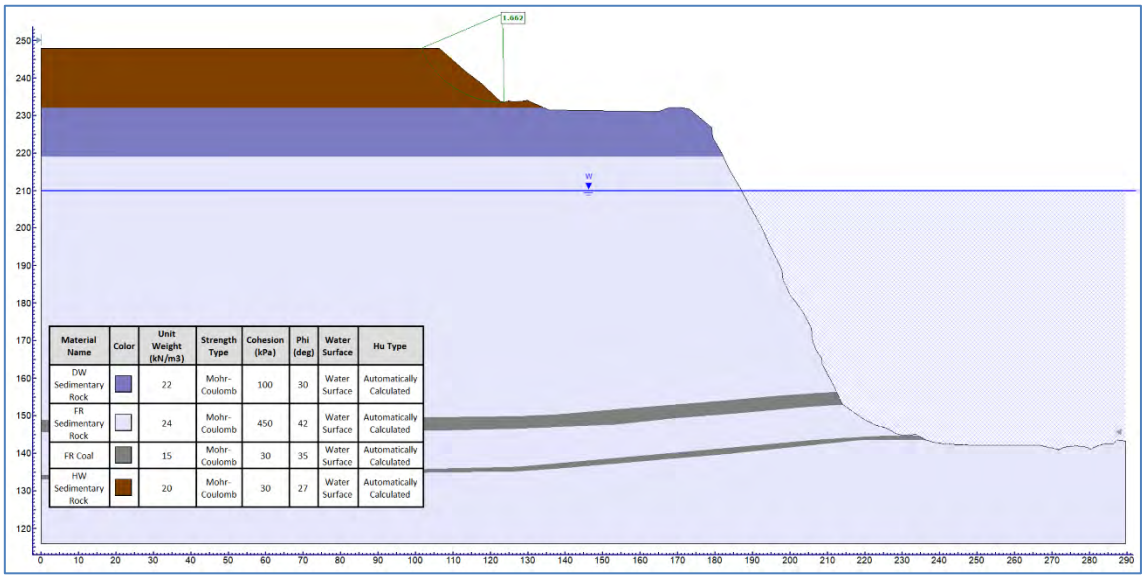


Figure 3. IP-N1-1 Existing final endwall geometry, calculated FOS = 1.66.

6.2 IP-N1-2

The existing highwall has a minimum calculated FOS = 2.37. This meets the minimum required FOS ≥ 1.5.

The upper stratum of highly weathered sedimentary rock has FOS = 2.90. Over time it is expected that the existing batter of approximately 43° will erode back to around 27°.

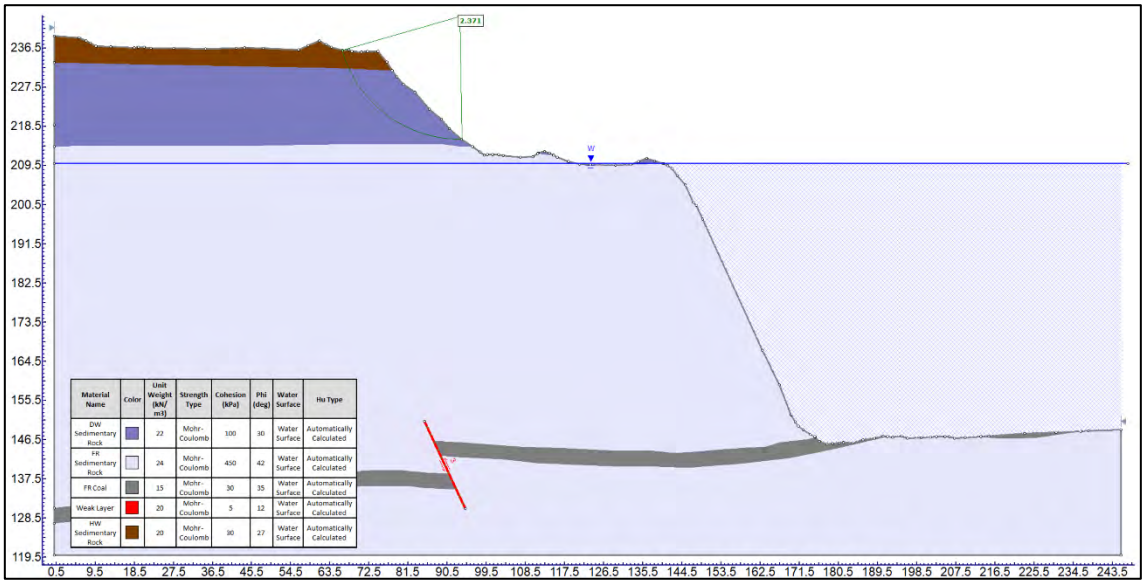
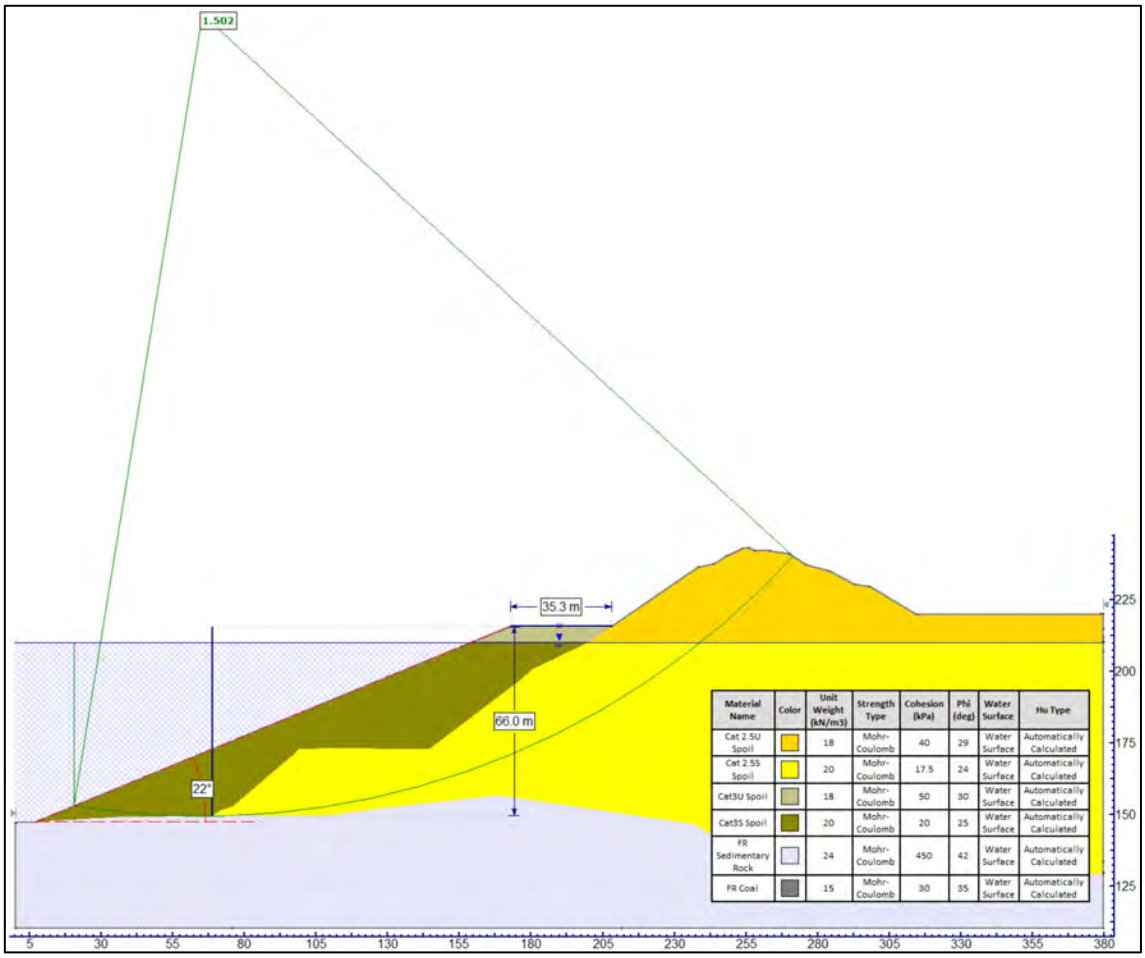


Figure 4. IP-N1-2 Existing final void geometry, calculated FOS = 2.37.

6.3 IP-N1-3

The existing lowwall geometry has a minimum FOS = 1.01 when the void is inundated owing to a thick layer of saturated Cat 2.5 spoil.

A number of iterations using various heights and widths for proposed buttresses were analysed. A buttress schema was derived to meet the FOS ≥ 1.5 criterion and is shown in Figure 5. The buttress covers the majority of the lowwall face, is created from Cat 3 spoil and measures 66 m high by 35 m wide with a batter angle of 22°.



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type
Cat 2.5U Spoil		18	Mohr-Coulomb	40	29	Water Surface	Automatically Calculated
Cat 2.5S Spoil		20	Mohr-Coulomb	17.5	24	Water Surface	Automatically Calculated
Cat3U Spoil		18	Mohr-Coulomb	50	30	Water Surface	Automatically Calculated
Cat3S Spoil		20	Mohr-Coulomb	20	25	Water Surface	Automatically Calculated
FR Sedimentary Rock		24	Mohr-Coulomb	450	42	Water Surface	Automatically Calculated
FR Coal		15	Mohr-Coulomb	30	35	Water Surface	Automatically Calculated

Figure 5. Proposed buttress design at Section IP-N1-3, calculated FOS = 1.50.

A more practical alternative would be to dozer push the existing spoil as shown in Figure 6 and the following FOS values were calculated for a range of batter angles:

- 23° FOS = 1.32
- 20° FOS = 1.43
- 18° FOS = 1.62

The reason for these lower FOS values compared with other spoil slopes is that the comparatively thick layer of saturated Cat 2.5 spoil is supporting a substantial load of unsaturated Cat 2.5U spoil.

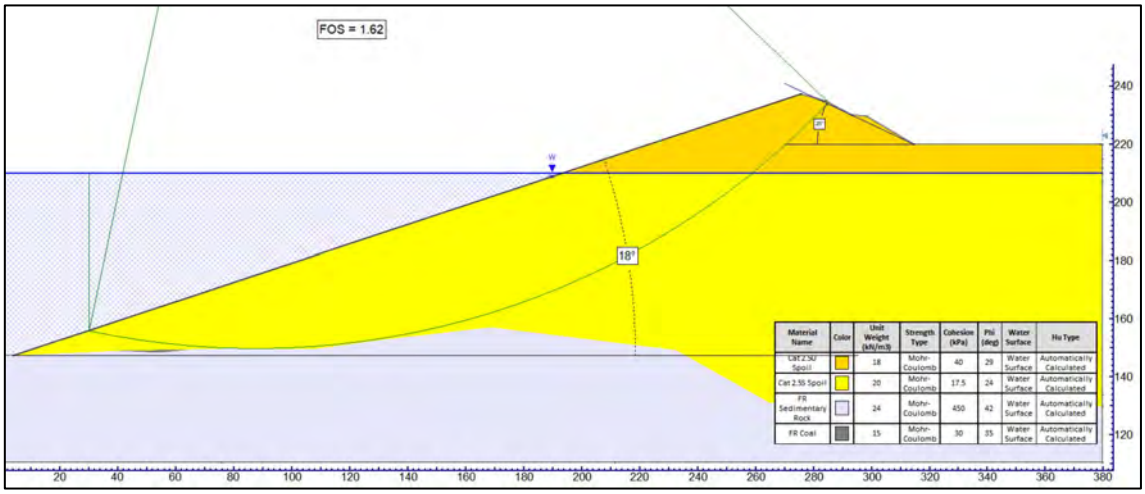


Figure 6. IP-N1-3 dozer pushed to 18°, FOS = 1.62.

6.4 IP-N1-4

The existing highwall has an overall FOS = 4.26.

The highly and distinctly weathered strata have a minimum FOS = 2.28.

There is an approximately 3 m thick highly weathered horizon at the top of the wall. Its current batter angle is 34°. Over time it is likely to erode back to 27° i.e. the crest would retreat by about 2.2 m. Such erosion is considered inconsequential. Alternatively, the batter could be trimmed back to 27° as part of the rehabilitation.

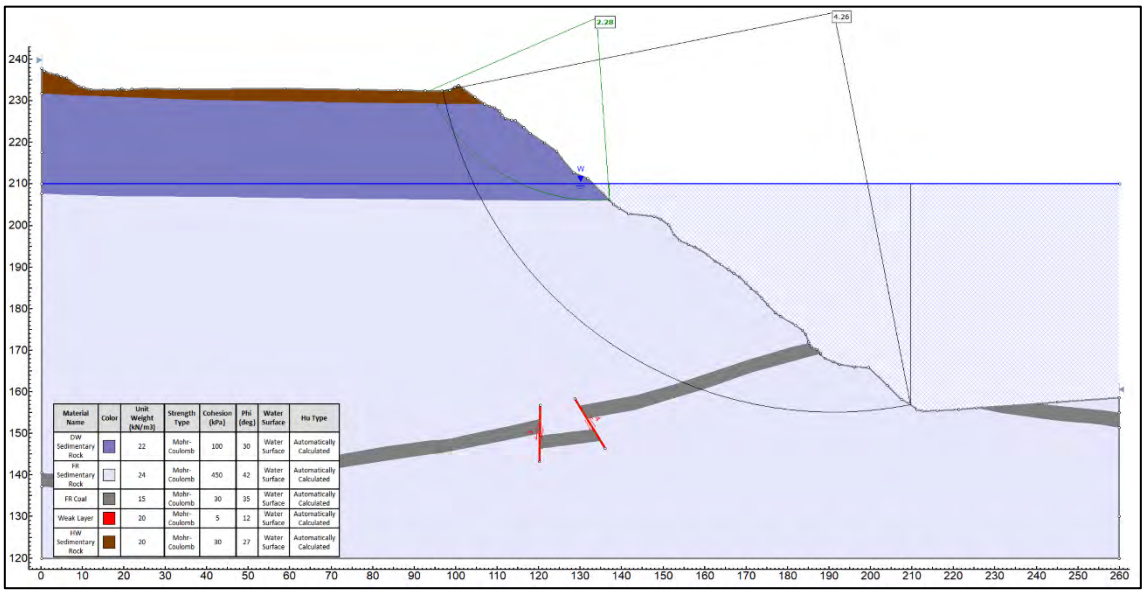


Figure 7. IP-N1-4 highwall overall FOS = 4.26, weathered horizon FOS = 2.28.

6.5 IP-N1-5

The existing endwall has a minimum overall FOS ≥ 4.

There is an approximately 10 m thick highly weathered horizon at the top of the wall. It has a minimum FOS = 2.02 as shown in **Error! Reference source not found.**. Its current batter angle is 40°. Despite its relatively high FOS, it is considered that over time it is likely to erode back to 27° i.e. the crest would retreat by about 11 m. Alternatively, the batter could be trimmed back to 27° as part of the rehabilitation.

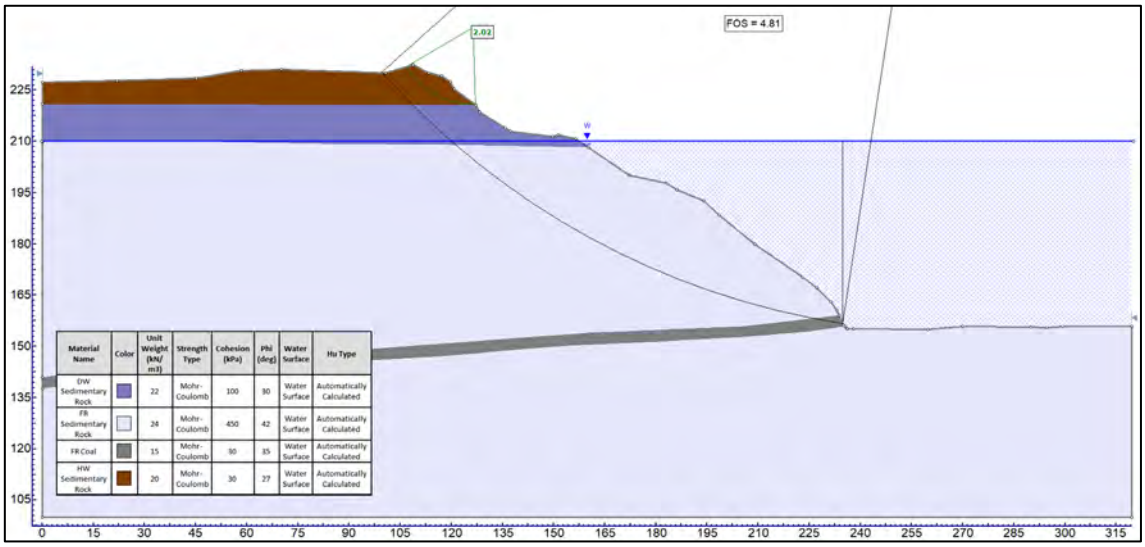


Figure 8. IP-N1-5 endwall overall FOS = 4.81, weathered horizon FOS = 2.02.

6.6 IP-S2-1

The existing endwall has an overall FOS ≥ 4.

There is an approximately 6 m thick highly weathered horizon at the top of the wall. It has a minimum FOS of 3.22 as shown in **Error! Reference source not found.**. The overall batter angle of the highly weathered horizon is 21°. Locally, it is steeper and these steeper zones may, in time erode back to the overall batter angle.

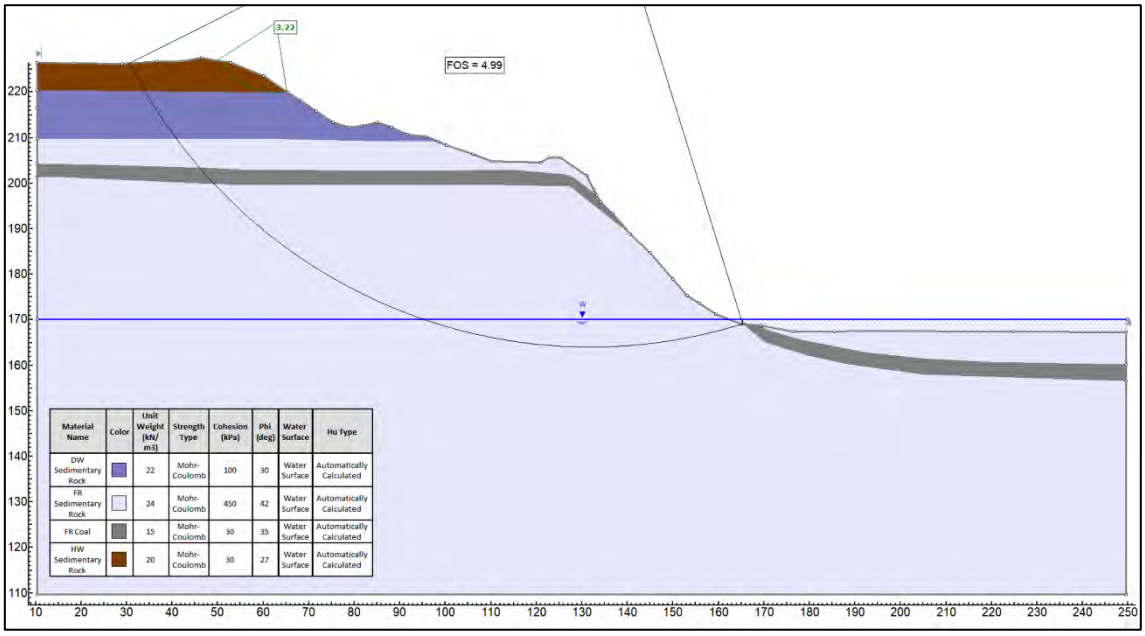


Figure 9. IP-S2-1 endwall overall FOS = 4.99, highly weathered horizon FOS = 3.22.

6.7 IP-S2-2

The existing highwall has an overall FOS = 2.32.

The critical failure surface passes through the upper distinctly and highly weathered horizons with a FOS = 1.58.

There is an approximately 6.5 m thick, highly weathered horizon at the top of the wall. It has a minimum FOS of 1.82. The overall batter angle of the highly weathered horizon is 62°. In time, it is likely that the highly weathered strata will erode back to about 27° i.e. the crest would retreat by about 10 m.

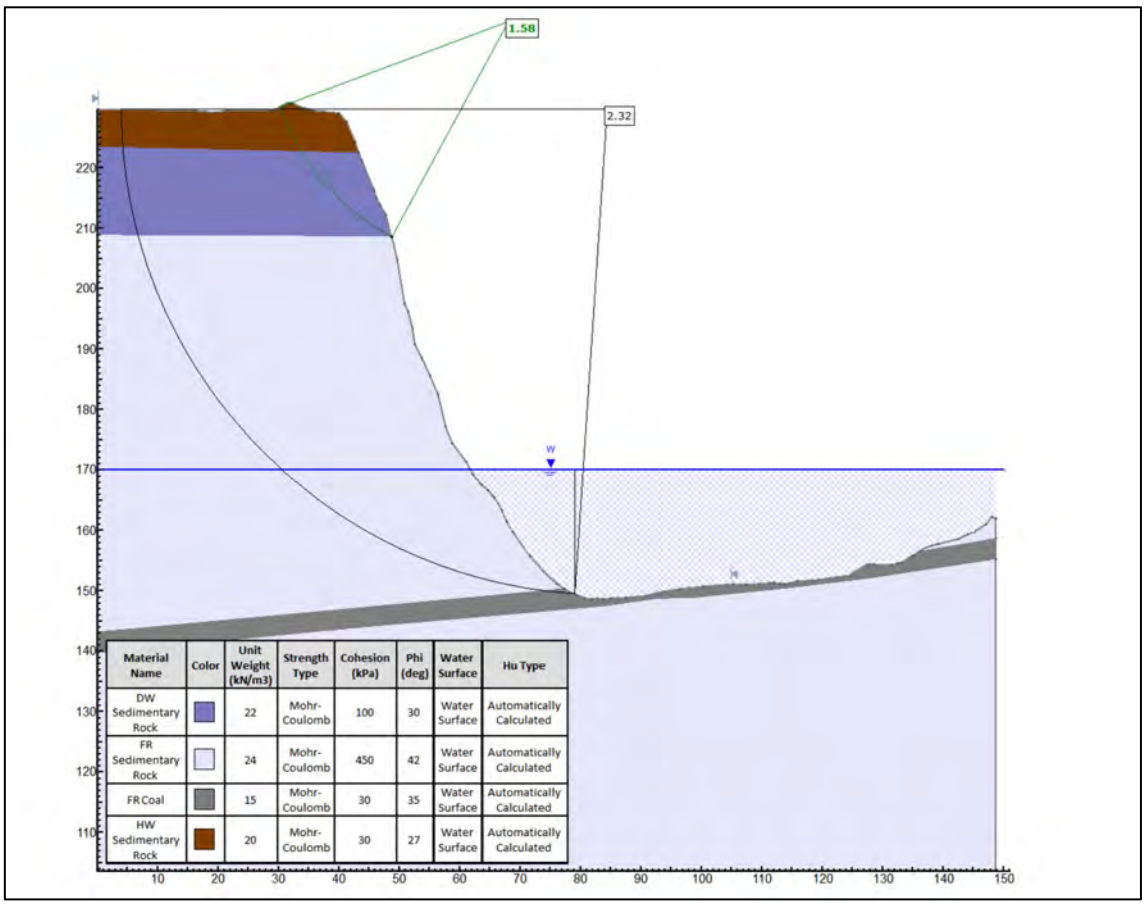


Figure 10. IP-S2-2 highwall overall FOS = 2.32, weathered horizon FOS = 1.58.

6.8 IP-S2-3

The existing final void geometry on section IP-S2-3 is shown in Figure 11. The Cat 2.5 spoil lowwall steps up with several changes in slope angle. The calculated FOS = 1.03 owing to the presence of the final void lake and saturation of the spoil.

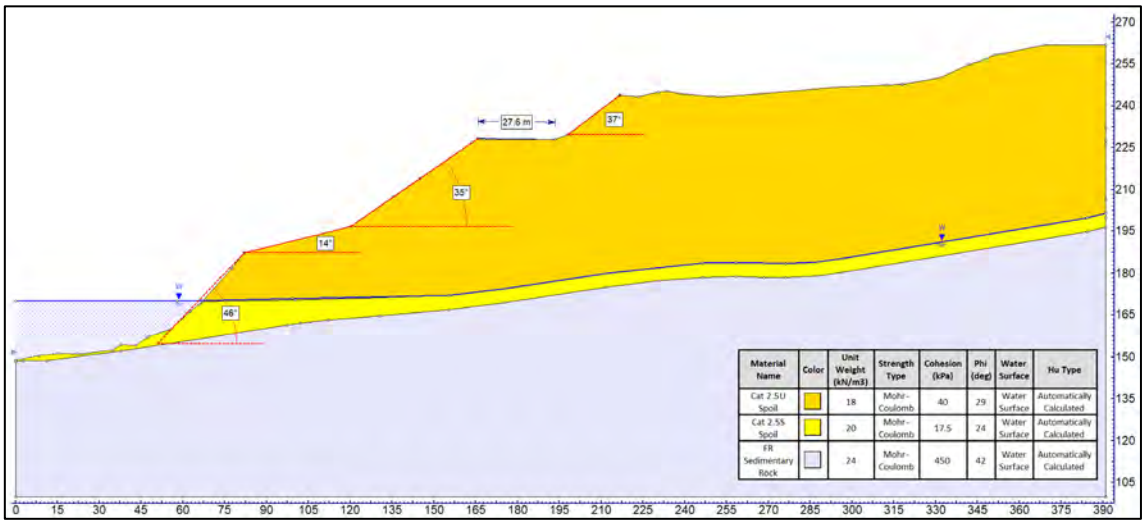


Figure 11. IP-S2-3 existing final void geometry.

A number of buttress scenarios were analysed but they did not provide a satisfactory FOS. A hybrid consisting of an 18 m high and 33 m wide buttress at 37°, constructed from Cat 3 material, while cutting the Cat 2.5 spoil to a slope angle of 23° generated FOS = 1.56. This design is shown in Figure 12.

Alternative approaches could include:

- Push the lowwall batter down to and angle of 23° as is shown in Figure 13. The FOS for this option is 1.49.
- Allow the dump to saturate and slump back to a saturated angle of repose which will have a similar effect as dozing the wall down to 23° and would establish a FOS = 1.5 backscarp about 40 m back from the existing crest.

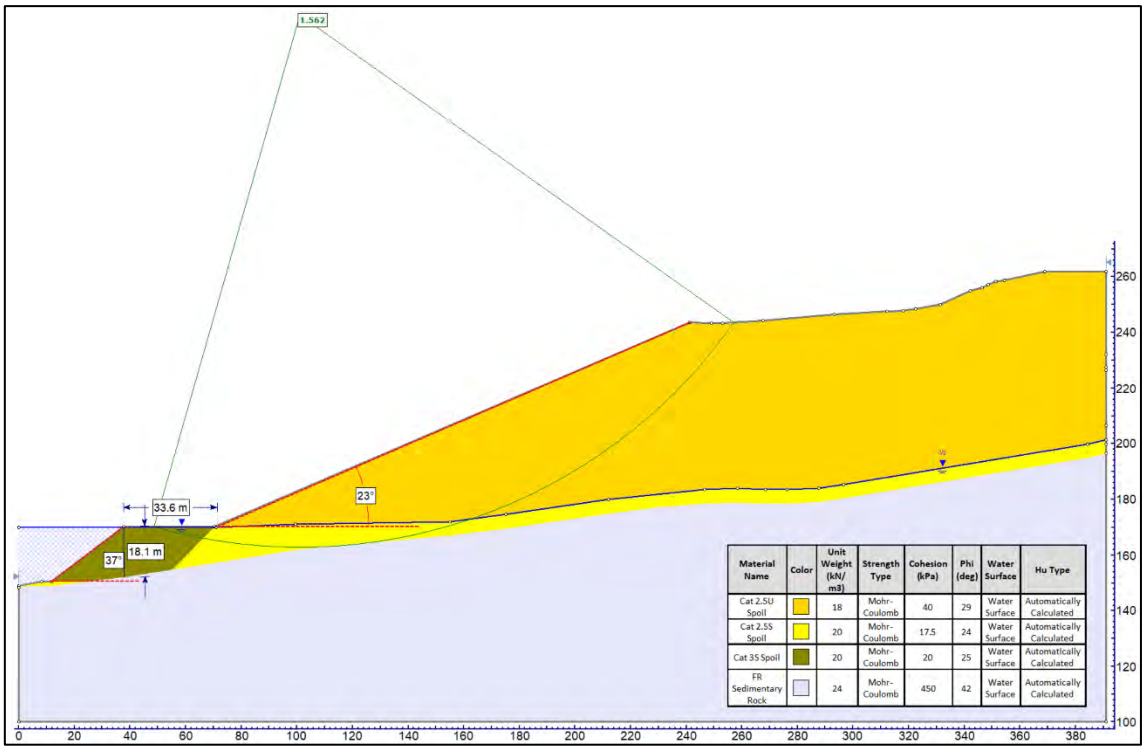


Figure 12. IP-S2-3 hybrid buttress and regrading, FOS = 1.56.

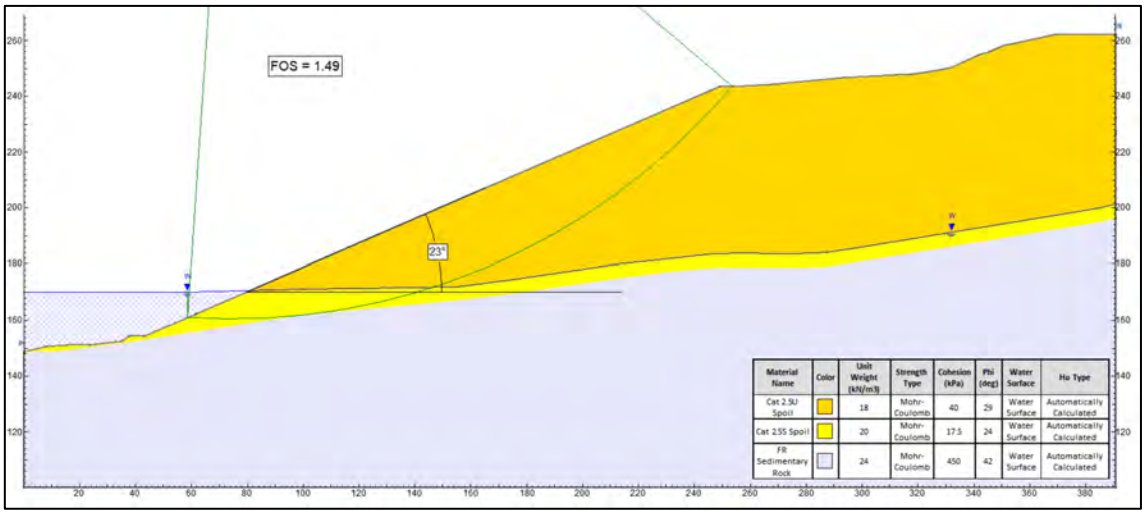


Figure 13. IP-S2-3 battered back to 23°, FOS = 1.49.

6.9 IP-S2-4

The existing highwall has an overall FOS ≥ 2.2.

The critical failure surface passes through the upper distinctly and highly weathered horizons with a FOS = 1.68.

There is an approximately 6 m thick, highly weathered horizon at the top of the wall. It has a minimum FOS of 1.73. The overall batter angle of the highly weathered horizon is up to 80°. In time, it is likely that the highly weathered strata will erode back to about 27° i.e. the crest would retreat by about 10 m.

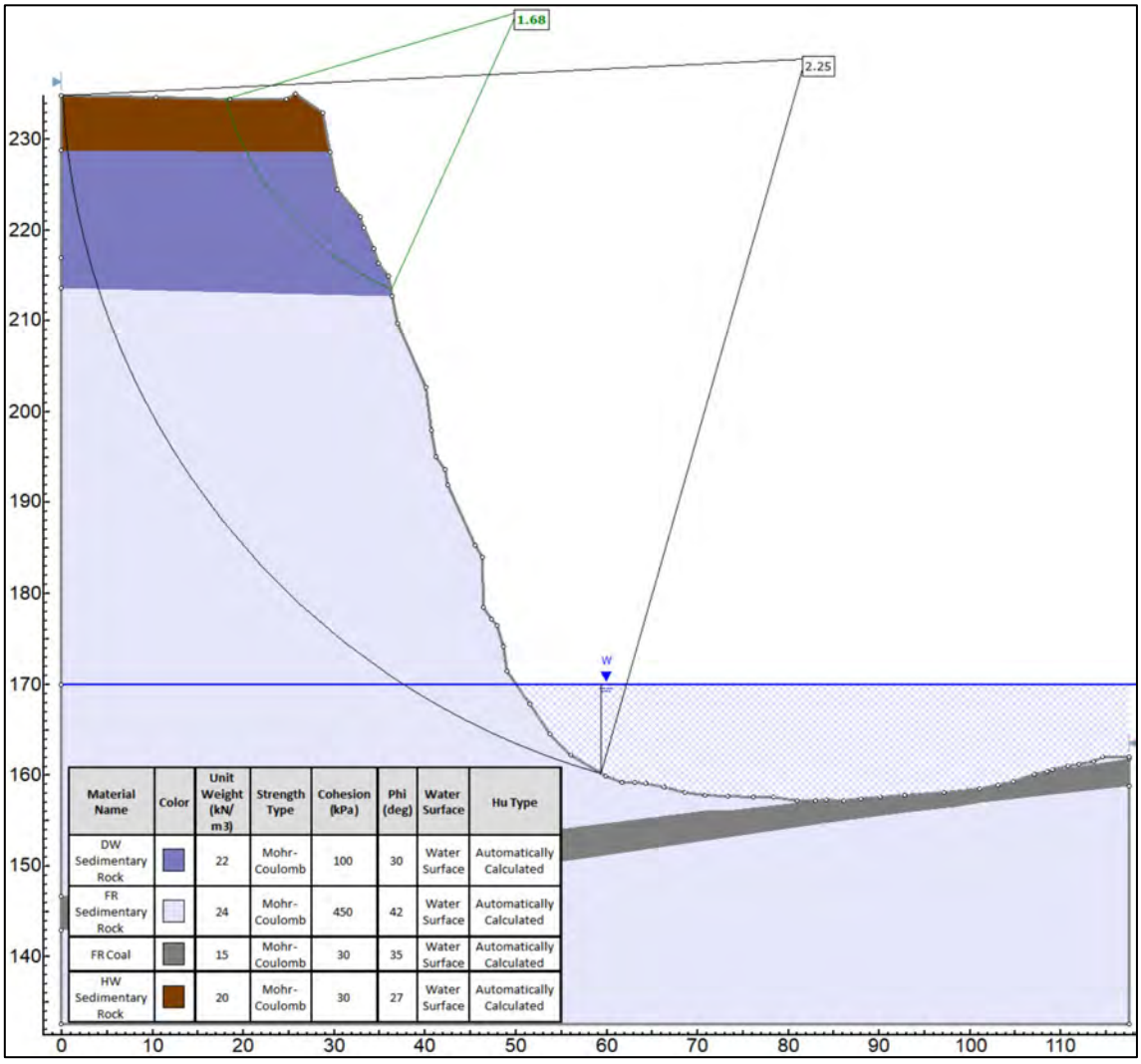


Figure 14. IP-S2-4 highwall overall FOS = 2.25, weathered horizon FOS = 1.68.

6.10 IP-S2-5

The existing final void geometry shows the Cat 2.5 spoil lowwall with several batters at angles between 33° and 46°. The profile has FOS = 1.21.

Several different buttress scenarios were analysed however, the calculated FOS values were unsatisfactory. A hybrid scenario in which two buttresses as shown in Figure 15 was formulated. The buttresses are constructed from Cat 3 material. The spoil behind the buttress is battered back to 27° and benched. This design, however difficult to construct, achieves FOS = 1.50.

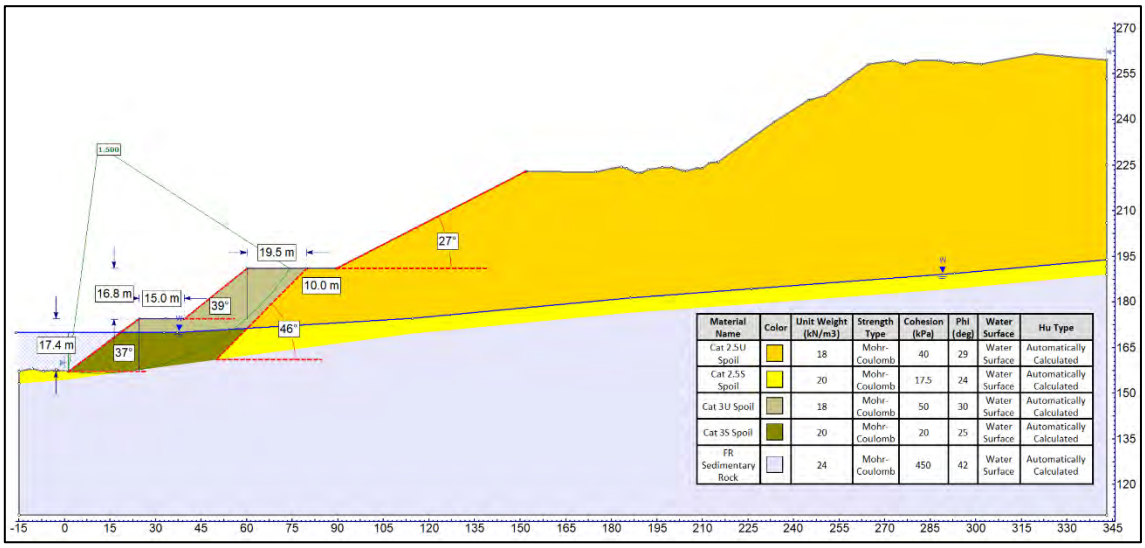


Figure 15. IP-S2-5 possible buttress / regrading design; FOS = 1.50.

Alternative approaches could include:

- Push the lowwall batter down to an angle of 23° as is shown in Figure 16. The FOS for this option is 1.52.
- Allow the dump to saturate and slump back to a saturated angle of repose which will have a similar effect as dozing the wall down to 23° and would likely establish a FOS = 1.5 backscarp within the RL225m bench.

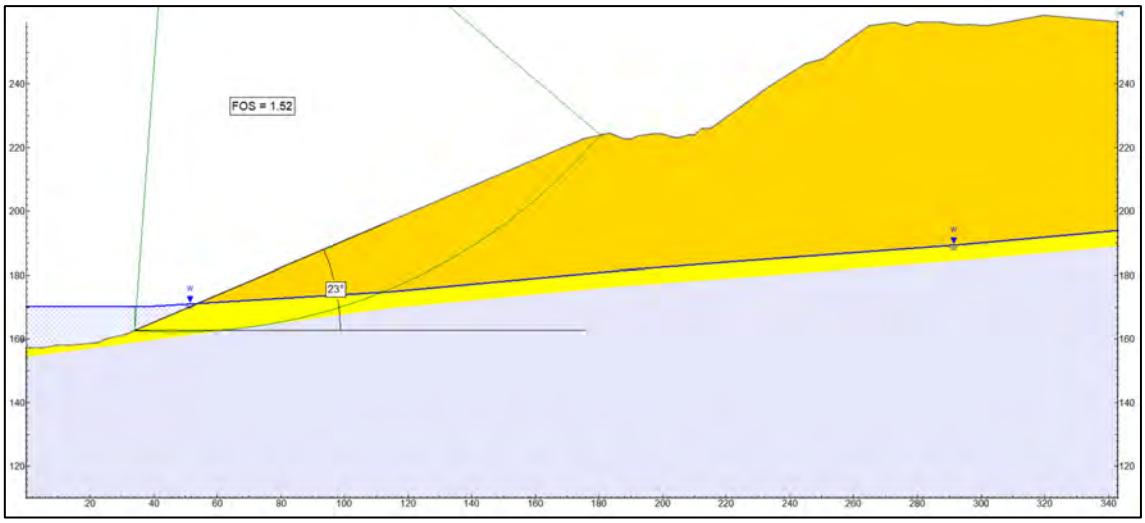


Figure 16. IP-S2-5 battered back to 23°, FOS = 1.52.

6.11 IP-S2-6

Cross section IP-S2-6 is located in a soft endwall. The overall profile has a FOS of 1.50.

There is an 8 m thick highly weathered horizon at the top of the endwall which has been excavated at a batter angle of about 80°. This horizon has a FOS = 1.36 and it is likely that in the long term it will erode back to an angle of around 27° at which point the FOS will exceed 1.5. To achieve this the crest would retreat by about 13 m. Alternatively, the highly weathered horizon could be battered back to 27° as part of mine site rehabilitation.

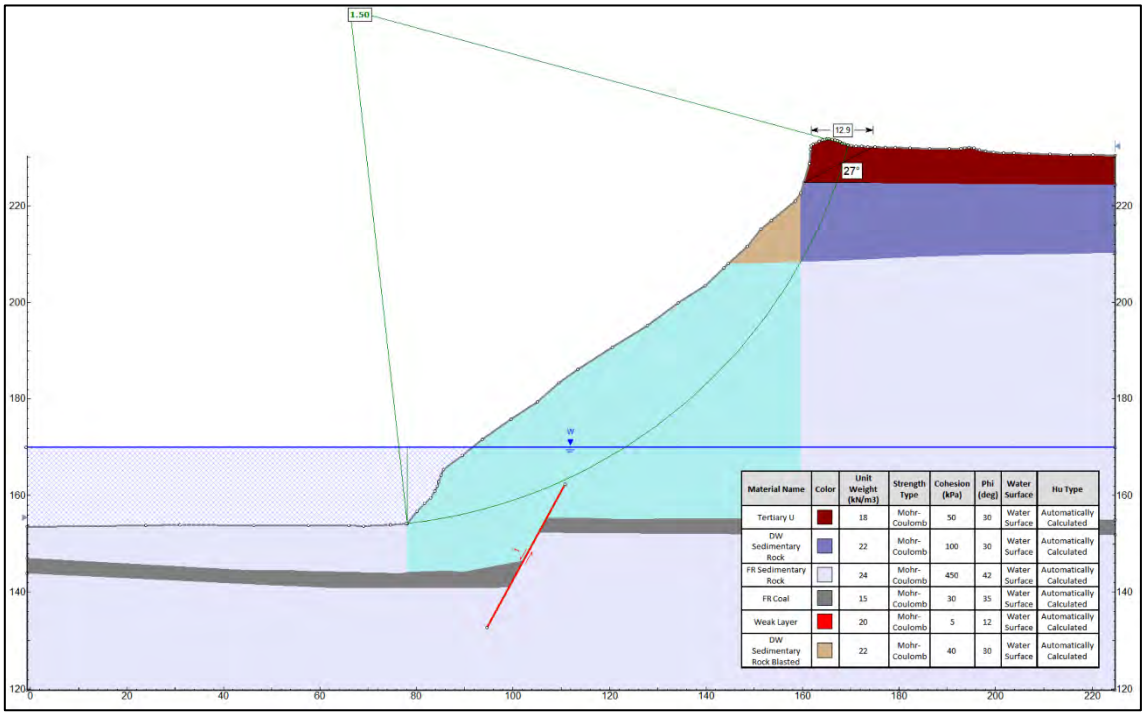


Figure 17. IP-S2-6 exisiting endwall overall FOS = 1.50.

6.12 IP-S3-1

IP-S3 was originally going to be completely filled. Spoil was pushed into the completed void from both the lowwall and highwall sides of the pit. The spoil cover over the former highwall is shallow and the presence of the strong highwall strata act as a constraint on any failure surfaces. Thus for the existing profiles with a predicted final void lake at RL170m, the minimum FOS on the highwall side is 1.22 and on the lowwall side is 1.17. In both cases the mode of failure is a partial failure of the spoil through the saturated underlying strata.

Raising the level of the floor of S3 to RL180m, i.e. 10 m above the predicted final void lake level, achieves a substantial increase in the calculated FOS values such that they are 1.45 on the highwall side and 1.51 on the lowwall side. The reason for the difference is that the height of the spoil on the highwall side is about 12 m higher than on the lowwall side.

If a FOS of at least 1.5 is required on the highwall side then one option would be to cut down the spoil by 12 m and use it to contribute to the backfill in the void to raise it by the required 10 m. Another option would be to construct an exclusion bund at the position of the former highwall crest since the spoil will not fail past that point.

These scenarios are illustrated in Figures 18 to 21.

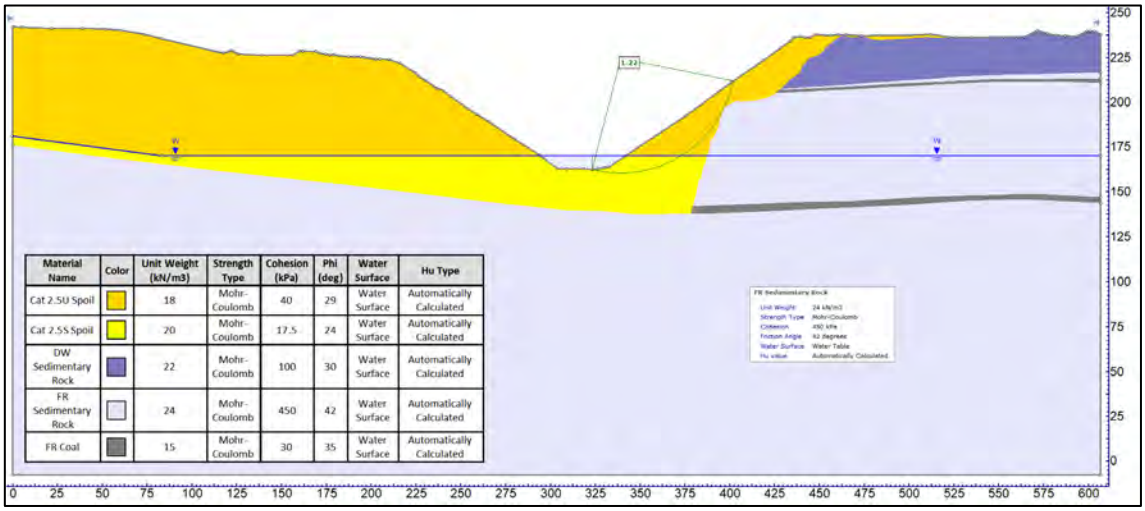


Figure 18. IP-S3-1 highwall side, exisiting void with pit lake, FOS = 1.22.

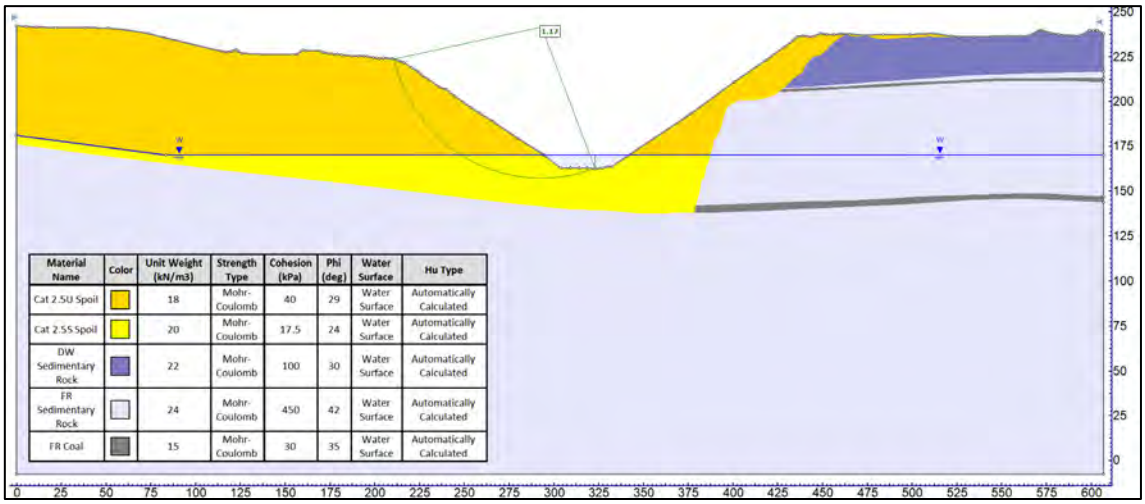


Figure 19. IP-S3-1 lowwall side, exisiting void with pit lake, FOS = 1.17.

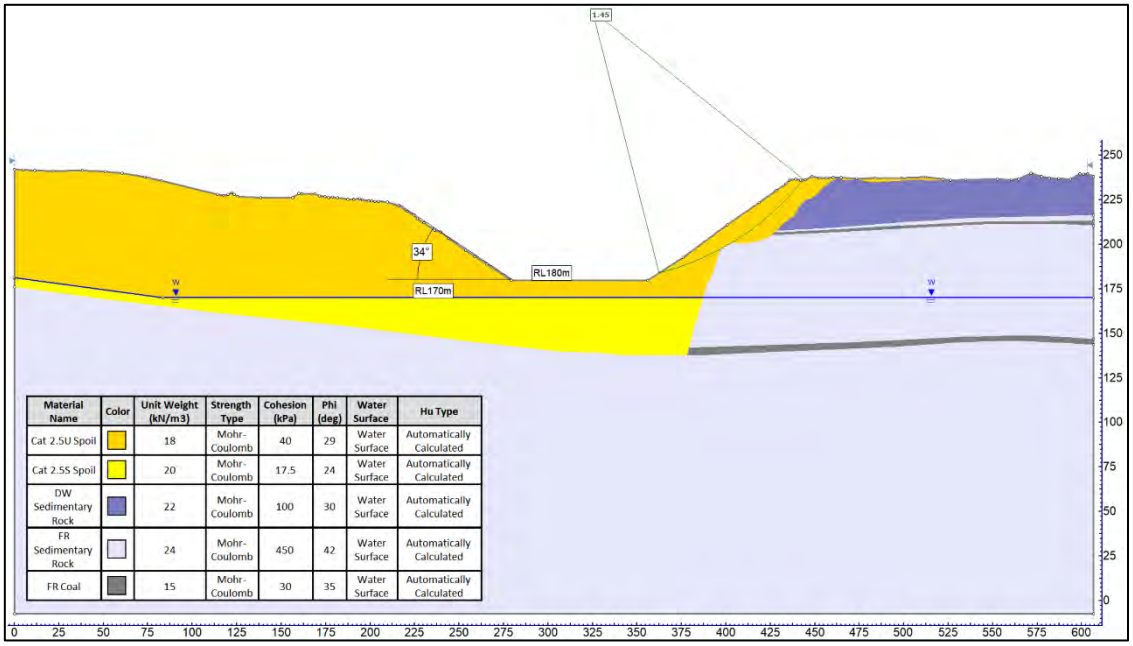


Figure 20. IP-S3-1 highwall side, pit floor level raised to RL180m, FOS = 1.45.

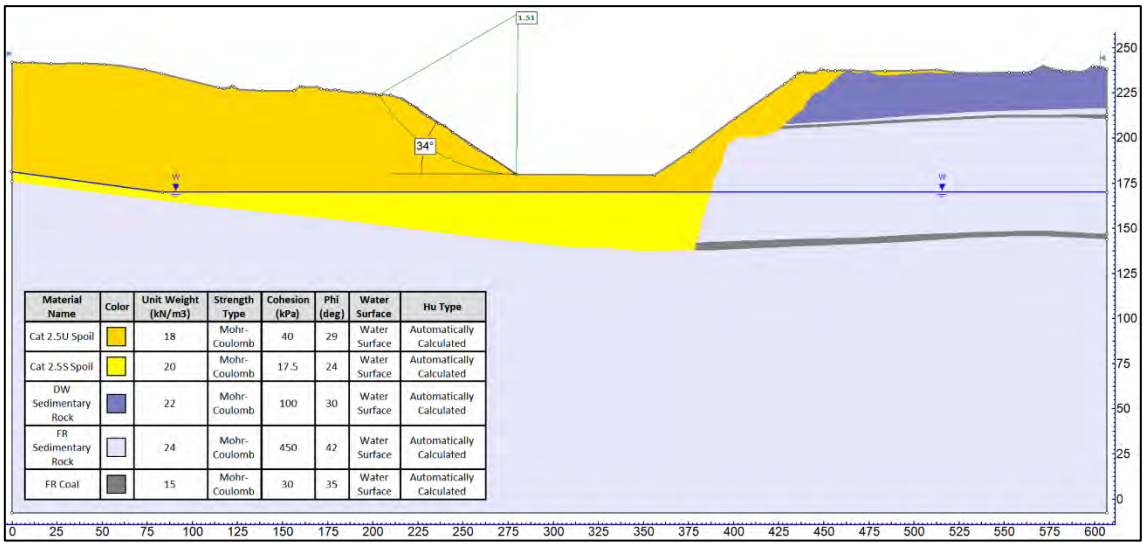


Figure 21. IP-S3-1 highwall side, pit floor level raised to RL180m, FOS = 1.51.

6.13 IPE-2-1

The existing highwall has an overall FOS ≥ 2.97.

There is an approximately 4 m thick, highly weathered horizon at the top of the wall. In time, it is likely that the highly weathered strata will erode back to about 27° i.e. the crest would retreat by about 8 m. It is considered that this inconsequential since it would not encroach on the existing bund that is shown in Figure 22.

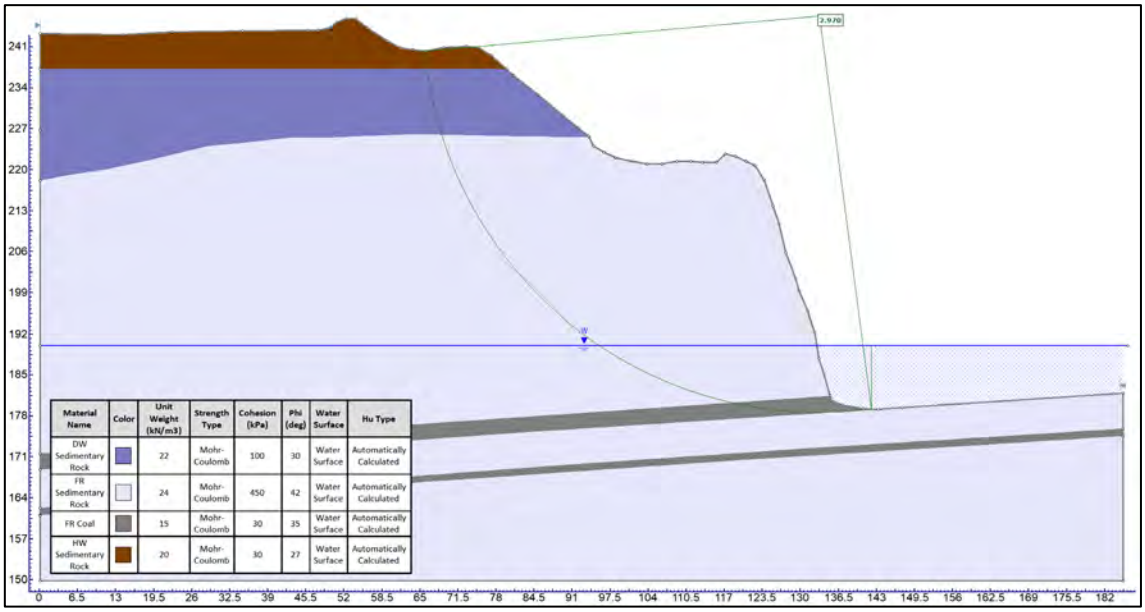


Figure 22. IPE-2-1 exisitng highwall and final void lake, overall FOS = 2.97.

6.14 IPE-2-2

Cross section IPE-2-2 cuts through a lowwall spoil dump as shown in Figure 23. The existing profile, plus the effect of the final void lake results in a calculated a FOS of 1.38.

Several iterations using various heights and widths for a toe buttress, using Cat 3 spoil, were analysed. A 10 m high and 20 m wide buttress shown in Figure 23, resulted in a calculated FOS = 1.55.

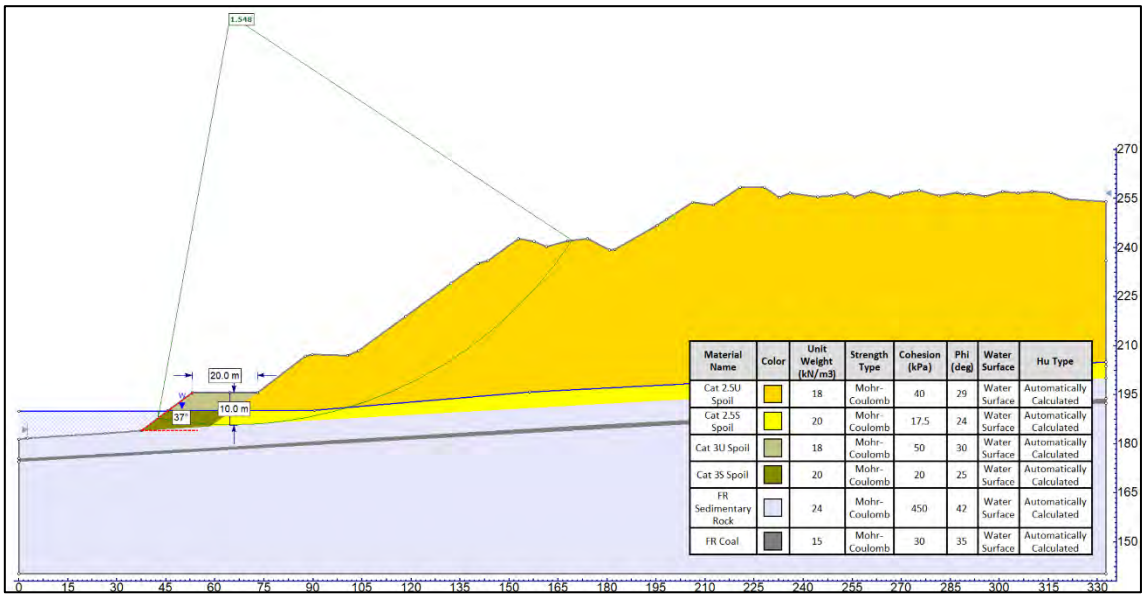


Figure 23. IPE-2-2 possible buttress resulting in FOS = 1.55.

Without a buttress the spoil would need to dozed down to an overall batter angle of 25° as shown in Figure 24 in order to achieve a FOS ≥ 1.5.

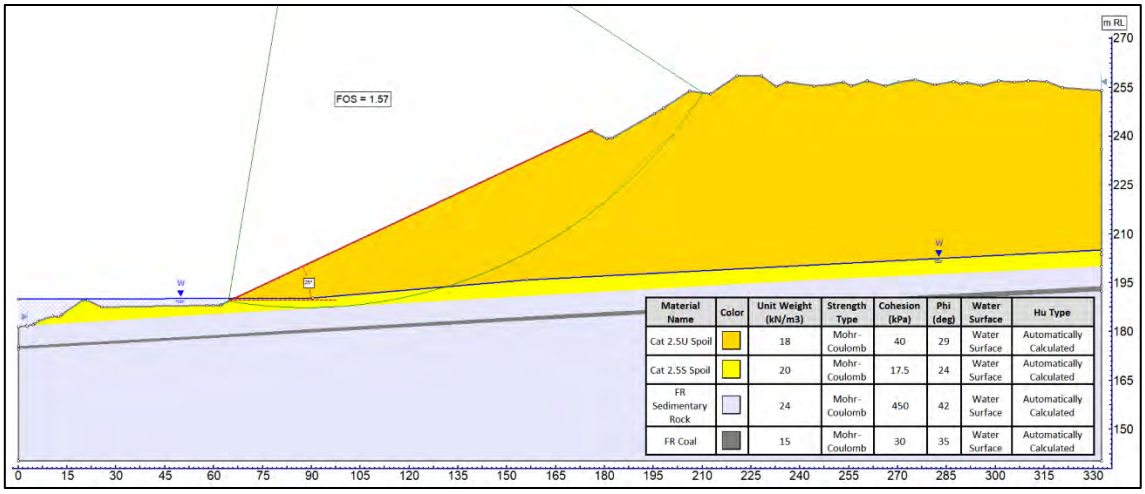


Figure 24. IPE-2-2 25° batter resulting in FOS 1.57.

6.15 IPE-2-3

The IPE-2-3 highwall cross section in 25 shows an overall FOS ≥ 3.

The critical FOS = 2.47 and is located in the highly weathered horizon. While this value is more than adequate it is considered likely that the highly weathered horizon will eventually erode back to a 27° slope. This would represent a crest retreat of approximately 6 m. Alternatively the highly weathered horizon could be battered back to 27°.

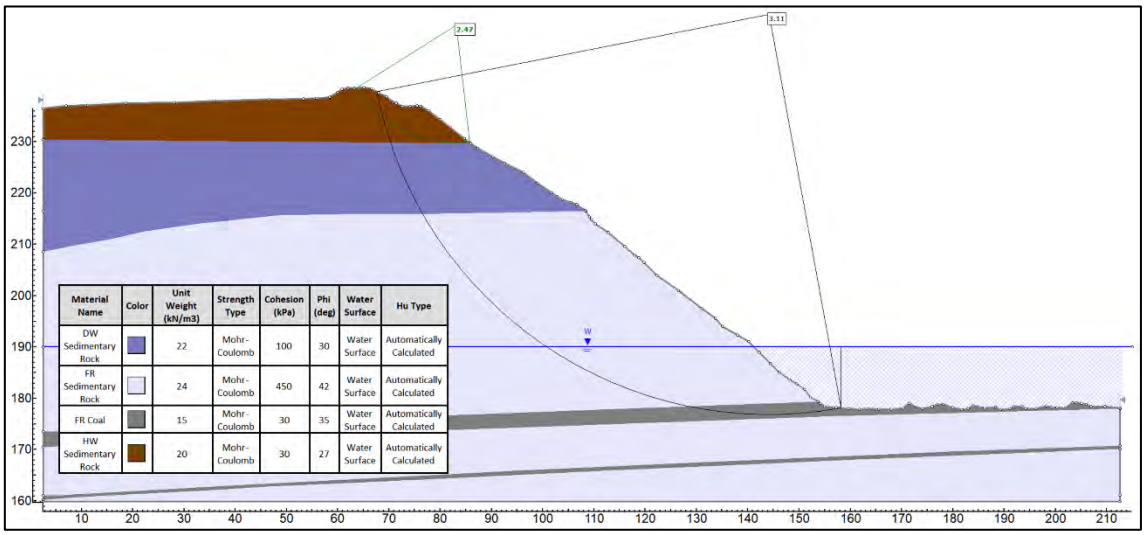


Figure 25. IPE-2-3 highwall cross section; overall FOS ≥ 3, critical FOS = 2.47.

6.16 IPE-3-1

The IPE-3-1 highwall cross section shown in Figure 26 results in an overall FOS ≥ 3.

The critical FOS = 2.27 and is located in the highly weathered and distinctly weathered horizons. It is likely that the highly weathered horizon which currently has a batter angle of 45° will eventually erode back to a 27° slope. This would represent a crest retreat of approximately 5 m. Alternatively the highly weathered horizon could be battered back to 27°.

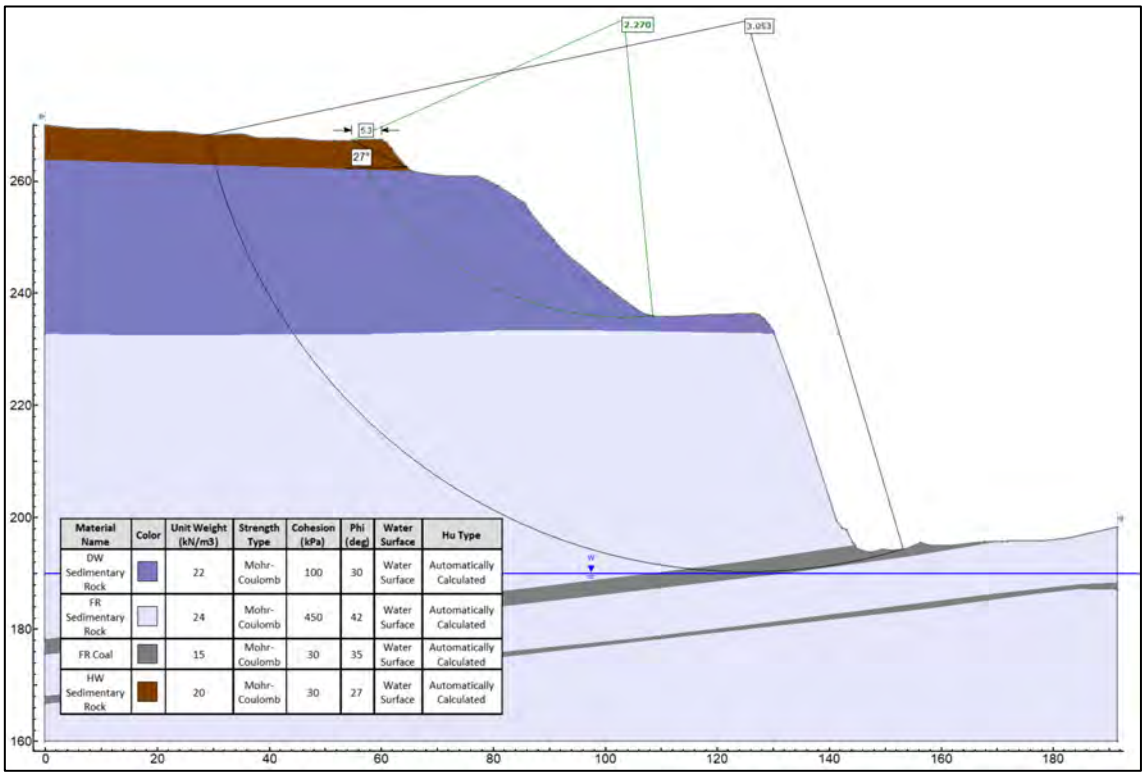


Figure 26. IPE-3-1 highwall cross section; overall FOS ≥ 3, critical FOS = 2.27.

6.17 IPE-3-2

The IPE-3-2 highwall cross section shown in Figure 27 results in an overall FOS = 2.64.

The critical FOS = 2.04 and is located in the highly weathered horizon. It is likely that the highly weathered horizon which currently has a batter angle of 45° will eventually erode back to a 27° slope. This would represent a crest retreat of approximately 9 m. Alternatively the highly weathered horizon could be battered back to 27° as part of the rehabilitation.

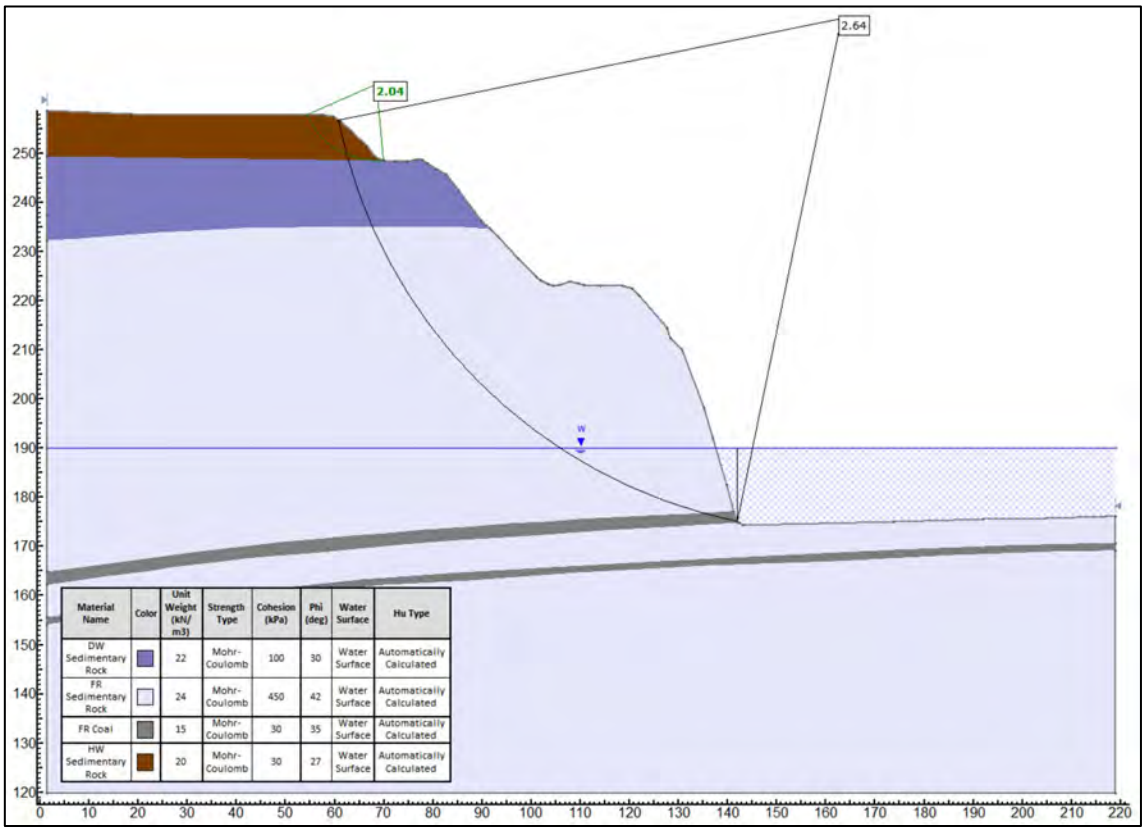


Figure 27, IPE-3-2 highwall cross section; overall FOS = 2.64, critical FOS = 2.04.

6.18 IPE-3-3

The IPE-3-3 lowwall spoil cross section is above the level of the final void lake. For this reason a wedge mode of failure was modelled with the basal plane constrained within a saturated horizon. The resultant critical FOS = 1.68 is shown in Figure 28.

This analysis emphasises the impact of the final void lakes in reducing the FOS of existing profiles.

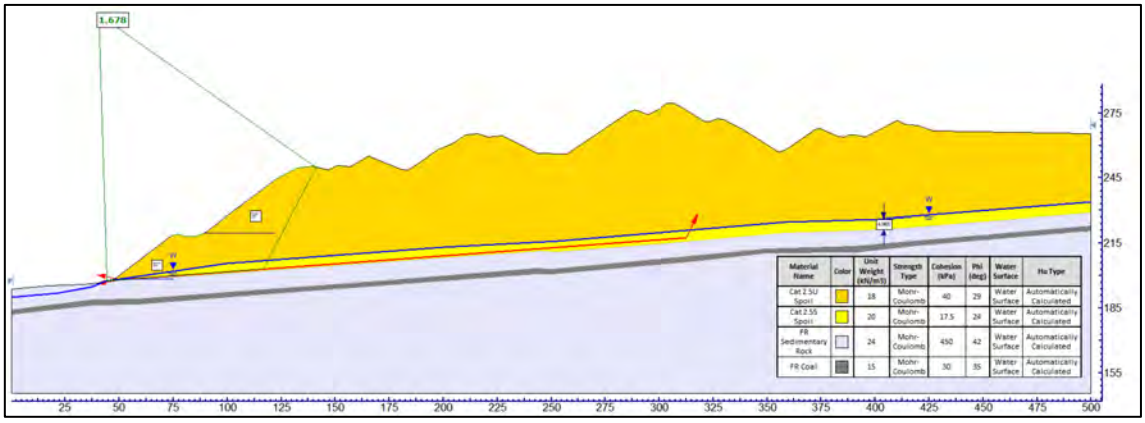


Figure 28. IPE-3-3 lowwall spoil cross section; critical FOS = 1.68.

6.19 IPE-4-1

The IPE-4-1 lowwall spoil cross section is substantially above the level of the final void lake. For this reason, a wedge mode of failure was modelled with the basal plane constrained within the saturated horizon. Analyses were carried out for the ramp level at about RL196m and the upper spoil level with the crest at about RL 247m. The results are shown in Figures 29 and 30.

For the lower level FOS = 1.91
For the upper level FOS = 1.74.

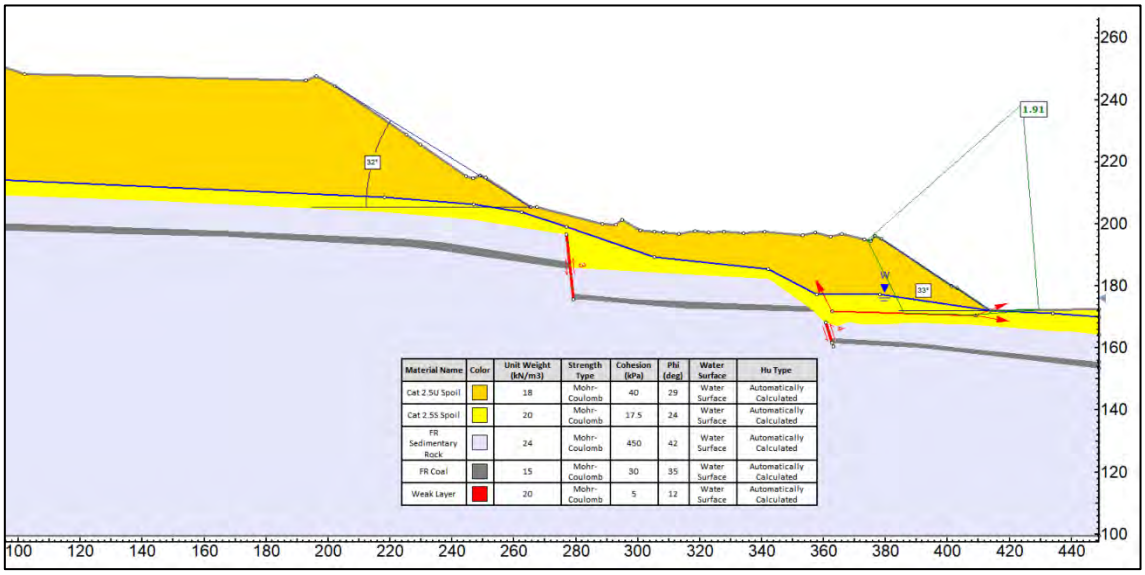


Figure 29. IPE-4-1 lowwall cross section; lower level critical FOS = 1.91.

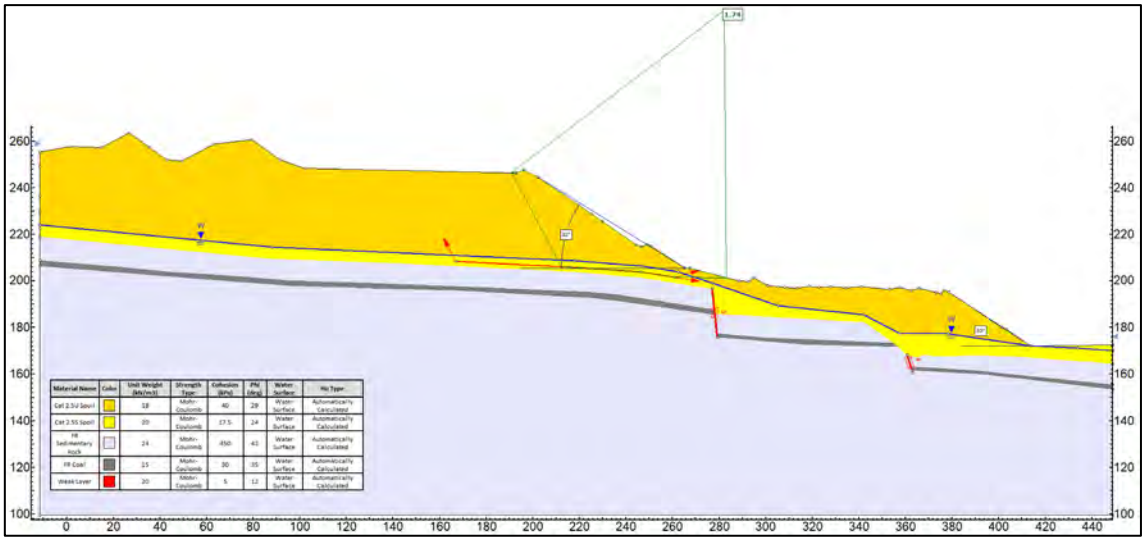


Figure 30. IPE-4-1 lowwall cross section; upper level critical FOS = 1.74.

6.20 IPE-4-2

The IPE-4-2 endwall cross section shown in Figure 31 results in an overall FOS = 4.80.

The critical FOS = 2.20 and the surface is located in the highly weathered and distinctly weathered horizons. It is likely that the highly weathered horizon which currently has a batter angle of 45° will eventually erode back to a 27° slope. This would represent a crest retreat of approximately 6 m. Alternatively the highly weathered horizon could be battered back to 27° as part of the final voids reshaping.

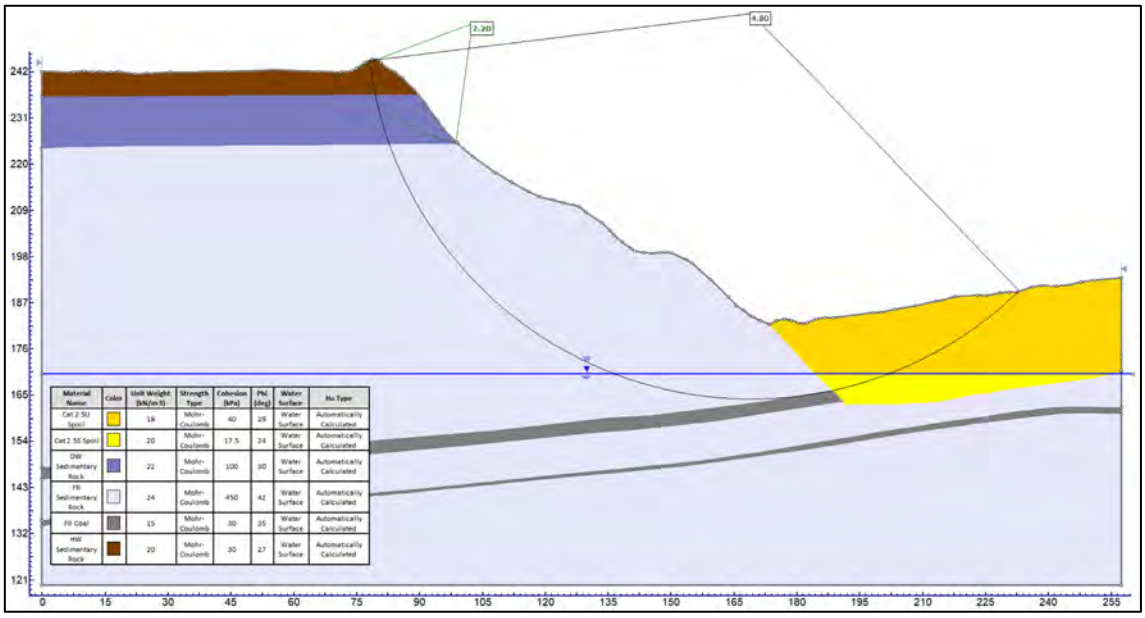


Figure 31. IPE-4-2 endwall cross section; overall FOS = 4.80, critical FOS = 2.20.

6.21 IPE-4-3

The IPE-4-3 highwall cross section shown in Figure 32 results in an overall FOS ≥ 3.

The critical FOS = 2.59 and the surface is located in the highly weathered and distinctly weathered horizons. It is likely that the highly weathered horizon which currently has a batter angle of 45° will eventually erode back to a 27° slope. This would represent a crest retreat of approximately 6 m. Alternatively the highly weathered horizon could be battered back to 27° as part of the final voids reshaping.

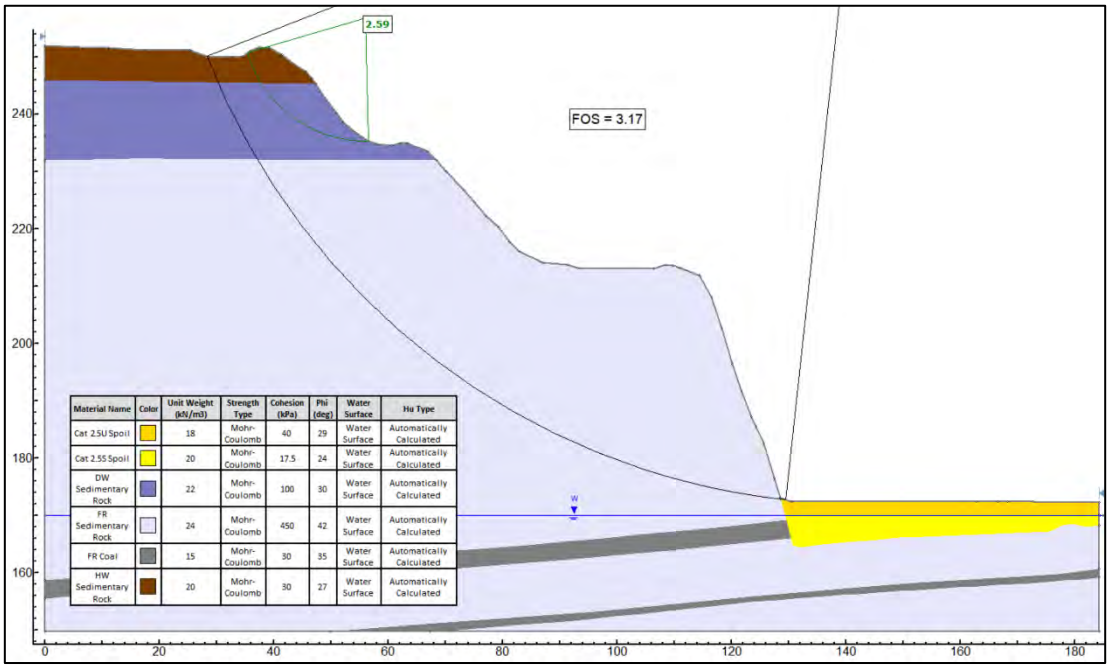


Figure 32. IPE-4-3 highwall cross section; overall FOS ≥ 3, critical FOS = 2.59.

6.22 IPE-4-4

The existing IPE-4-4 cross section of the lowwall spoil, which is likely to be the final void geometry is shown in Figure 33. The spoil is all located above the level of any predicted final void lake. Consequently, the stability analysis has assumed a wedge style failure on a basal plane within the saturated base of the spoil for the eastward facing spoils and a circular analysis for the westward facing spoil where a failure through the saturated layer is unlikely.

In all cases the calculated critical FOS > 1.5. as shown in the plots in figures 34 to 36.

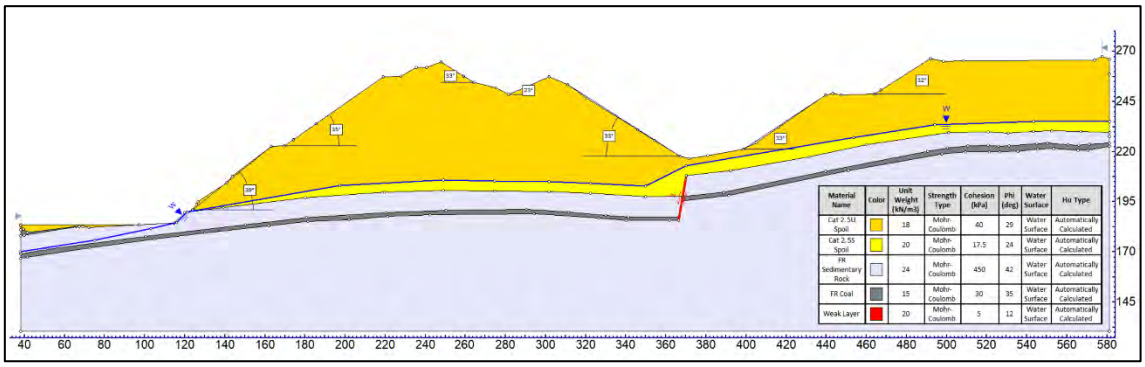


Figure 33. IPE-4-4 final void geometry.

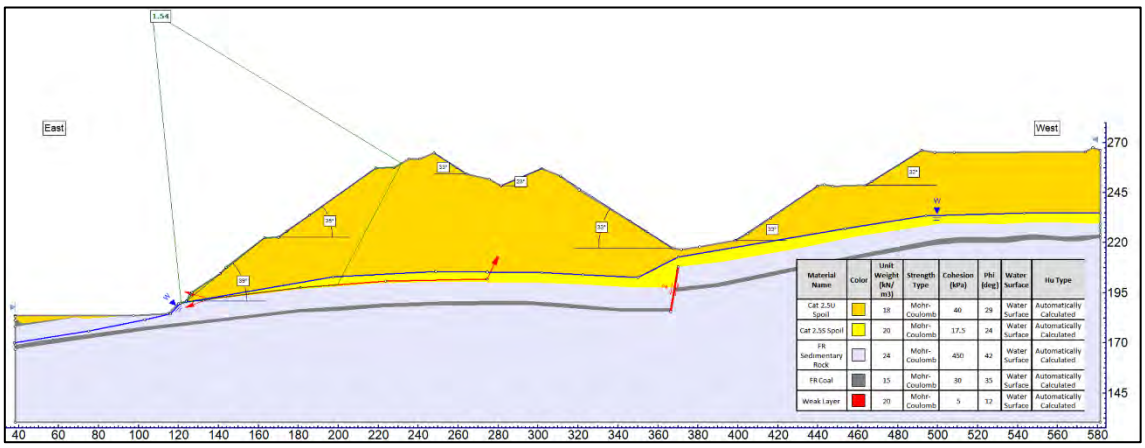


Figure 34. IPE-4-4 eastern most spoil batter; FOS = 1.54.

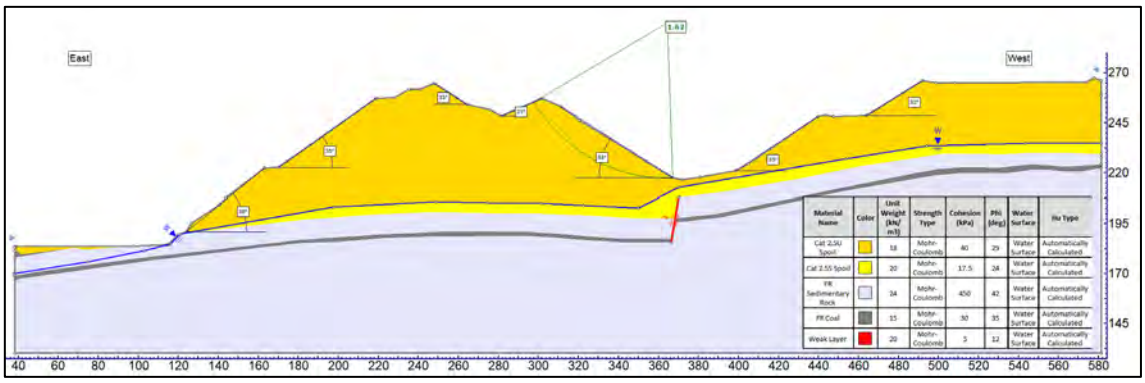


Figure 35. IPE-4-4 eastern internal batter; FOS = 1.62.

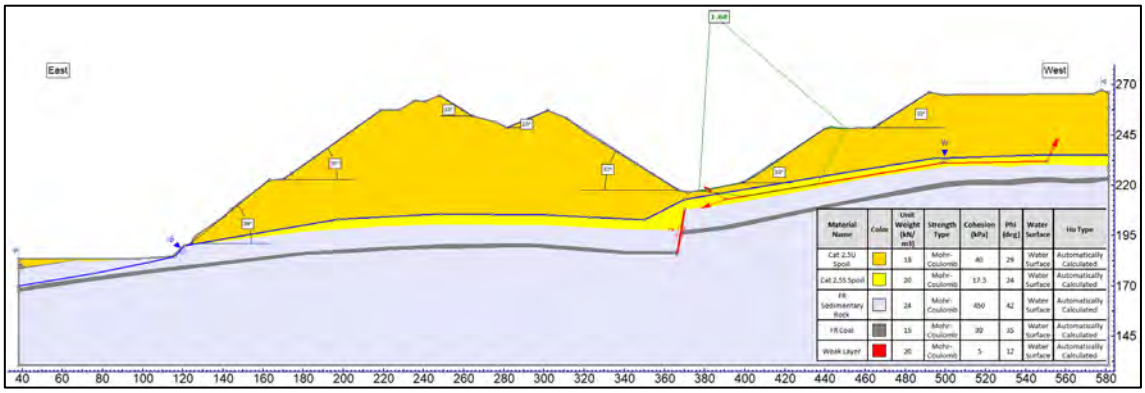


Figure 36. IPE-4-4 western internal spoil batter; FOS = 1.68.

6.23 IPE-4-5

The IPE-4-5 highwall cross section shown in Figure 37 results in an overall FOS = 2.89.

The critical FOS = 2.27 and the surface is located in the highly weathered and distinctly weathered horizons. The highly weathered horizon has been battered back to 27° and is unlikely to erode much more.

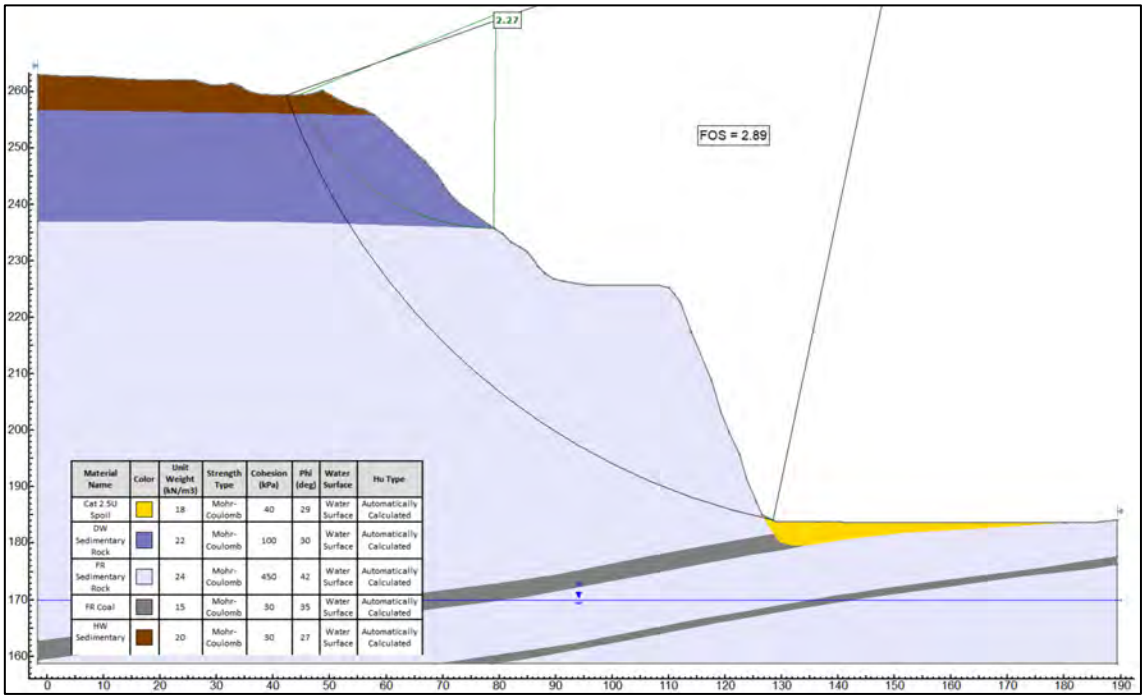


Figure 37. IPE-4-5 highwall cross section; overall FOS ≥ 3, critical FOS = 2.59.

7 RELEVANCE OF SINGLE DESIGN FOS ≥ 1.5

Guidelines for typical factors of safety and probability of failure have been published in Wesseloo, J. and Read, J., 2009. Acceptance Criteria in Guidelines for Open Pit Slope Design Eds. J Read and P Stacey, CSIRO. This publication is very widely accepted both in Australia and internationally

The Wesseloo and Read Table 9.9 indicates that a FOS of 1.5 is appropriate where there is a high consequence of failure and that the FOS would apply to the overall slope. In civil engineering a FOS of 1.5 would be appropriate to permanent works where there is a high level of public exposure such as a road or rail cutting.

For final voids where there is virtually no public exposure, and particularly where any failures are fully contained within existing pits, a FOS of 1.2 or 1.3 is considered more appropriate.

Theoretically, slopes with a FOS of 1.2 should not fail but because of the uncertainties associated with the materials, groundwater conditions and methods of analysis, it is known that there is a small chance of failure. The calculated probability of that failure depends on the variability of the input parameter values. In the case of the final voids such failures would probably take the form of slumps through the saturated spoil.

If, nevertheless a FOS ≥ 1.5 is required then considering the volumes of spoil that would need to be moved to construct the buttresses shown in these analyses, a cheaper solution is likely to be to simply to dozer push the spoil down at an angle 23°. By adopting that solution IPC would achieve a more certain outcome, a FOS of 1.5 and at a lower cost.

In the case of IP S3 the existing spoil on both sides is full contained and has an existing FOS around 1.2 under the high water level condition. Were the spoil to fail it is likely to slump and self buttress against the wall opposite and re-establish an equilibrium profile not very different from the existing profile. It is therefore suggested that leaving S3 in its present condition is geotechnically valid.

Table 4. Typical FoS and PoF acceptance Criteria (Table 9.9 in Wesseloo and Read, 2009)

		Acceptance Criteria[1]		
Slope Scale	**Consequences of failure[2]**	**FoS (min) (static)**	**FoS (min) (dynamic)**	**PoF (max) P[FoS≤1]**
Bench	Low-high	1.1	NA	25-50%
Inter-ramp	Low	1.15-1.2	1.0	25%
	Medium	1.2	1.0	20%
	High	1.2-1.3	1.1	10%
Overall	Low	1.2-1.3	1.0	15-20%
	Medium	1.3	1.05	5-10%
	High	1.3-1.5	1.1	≤5%

1. Needs to meet all acceptance criteria
2. Semi quantitatively evaluated (see Figure 13.9)

8 MANAGEMENT BY DEFORMATION

It is evident that to achieve a FOS of 1.5 for the final void landforms a very large amount of spoil would need to be moved.

An alternative approach to consider is to undertake numerical modelling of the existing landforms to determine the extent of deformation associated with the effect of final void lakes.

This has been beyond the scope of the current report but as an example a very simple analysis using Rocscience RS2, a 2D finite element program was caried out on the cross section IPE-2-2 and compared with results obtained from the limit equilibrium analysis in Slide2. Output plots from these analyses are shown in Figures 38 and 39.

In both cases the factor of safety is almost identical with Slide2 FOS = 1.38 and RS2 critical stress reduction factor (SRF) = 1.36. The critical path obtained from Slide2 corresponds with the zone of maximum shear strain obtained from RS2.

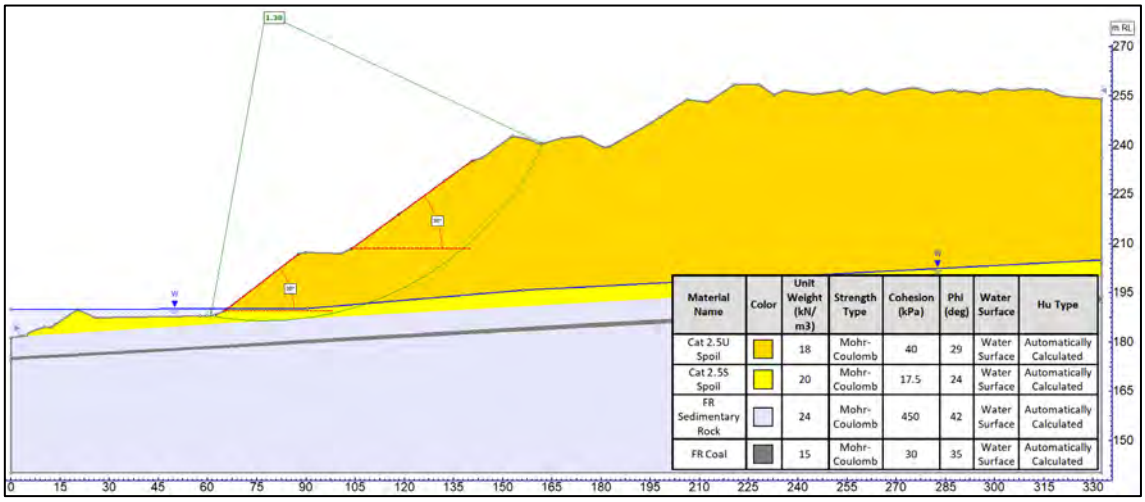


Figure 38. IPE-2-2 exisiting lowwall plus final void lake; critical FOS = 1.38.

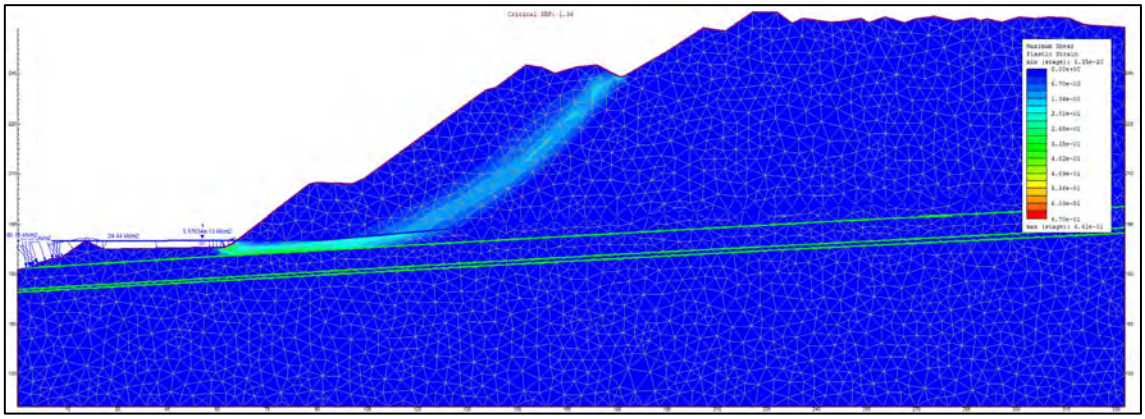


Figure 39. IPE-2-2 existing lowwall plus final voids lake showing zone of maximum strain; critical SRF = 1.36.

A finite element program because of its very nature determines stress and strain and redistributes the stress in response to the strain. This is not possible in a limit equilibrium program which simply resolves static forces.

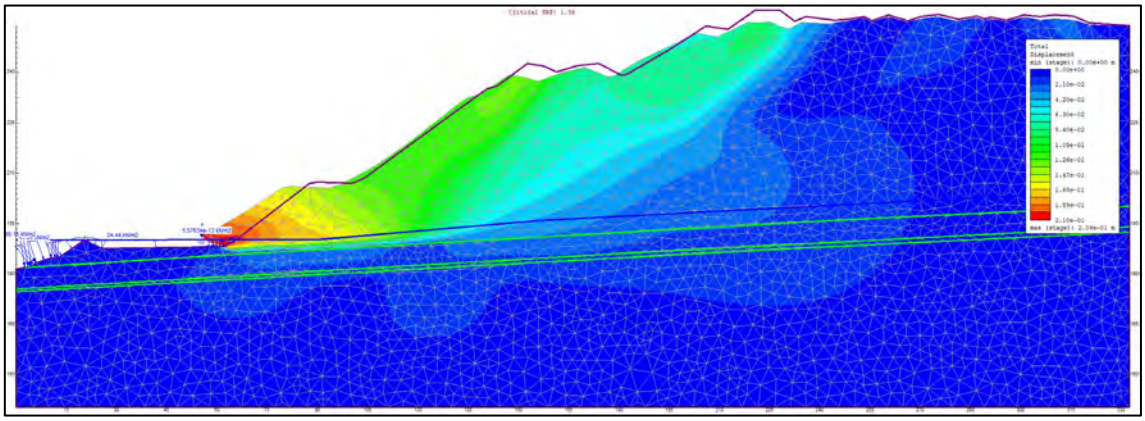


Figure 40. IPE-2-2 exisiting lowwall plus final voids lake showing total displacement contours; maximum is approximately 200 mm.

Figure 40 shows the total displacement associated with the flooding of IPE Pit 2 final void and its presumed softening of the basal spoil. The maximum total displacement is about 200 mm in the toe of the spoil. At the crest of the spoil the total displacement is virtually zero which is considered to constitute geotechnically stable ground conditions. The modelled deformation is considered to be consistent with a spoil dump in which FOS = 1.36 or the critical SRF = 1.38. As noted, the model is simplified; it has not been calibrated and further work is required to refine some of the parameter values. Nevertheless, it is indicative of what can be achieved using stress strain software and shows an alternative basis for final void management, that of management by deformation.

9 TAILINGS CAPPING

Tailings have been and will continue to be disposed in parts of IP-N1. Eventually these tailings storage facilities (TSFs) will be capped and rehabilitated. Typically, tailings are allowed to dry out for a period of time until a crust has formed. The strength and thickness of the crust is evaluated and a design is generated for capping the tailings. Usual practice is initially to cover the tailings with a thin layer of spoil using lightweight equipment such as “swamp dozers” and then, having created a platform of sufficient strength, place additional spoil using heavier equipment. Geotechnically, the overburden spoil that has been generated at Isaac Plains is considered suitable as a capping material.

10 DISCUSSIONS AND CONCLUSIONS

The nominated target geotechnical factor of safety (FOS) for the final voids landforms is 1.5.

The current ground surface, including the existing voids approximates the landform proposed for relinquishment. A series of stability analyses was undertaken to check the FOSs of the existing voids and where the calculated FOS was less than 1.5, alternative scenarios were tested to achieve the target

All of the highwalls in fresh rock achieved a FOS ≥ 1.5.

Over steepened, highly weathered and soil horizons at the top of highwalls typically have FOS values < 1.5. However, these horizons are usually just a few metres thick. They have been excavated to batter angles of around 45° and could be re-shaped or be allowed to erode back to a geotechnically stable slope of around 27° (1V in 2H).

All of the overburden dumps in which the base of the spoil is not inundated by a final void lake have critical FOS values ≥ 1.5.

All of the overburden dumps in which the base of the spoil is inundated have a critical FOS <1.5. Alternative geometries have been analysed that would achieve a critical FOS of 1.5. Any of the solutions would require extensive movement of spoil. If a FOS ≥ 1.5 is required, the most practical solution, rather than building buttresses out of imported Cat 3 spoil would be to simply doze the existing spoil down to angles that would range between 23° to 19° the angle depending specific pit geometries.

Although outside of original consideration, a simple numerical analysis has been undertaken on cross section IPE-2-2 and this demonstrates that while the FOS is 1.38 the amount of movement expected due to softening of the spoil due to inundation is less than a metre. An alternative approach to designing to a FOS could be to design to a maximum deformation.

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Engineering Geologist

Paul Maconochie RPEQ 5828
Principal Geotechnical Engineer

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APPENDIX K MINING WASTE MANAGEMENT PLAN

C&R CONSULTING
Geochemical & Hydrobiological Solutions Pty Ltd
ABN 72 077 518 784

Underground Coal Gasification / Coal Seam Gas Investigations
Mineralogical, Geological, Petrographic and Soils Services
Hydrogeomorphic and Palaeogeomorphic Evaluations
Terrestrial and Aquatic Fauna and Flora Surveys
Climate History and Extreme Events Analysis
Contaminated Site and Mine Water Analysis
Environmental Compliance and Monitoring
Estuarine and Marine Water Assessments
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ISAAC PLAINS COMPLEX

2018 Mining Waste Management Plan

REPORT PREPARED FOR:

stanmore IP Coal

Date: June 2018

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Dr Chris Cuff Director	Dr Cecily Rasmussen Director
28/06/2018	28/06/2018
Date	Date

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6. The assessment of the site/s is based on information supplied by the client, and on-site inspections by C&R Consulting.
7. The report reflects both the information provided to C&R Consulting in documents made available for review and the results of observations and consultations by C&R Consulting staff.

SUMMARY OF RELEVANT INFORMATION

Project Title	2018 Mining Waste Management Plan
Property Location	Isaac Plains Complex
Property Description	Open cut coal mine
Project Purpose	Update the existing Mining Waste Management Plan to accurately reflect current site activities, integrate the new mining area to the east and reflect current Environmental Authority **Condition E6**
Project Number	
Client's Details	
Nominated Representative	Belinda Parfitt
Title/Position	Senior Advisor – HSEC
Company	Stanmore IP Coal
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Acknowledgements:	

DOCUMENT CONTROL

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Draft 2	S Kennare	27/07/2018	B Parfitt / R Oldham	28/06/2018
FINAL	S Kennare	28/06/2018	-	-

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1. INTRODUCTION

Isaac Plains Complex (IPC) commissioned C&R Consulting Pty Ltd (C&R) to provide a Mining Waste Management Plan that incorporated both the mining operational areas of Isaac Plains Mine (IPM) and the recently approved Isaac Plains East Mine (IPE). Collectively, IPM and IPE are knowns as the Isaac Plains Complex (IPC). The purpose of this report is to comply with **Condition E6** of the Isaac Plains Environmental Authority (EA) (EPML0093213).

1.1 SCOPE

In the context of this plan, mining waste refers to:

- Coal reject and tailings generated at the Coal Handling and Preparation Plant (CHPP); and
- Overburden (spoil).

IPC have been approved to construct and operate in-pit tailings storage. Management of tailings mining waste within the proposed in-pit tailings storage has been detailed in a separate stand-alone document – Isaac Plains Complex Tailings and Rejects In-pit Disposal Management Plan (Golders Associates, 2018).

IPC currently utilises a belt filter press to dewater the tailings. The dewatered tailings are combined with rejects and then trucked to designated locations within the mine pits for disposal. Management of rejects and tailings from this process is described in this report.

This Mining Waste Management Plan has been developed to comply with the Isaac Plains Coal Mine Environmental Authority (EPML00932713) as outlined below.

Condition E6 Mine Waste

A Mining Waste Management Plan must be developed and implemented by an appropriately qualified person for every stage of the mining activities. The Mining Waste Management Plan must be submitted to the administering authority by 29 June 2018 for review and comment. The Mining Waste Management Plan must at a minimum include:

a) Characterisation programs to ensure that all mining waste is progressively characterised during disposal for net acid producing potential, salinity and the following contaminants analytical parameters: pH, electrical conductivity (EC), Acid Neutralising Capacity (ANC), Net Acid Generation (NAG) (reporting NAG capacity and NAG pH after oxidation), Total Sulphur (S), Chromium Reducible Sulphur (SCR), Boron (B), Cadmium (Cd), Iron (Fe), Aluminium (Al), Copper (Cu), Magnesium (Mg), Manganese (Mn), Calcium (Ca), Sodium (Na), Zinc (Zn and Sulphate (SO_4);

b) Characterisation programs to ensure that the physical properties of the mining waste is progressively characterised during disposal;

c) The availability or leachability of metal from the mining waste;

d) Quantification of PAF from mining waste present;

e) Review impacts of the PAF mining waste on the rehabilitation;

f) Management actions for mining waste that has been identifies as having a high availability or leachability of metals;

g) Management actions for mining waste that has been defined as PAF;

h) Identification of environmental impacts and potential environmental harm;

i) Contingency plans and emergency procedures for non-routine situations;

j) Periodic review of environmental performance and continual improvement;

k) Containment of tailings;

l) Records to indicate locations and characteristics of tailings stored within the tailings stored facility;

m) The management of seepage and leachates from tailings storages both during operation and the foreseeable future;

n) The control of fugitive emission to air; and

o) A program for progressive sampling and characterisation to identify acid producing potential and metal concentrations of tailings.

Condition E6 sub-conditions **(L to N)** relating to management of tailings within the in-pit tailing storage facilities are not addressed within this document. Please refer to the Isaac Plains Complex Tailings and Rejects In-pit Disposal Management Plan (Golders Associates, 2018) for further details.

1.2 MINE DETAILS AND LOCATION

IPC is located within the area administered by Isaac Regional Council on both Freehold Land and State Leasehold Land in Central Queensland, approximately 10 km to the northeast of Moranbah and 140 km south-west of Mackay (Figure 1). The project is situated immediately north of the Peak Downs Highway between Moranbah and Coppabella and has a rail loop off the south of the Goonyella Branch Rail Line (Figure 2).

IPM, on ML70342, can be separated into five primary pits, N1, N2, S1, S2 and the S3 Pits (Figure 2). The N pits are north of Smoky Creek which bisects the mining lease area. The three S pits are south of this watercourse (Figure 2). The S3 Pit is currently acting as the main water storage for the site, storing mine-affected water for re-use on site and potential controlled releases.

IPE includes four Mining Leases, ML700016, ML700017, ML700018 and ML700019 and is located directly east of the IPM ML70342 (Figure 2). Environmental approvals for the IPE were granted in early 2018 with operations commencing mid-2018. The Isaac Plain East project is underlain by Permian coal measures, assigned to the Leichardt seam of the Rangal Coal Measures. These coal seams are the down dip extension of the coal seams mined at the adjacent IPM.

The combined existing operations of IPM and the operations at IPE will be referred to hereafter as Isaac Plains Complex (IPC).

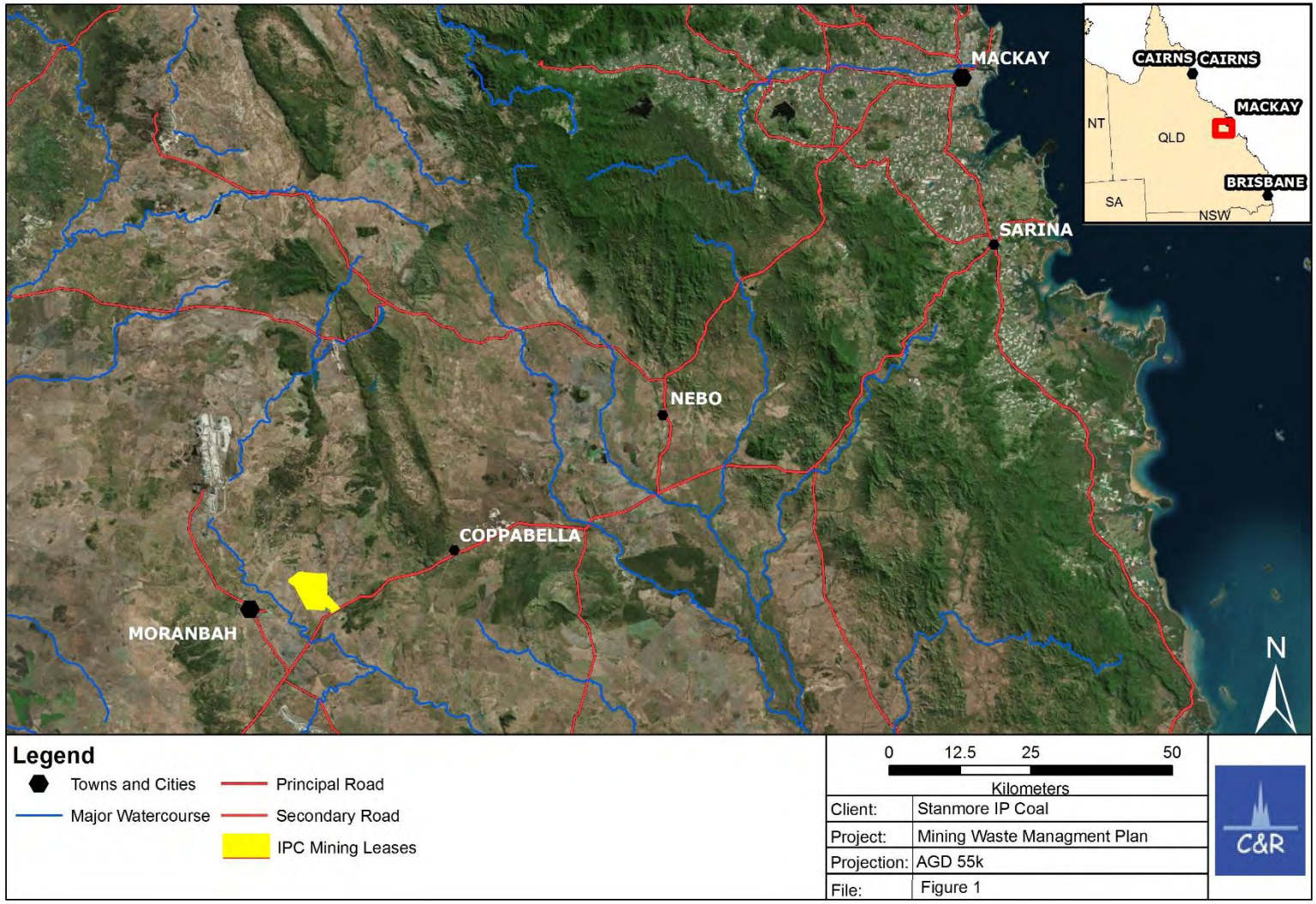

Figure 1: Locality of Isaac Plains Complex

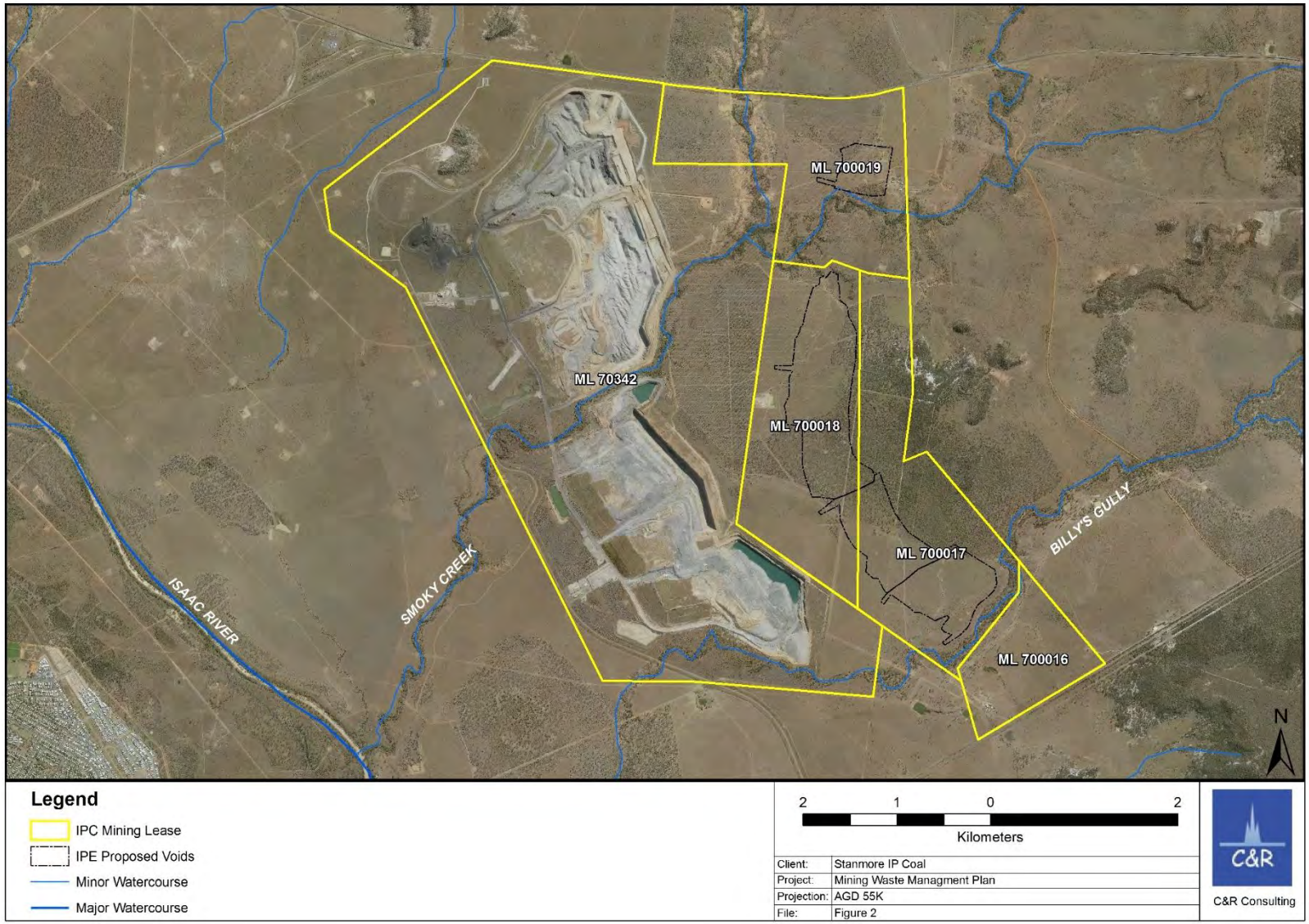

Figure 2: Isaac Plains Complex mining leases

1.3 MINING AND INFRASTRUCTURE

Overburden is removed by a combination of drilling, blasting, bulldozing, dragline and excavator/truck methods. Overburden material from open cut areas is placed in out-of-pit dumps and previously exhausted pits. Once each pit has been mined, residual voids will be left in preparation for rehabilitation in accordance with EA requirements. When final landform contours have been completed, topsoil will be replaced, and disturbed areas replanted with suitable predefined vegetation. As of March 2018, approximately 248 hectares of rehabilitation had been completed on the outer spoil dumps at IPC.

IPC has approval to produce 4 million tonnes of product coal per annum through a combination of truck & shovel and dragline operations.

The major components of the IPM include:

- Five open cut pits;
- In-pit spoil dumps;
- Access and haul roads;
- ROM coal stockpile;
- Coal handling and preparation plant (CHPP) including crushing facility, a coal stockpile pad, a temporary reject stockpile, a rail loop and rail loading facilities;
- Mine infrastructure areas including office buildings, workshops and a septic system and transpiration trench; and
- Mine water management structures.

The major components of IPE are proposed to include:

- Five open cut pits;
- In-pit spoil dumps;
- Access and haul roads; and
- Mine water management structures.

1.3.1 OVERBURDEN

IPM open cut mining reserve in the deposit area has been estimated at 1.7 Mt, based on a strip ratio of 16:1 bank cubic metre per tonne (bcm/t) with a maximum depth of approximately 80 m. Based on this rate, and prevailing economic limits, the life of mine as an open cut deposit is estimated at approximately one year. Mining in ML 70342 is currently open cut and is based on a strip mining technique with waste removed by a combination of truck and excavator removal, cast blasting, dozing and dragline spoiling. Maximizing dragline usage is critical in order to reduce waste removal costs in high strip ratio mines such as IPC.

The IPE deposit area has been estimated at 11 Mt, based on a strip ratio of 11:1 bcm/t with a maximum depth of approximately 100 m. Based on this rate, and prevailing economic limits, the life of mine as an open cut deposit is estimated at approximately 8 years. Mining in MLs is open cut and is based on a strip mining technique with waste removed by a combination of truck and excavator removal, cast blasting, dozing and dragline spoiling.

1.3.2 COAL REJECTS

A disposal system is currently employed to manage coarse and fine rejects produced during the coal preparation process. This system involves the use of belt filter presses. Under this system fine coal rejects recovered from the process are then added to the coarse reject

stream and disposed of in-pit.

Stanmore proposes an in-pit tailings and coarse rejects disposal facility, which is the subject of the Isaac Plains Complex Tailings and Rejects In-pit Disposal Management Plan (Golders Associates, 2018).

The belt filter presses to create the ability of disposing of 'dry' fine tailings. Belt press filters compress the cake between two layers of filter cloth medium by passing a sandwich of cloth and filtrate over a series of high pressure rollers to squeeze free water from the resulting cake. The final cake material is still "saturated" and water is removed by compression and shearing only. The final discharged cake is disposed of in-pit as part of the Isaac Plains co-disposal process.

If a poorly consolidated cake forms, usually when processing fine feeds with high levels of slaking clays, the cake can be squeezed out from between the cloths. The final discharged cake is then thin, sticky and very difficult to handle. The presence of some fine grit in the feed helps to provide better cake structure, but at the expense of increasing the quantity of material to be processed through the belt press filters.

Through the use of belt filter presses, the fine rejects are dewatered to around 70% solids (30% moisture), recovering water at the CHPP, and negating the need for a tailings dam.

Reject generation at IPM is in the vicinity of between 30,000t and 60,000t of coarse reject and 10,000 and 30,000t of fine reject per month. This generally leads to a total production of between 350-400,000t of coarse reject and 150-250,000t of fine reject per annum.

1.3.3 REHABILITATION

Prior to 30 June 2022, all rehabilitation will occur on ML70342, where mining operations have ceased. Between June 2022 and June 2025, progressive rehabilitation will continue on ML70342, as well as commence on overburden emplacement areas on the IPE mining leases.

Between June 2025 and June 2029, all mining operations are expected to cease and rehabilitation will be completed on all remaining areas, including infrastructure areas. Proposed rehabilitation during the plan of operations period ending 30 June 2019 is shown in Figure 4. The proposed rehabilitation covers an area of approximately 146 ha, of which 99 ha requires landform reshaping, topsoiling and seeding and 47 ha requires topsoiling and seeding. According to the EA, 240 ha are scheduled to be rehabilitated by June 2022.

Based on the current plan of operations, where 146 ha of rehabilitation are planned by June 2019, Stanmore is well placed to achieve progressive rehabilitation of 240 ha by June 2022.

2. SITE CONDITIONS

2.1 CLIMATE

The climate in Central Queensland is seasonally arid. Rainfall in the area is notoriously unreliable in its intensity and duration, both temporally and spatially. Intense rainfall events throughout the summer months (wet season) dominate the climate cycle (Figure 3). The majority of these rainfall events occur in distinct, spatially separated cells across the landscape. Intense rainfall events are typically associated with tropical cyclone activity on the coast, and the remnant low pressure systems that move inland.

Far less rainfall is experienced throughout the dry season, with 35% of total rain typically falling in the winter months (May to October). Evaporation tends to exceed rainfall for almost all days of the year except during intense rainfall events (Figure 3). The extended dry season causes baking and crusting of surface soils. These processes lead to greatly reduced infiltration of surface soils unless suitable pre-wetting can be provided by gentle rain prior to the wet season. If pre-wetting rains have not occurred, >90% of rainfall can eventuate as runoff throughout catchments altering stage-discharge relationships within waterways.

The distribution of rainfall over the previous wet season will have a dramatic role in determining the status of rehabilitation across Bowen Basin Coal Mines. An above-average wet season can result in almost 100% groundcovers being experienced in areas where buffel grass is prevalent, and can also result in significant erosion and incision of rills. A below-average wet season can result in ground-covers reducing to below targets (i.e. below 70%) while the dry-matt cover drastically increases, and minimal erosion is expected to occur when compared to previous rehabilitation inspections.

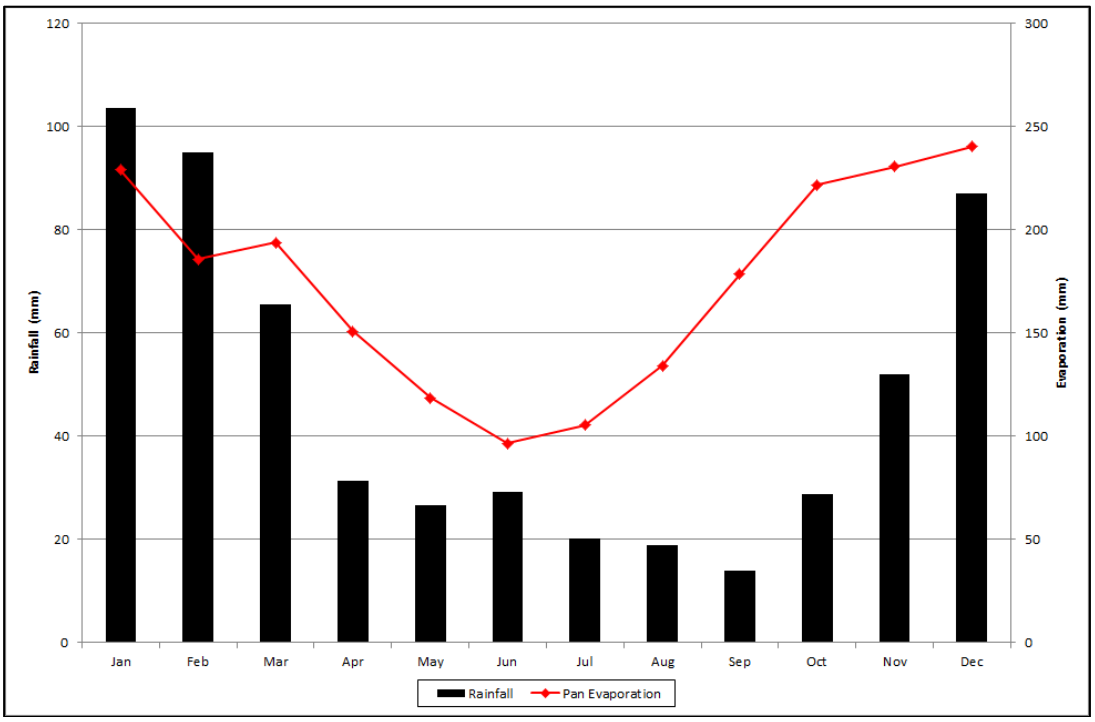

Figure 3: Average monthly rainfall and evaporation values for the region

2.2 GEOLOGY

IPC is located within the north western regions of the sedimentary Bowen Basin comprising essentially Permian and Triassic rocks. The two mining projects (IPM and IPE) mine through similar geological strata. The majority of the land surface is made up of deeply weathered profiles of Permo-Triassic rock with *in situ* weathering and soil development and minor alluvium that, for the most part, conceal these rocks across the lease.

Poorly consolidated, sandstone of Cenozoic (Tertiary) age forms part of an earlier thin sequence that covered much of the district. This sequence, and older lithologies, were eroded down to a flat surface (peneplain), subsequently capped by duricrust (ferricrete) or laterites containing secondary carbonate minerals. Locally the sequence has been eroded back to a table top leaving behind mesas of sandstone on and around the lease.

Prior to and during the Tertiary period of erosion volcanic activity produced widespread basalt lava flows. At least two basalt flows have taken advantage of an earlier deep river passing down the eastern length of the lease. Remnants of the lava flows persist in mesas east of the lease and part of the northern table top. The remainder across the site has been weathered down to the current alluvial flat.

The coal beds exist as layers in packages of sedimentary beds (Coal Measures), reflecting the fact that coal seams split, thicken and thin, and are interfingered with other sediments at the time of formation. These sediments often include relatively porous sandstones conducive to groundwater flow. The coal beds themselves are frequently significant conduits to groundwater and provide local aquifer systems.

The economic coal measures at IPC are the Rangal Coal Measures is part of the Late Permian Blackwater Group which extends throughout the western half of the Bowen Basin.

2.3 SOILS

Several soil types are located within the IPC Mining Leases. These are described in the Integrated Isaac Plains Project Expansion Area Soil and Land Suitability Study (Matrix Consulting 2009) and include:

- A1 Alluvial sandy duplex soil.
- A2 Red Duplex with thin sandy clay loam overlying hard, coarse structured brown clay.
- B1 Uniform grey/brown clays with areas of gilgai on flat to gently undulating plains.
- B2 Sandy uniform clay or thin red/brown duplex soils overlying weathered shale/mudstone on undulating plains. Sandy surface which is often gravelly.
- B3 Crusting and often gravely sand clays associated with mesa scree slopes.
- B4 Melan-holed clay lowlands.
- B5 Hard setting, gravely brown clay.
- E1 Sandy duplex on undulating plains.
- R1 Residual low hill of lateritised basalt.

These soil types can be grouped into the following three broad categories under the Australian Soil Classification system: Brown Sodosols, Red Chromosols and Vertisols.

2.3.1 SODOSOLS (A1 B5 E1)

This soil type occupies older alluvial plains associated with the Isaac River. It occurs on flat plains and is susceptible to occasional flooding. Soils are uniform silty clays and mostly

cleared of vegetation. Nutrient levels are strong within the surface 30-40 cm layer, with levels decreasing below this depth. The surface structure is fine sandy clay over a silty clay profile with substantial rooting depth. The soil is not reactive, although the stratified alluvial nature of the medium is such that it should not be used for water holding structures. This soil will respond well to nitrogen application for pasture establishment and is best stripped dry. The top 30 cm may be stripped for use as topsoil with potential to take more subject to pH and EC levels. Material below 30cm within the B2 horizon may be slightly sodic and should therefore be avoided. The top 30cm within the soil profile will be useful on rehabilitation of level surfaces such as dump tops. The area currently supports strong buffel pasture and is very suitable for grazing. However, no cropping potential is indicated.

2.3.2 CHROMOSOLS (A2 B2 B3)

This soil occupies mid to upper slope positions within undulating lands. The surface structure is firm and sandy with ironstone gravel common. A significant and productive grazing soil but lighter texture and reduced soil depth would reduce moisture storage and increase drying rates with the onset of the dry season. These soils have fairly hard structured light clay subsoils over weathered material but appear to be well drained to at least 40 cm in most instances. There are problems apparent from subsoil sodicity and salinity below 30 cm depth which is not assisted by its coarse structure. General fertility is not high although reasonable for grazing lands. The soil is well suited to grazing and pasture improvement with favourable responses to fertiliser addition expected. The soil should preferably be stripped when dry to minimise action and structural decline. The top 20 cm may be stripped for topsoil only. The soil will be useful on rehabilitation in a variety of situations. The soil has a sandy surface and supports strong Buffel pasture.

2.3.3 VERTISOLS (B1 & B4)

These are productive grazing soils with desirable all round qualities on very low slopes with reduced degradation potential from erosion following dry periods. The soils are brown to grey, moderately well structured, generally non-cracking clays which support abundant Buffel pasture. Nutrient levels are quite good on the surface layers. However, saline and sodic conditions prevail immediately below 20 cm depth. Some of the area may include shallow (up to 15 cm deep) gilgai of brown sandy clay interspersed with grey clay depressions. The surface structure is sandy and firm with areas of ironstone gravel. In most instances drainage is not impeded to 40 cm. A high cation exchange capacity will facilitate favourable responses to fertiliser application for pasture improvement. Preferably, the soil should be stripped when dry to minimise compaction and structural decline. The top 20 cm may be stripped for topsoil with little potential for stripping to any deeper depths. The soil will be useful on rehabilitation in a variety of situations.

2.4 SOIL SUSCEPTIBILITY

Land capability classification identifies the required soil and vegetation inputs to ensure effective management for crop growth and grazing. Class 3 soils (the majority around the site) are prone to erosion and will require erosion control measures, such as:

- Retention of sediment and sediment-laden runoff;
- Diversion of runoff around the site (if off-site runoff becomes an issue);
- Containment of contaminated run-off and onsite treatment as necessary;
- Vegetation management in the Environmental Buffer Zone; and
- Rapid stabilisation of disturbed areas to prevent erosion from disturbed and/or exposed topsoil.

3. MINING WASTE DESCRIPTIONS

3.1 ACID ROCK DRAINAGE

Mining exposes material deep within the ground to oxygen. Mining also breaks the structure of the material from a compacted to a loose form, maximising the surface area available for oxygen ingress. Pyrite (FeS_2) is a mineral formed diagenetically by microbial action, usually on seawater sulphate, under anoxic conditions. Pyrite is common in the geology of the Bowen Basin, including at IPC. Oxidation of the pyrite mineral (i.e. exposure to oxygen), generates sulphuric acid with the accompanying release of metal contaminants into the ambient water. Following exposure to water, the metal contaminants and acidity are transported by local runoff to dams, pits or creeks.

Bowen Basin rock formations also possess large volumes of calcium carbonate ($CaCO_3$), an alkaline material that counteracts the acidity generated by pyrite and is typically found in the overburden.

3.2 OVERBURDEN QUALITY

Open cut mining generally exposes stratigraphic material to direct chemical and physical weathering at much higher rates. Spoil material is often liberated from the open cut pit and dumped as boulder sized material. Direct exposure to weathering processes can cause this material to disintegrate into cobble / pebble and sand sized material within a few years, increasing the ability for sheet flow and erosion to remove sediments from spoil dumps. Spoil material is often dispersive, increasing the rate of breakdown and liberation into surface water flows. Ready erosion of this material then occurs from rainfall and runoff, often evident in spoil dumps.

Overburden testing undertaken by Geo-Environmental indicated an alkaline subsoil with pH values (in a 1:2 soil:water ratio contrasted to typical testing undertaken in a 1:5 soil:water ratio) typically above 9, suggesting seepage through spoil dumps may be alkaline, causing waters stored in dams across site to increase pH with residence time.

Sodicity (a measure of the sodium based dispersion of a soil) values of the spoil are variable with 44% of the samples tested during the mining lease approvals stage considered to be moderately sodic, with the remaining samples considered to be slightly sodic. This indicates that there are areas of overburden that will be subject to relatively high erosion rates compared with non-sodic samples.

3.3 OVERBURDEN DISPERSION AND BREAKDOWN

Rock material (overburden or waste rock) above the coal seam has little economic value and the material needs to be removed prior to accessing the coal seam. The material is sedimentary (sand, silts, mud and clay), compressed over time to form hard rock. On disturbance this material is highly prone to break down from large boulder sized rocks to a sand/gravel (Figure 4). Disturbance associated with mining activities is often exacerbated by (a) exposure to oxygen, and (b) by the swelling and shrinking of clays held within the material as a function of wetting and drying (e.g. seasonal rainfall patterns of the Seasonally Arid Tropics). Clays within the material are typically dispersive or subject to slaking on wetting and will disaggregate and decrease the structure of the rock / soil. This is shown in Figure 5 and Figure 6 where mudstone and sandstones were immersed in water for up to 80 hours and repeated photographs taken (C&R Consulting, 2012).

Once the sedimentary rock has broken down to gravel / sand sized particles it becomes considerably more subject to erosion by runoff. The slopes on overburden dumps enhance runoff velocities, promoting transport of this material down slope and either back into the pit or into local dams as sediment.

Evidence of dispersion can be seen where thin crusts have formed on the surface of spoil dumps. These crusts form when the material has been wetted, the clay particles dispersed into the water column, and the water component is subsequently removed by evaporation (C&R Consulting, 2012).

Figure 4: Breakdown of overburden in spoil from rock to gravel through natural weathering processes.

Time 0 hours | Time 2 hours | Time 80 hours

Figure 5: Breakdown of 'hard' sedimentary rock (mudstone) in water from a nearby coal mine

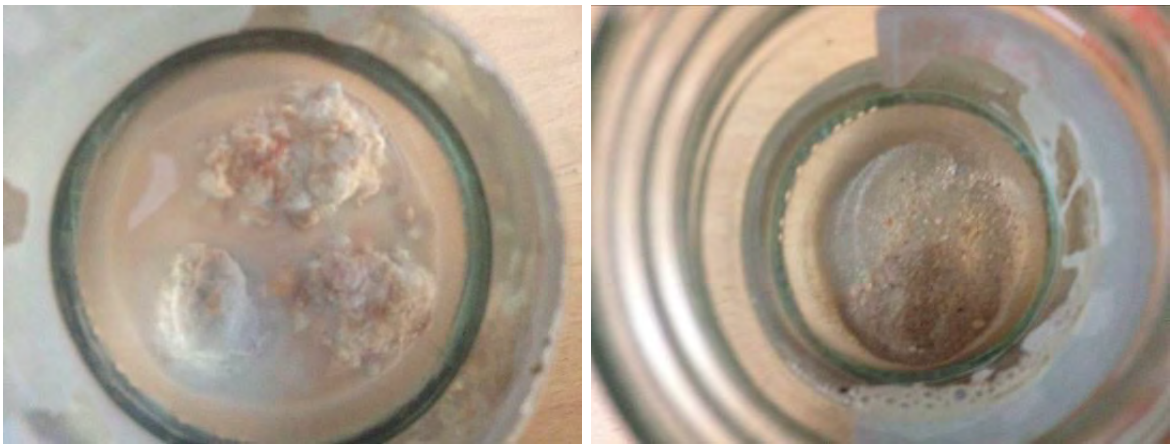

Figure 6: Breakdown of soft sedimentary rock (sandstone) after 2hrs (left) and 20hrs (right)

3.4 DEFINITIONS

Acid Neutralising Capacity (ANC)	A measure for the overall buffering capacity against acidification for a solution (e.g. acid sulphate soil solution). Conventionally expressed as equivalent % $CaCO_3$ or in kilograms of sulphuric acid (H_2SO_4) per tonne of rock.
Exchangeable Sodium Percent (ESP)	The percentage of sodium within the sample. Values above 6 typically indicate that the material may be dispersive.
Maximum Potential Acidity (MPA).	Calculated from the total amount of sulphur in a sample and is an estimate of the maximum acidity a soil can generate.
Net Acid Generation (NAG)	A direct measure of the acid potential of a sample containing sulphide. It consists of: • **Final NAG pH** – this is the pH of a slurry of the sample that has been oxidised; and • **NAG Value** – this is the measure of acidity after oxidation of the sample and is expressed in KgH_2SO_4/tonne of sample.
NAPP (Net Acid Production Potential)	NAPP is a theoretical calculation to assess if a sample may produce acid. If in the equation: NAPP = MPA – ANC, If MPA < ANC and NAPP is negative, then the sample may have sufficient ANC to prevent acid generation. If NAPP is positive then the sample may be acid generating.

	Similarly, the ratio ANC:MPA may be used to assess the risk of acid generation. If the ratio is greater than 1, then the likelihood of acid generation decreases with the magnitude of the ratio. Conversely, if the ratio is less than 1, then the risk of acid generation increases as the ratio decreases.
Potential Acidity **S_{CR} or S_{POS}**	Measure of sulphide content and used to calculate potential sulphidic acidity, expressed as: • S_{CR} is used for determining net acidity in sediments with lower percentage of sulphide and/or significant amounts of organic material • SPOCAS (Suspension Peroxide Oxidation Combined Acidity and Sulphur) is generally used for determining net acidity for coarse textured sediments
TSA (Total Sulphidic Acidity) or TPA (Total Potential Acidity)	Measure of acidity from sulphide oxidation minus self-neutralising capacity.
Net Acidity.	Providing there is consistency of unit (%S or mol H^+/tonne), then net acidity may be calculated: • Net Acidity = Potential acidity + actual acidity + returned acidity – (ANC/FF). Where FF is the fineness factor.
Fineness Factor (FF)	An empirical factor applied to the ANC result in acid-base accounting to allow for the poor reactivity of coarser carbonate or other acid neutralising material.

4. WASTE CHARACTERISATION

4.1 OVERBURDEN AND REJECT ANALYSES (2005 – 2012)

Waste characterisation projects have been undertaken across the IPC with the majority of projects a function of IPM. Operational open cut mining at IPM will cease within one year, with future opportunities reliant on exploration activities and results. A high percentage of outer slope waste rock has been rehabilitated over a series of campaigns spanning several years starting in 2007 and continuing to present day at IPM.

Overburden and coal reject characterisation programmes were undertaken by Geo-Environmental Management (GEM) in 2005 for IPM. In 2012 C&R was contracted to undertake an environmental geochemical assessment of coal rejects and overburden from IPM. Data gained from this assessment improved the understanding of chemical stability and any contaminant transport processes within the rejects. The results demonstrated that there were no acid metalliferous drainage concerns at IPM from the overburden, but seepage through the overburden dumps was expected to be alkaline and slightly saline (C&R Consulting, 2012).

These test results are consistent with operational experience at IPM over the operational life including alkaline pit water quality, the absence of any problems with rehabilitation from acidic overburden and no other observed signs of acid drainage.

Table 1: Geochemical summary of overburden at IPM between 2005 & 2012

Parameter Range	Implications
pH between 7.0 to 9.7	**Alkalinity:** • Seepage through the disturbed overburden is likely to produce waters with a higher alkalinity than the surrounding surface waters.
EC between 274 to 1136µS/cm	**Salinity:** • Slightly saline. • Seepage through disturbed overburden is likely to produce waters with a higher salinity than the surrounding surface waters
Sodium Adsorption Ratio (SAR) between 5 – 15	**Sodicity / Dispersivity:** • Overburden dumps are likely to be slightly dispersive and subject to water erosion.
All samples have an ANC/MPA Ratio above 1 No samples tested NAPP Positive	**Acid buffering capacity:** • Overburden has a higher acid buffering capacity than its potential to produce acid.
Selenium, antimony and arsenic in overburden: Enrichment compared to average crustal values. Molybdenum, selenium – Highly soluble. Arsenic and antimony – Low solubility	**Potentially elevated contaminant levels:** • Selenium and molybdenum concentrations in runoff / seepage from overburden may be elevated compared to surrounding background values.

The GEM 2005 results found that arsenic and selenium in the coal rejects were particularly soluble and also elevated. Subsequent analysis and geochemical modelling by C&R Consulting (2012) detected leachable aluminium and molybdenum concentrations that may also be of concern. The actual concentrations of metals analysed in the rejects are all well below Residential Contaminated Land Guidelines (HIL-A) as outlined in the National Environmental Protection Measure for Site Contamination (2013).

Table 2: Geochemistry summary of coal rejects at IPM between 2005 & 2012

Parameter Range	Implications
Generally all $pH_{1:2}$ values (except from one hole) are below 6.0 with an average of 5.2 for coarse reject and an average value of 4.0 for fines	**Alkalinity:** • Fine coal reject is generally slightly to moderately acidic and coarse coal reject is slightly acidic.
$EC_{(1:2)}$ for fines is 903µS/cm and 576µS/cm for the coarse reject	**Salinity** • Fines are more saline than coarse reject. However fines and coarse reject are less saline that overburden.
One coal reject sample out of seven has an ANC:MPA Ratio<1 with a NAPP value of 8kg H_2SO_4/t. Three of five fines samples have an ANC/MPA ratio <1 with NAPP range from 7 to 42kg H_2SO_4/t.	**Acid Buffering Capacity:** • There is a moderate chance of acidity production from the fine coal reject. • Coarse rejects have a slight chance of producing acidity but the majority of the coarse reject have moderate acid neutralising capacity.
Enrichment of silver, arsenic, cadmium, antimony and significant enrichment of selenium. Highly soluble arsenic, cobalt, copper and selenium.	**Potentially elevated contaminant levels:** • Arsenic and selenium concentrations can be high in waters draining coal reject stockpiles. • Copper, cobalt, antimony, and cadmium may be elevated.

4.2 OVERBURDEN AND REJECT ANALYSES (2016 – 2018)

As a function of IPM and IPE's close proximity and comparable geology, the analyses undertaken are considered representative for the IPC as a whole. Environmental geochemical assessments were undertaken in 2016 by Ardent Group Pty Ltd (Ardent, 2016), 2017 by Terrenus Earth Sciences (Terrenus, 2017) and 2018 by C&R Consulting to determine the environmental geochemical characteristics of potential overburden and coal reject materials from the IPC.

In 2016 Ardent Group was engaged by Stanmore to specifically undertake the initial assessment of the acid mine drainage potential within the IPE coal deposit. Drill hole data indicate that the overburden and coal seams have a consistent distribution and lithology across the area of the project. Within the pit boundary it is estimated that there is approximately 90% overburden with 7 % coal product available. The lithology suggests that overburden will consist of the following proportions (Ardent Group, 2016):

- 43% siltstone;
- 24% unconsolidated sediments;
- 24% sandstone; and
- 9% carbonaceous siltstone.

The characterisation of all materials has been separated into the geological mediums listed above plus the inclusion of coal rejects. Mine waste characterisation on site must ensure that the physical properties of mining waste are progressively characterised to ensure the manner of disposal remain appropriate. All laboratory analyses completed on overburden since 2016 have been collated and presented in a series of figures to express the level of inherent environmental risk and management posed by IPC mining waste. It is the assumption that all laboratory data and technical results in the report are accurate and correct.

4.2.1 pH and Electrical Conductivity

The samples displayed in Figure 7 are collated results from the mine waste geochemical analysis completed by Terrenus in 2017 and C&R Consulting in 2018. All geological mediums, including coal rejects, have been included, demonstrating that the range of pH is steady between 8.2 and 9.7 pH units. The slightly alkaline soils of IPC are common across many mining leases within the Bowen Basin. While the increased alkalinity will help to counteract any occurrence of acid forming properties within the mining waste, it will also consequently increase the alkalinity of runoff during rainfall events.

Electrical conductivity, being a numerical value, has a far greater range than that of pH (a negative log base 10 scale). With an average concentration of 802 µS/cm, unconsolidated overburden produced the lowest concentration (102 µS/cm) while siltstone recorded the highest concentration of 1,290 µS/cm. Figure 7 shows that although reaching the upper limits of the growth spectrum at 1,290µS/cm, vegetation should successfully grow with salt levels mobilising from within the overburden.

Samples collected by Ardent Group in 2016 have not been included within Figure 7 as pH and electrical conductivity concentrations were analysed via saturated paste and cannot be accurately assessed against the chosen analysis completed by both Terrenus and C&R Consulting.

Based on the current rehabilitation success level at IPM and the similar geological mediums assessed at IPE, it is considered than neither pH nor EC within overburden will be detrimental to vegetation growth. Mine affected water from overburden stockpiles is managed directly with the IPC Water Management Plan (WRM, 2018) and IPC Soil Erosion Sediment Control Plan (C&R, 2018).

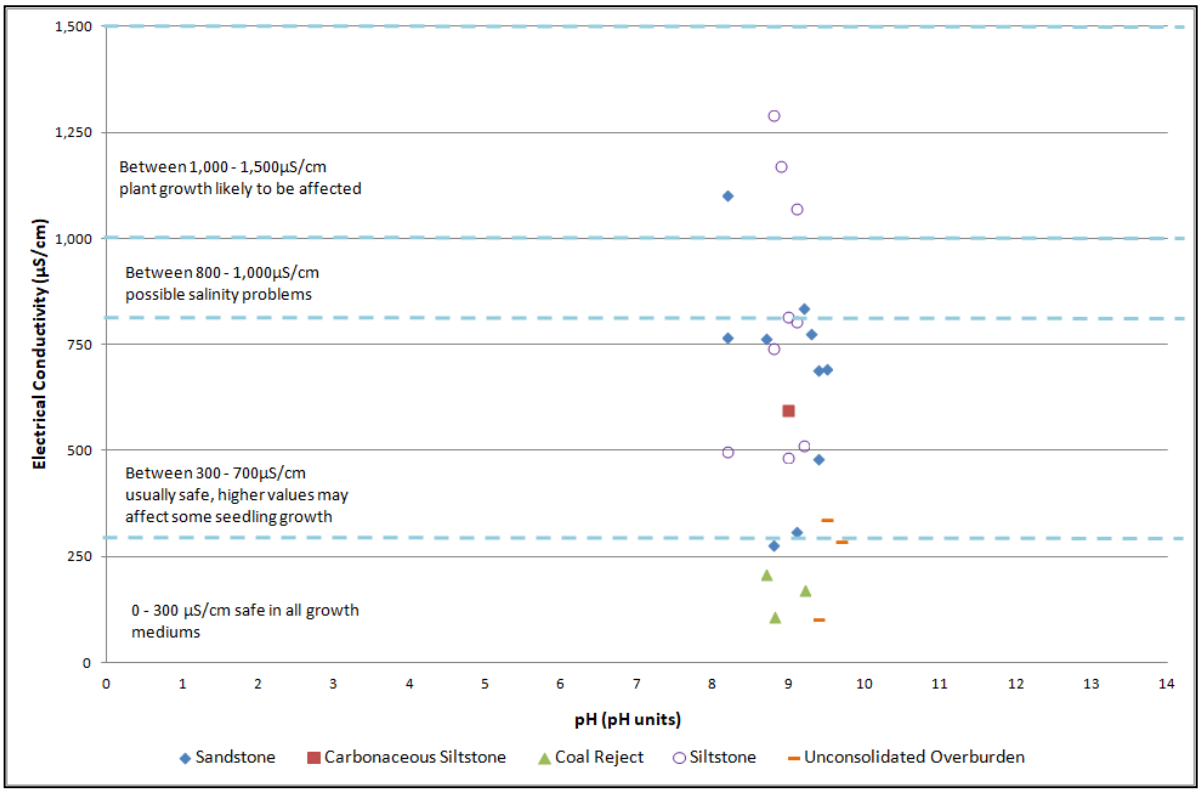

Figure 7: Range of pH and electrical conductivity of samples analysed between 2017 and 2018.

4.2.2 ACID GENERATING POTENTIAL

The collation of 51 samples collected from across IPC over a three year period show that the majority of the samples exhibit non acid forming characteristics. These have been presented within the Ardent Group (2016) and Terrenus (2017) reports. However, the highlighted section within Figure 8 raises the necessity for management at IPC with all geological mediums presented within the area bordering uncertainty. It is important to note that the geochemical analyses completed on the soil samples were completed in a controlled manner and do not specifically replicate site conditions. These analyses, however, provide the closest indication to potential reactions that may occur on site when overburden and coal rejects are exposed to oxidation and environmental conditions.

However, using lower risk, more conservative, criteria, C&R Consulting believe the highlighted area on Figure 8 indicates an area of potential risk. Uncertainty does not mean negligible risk. Consequently, a risk minimisation approach should consider all samples across all geological strata with a potential risk. This level of conservatism will ensure IPC Management is exposed to a minimum level of risk from adverse events.

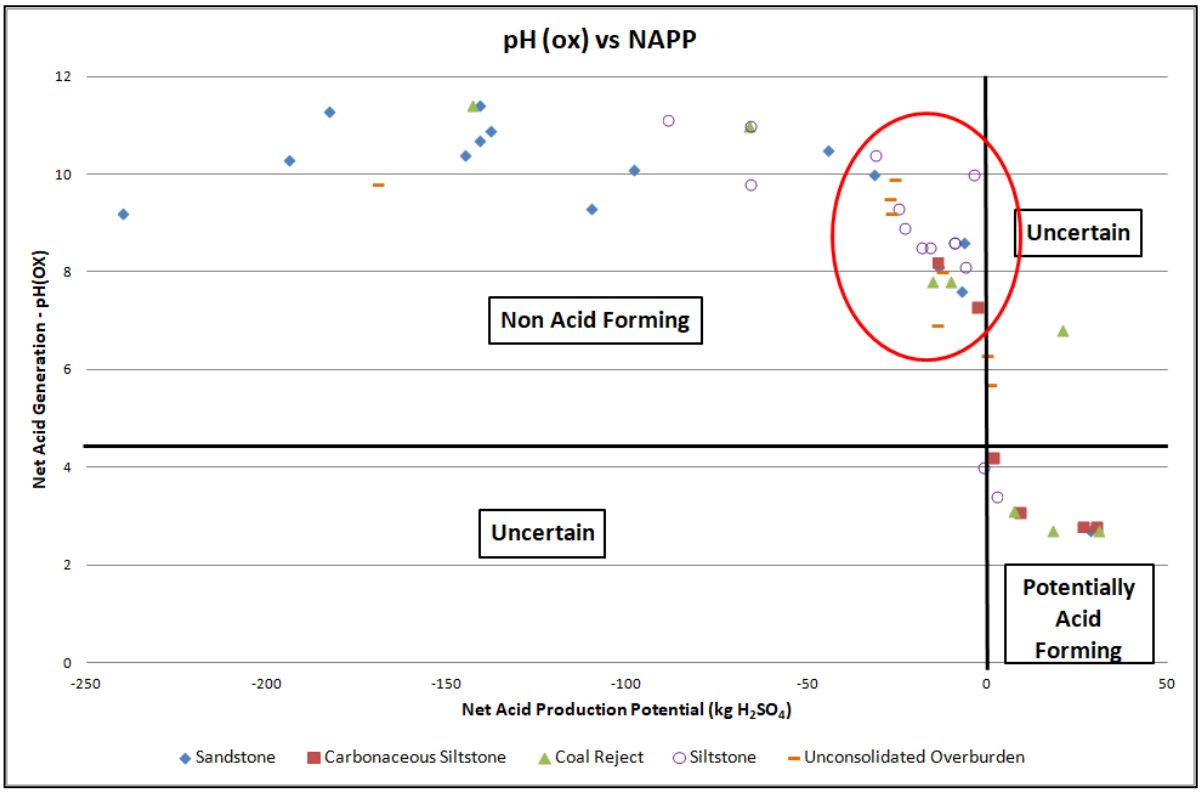

Figure 8: Net acid generation pH (NAHpH) Vs Net acid producing potential (NAPP)

Figure 8 indicates that several carbonaceous siltstone, siltstone and coal rejects contain concentrations of low pH and positive values of net acid producing potential (H_2SO_4). In comparison, the majority of sandstone samples reflect a higher pH and negative net acid producing potential (Figure 8). Consequently, it is recommended that the lithologies positioned within the range of "**Uncertain**" (Figure 8), and those within the range of "**Potentially Acid Forming**" (Figure 8), are buried within the void and capped with sandstone or unconsolidated overburden. The specific IPC characterisation and management programme is outlined in Section 5.

The acid neutralising capacity against total sulphur within the 51 potential mine waste samples collected, is presented in Figure 9. The three lines represent stoichiometric relationships between %S and Acid Neutralising Capacity (ANC) (as in Kg H_2SO_4 equivalent per tonne). The lower line (Line 1) represents where the ANC is just sufficient to account for any potential acidity generated by the sulphur. Points below this line will always be potentially acid generating. The middle line (Line 2) represents approximately a 50% excess of ANC over potential Acid Generating Capacity (AGC). Points between Lines 1 and 2 are likely, but not certain, to have a real excess of ANC over potential (AGC). Points lying between Lines 2 and 3 are likely (>80%) to have an excess of ANC over AGC. Points lying above Line 3, representing approximately 100% excess of ANC over AGC will have a >95% chance of ANC being greater than any potential AGC. These points are associated with a very low risk.

The data suggest that the majority of the samples have a relatively low percentage of sulphur (<1%). Figures 8 and 9 also suggest that the ANC is able to neutralise any potential acid generated. However, these plots further suggest (Figure 8) that there is a group of samples which are potentially acid forming, and another group where the NAPP may be in excess of the capacity of the ANC to counteract any acid generated. These samples are grouped as "uncertain" on Figure 8. Risk minimisation demands that these are treated as potentially acid forming.

Figure 8 and Figure 9 demonstrate the likelihood of acid generation within mine waste at IPC remains relatively low, although characteristics within all geological mediums tested have no potential to react when exposed to environmental elements. Coal rejects remain as the greatest risk with the highest percentage of sulphur and potentially acid forming characteristics.

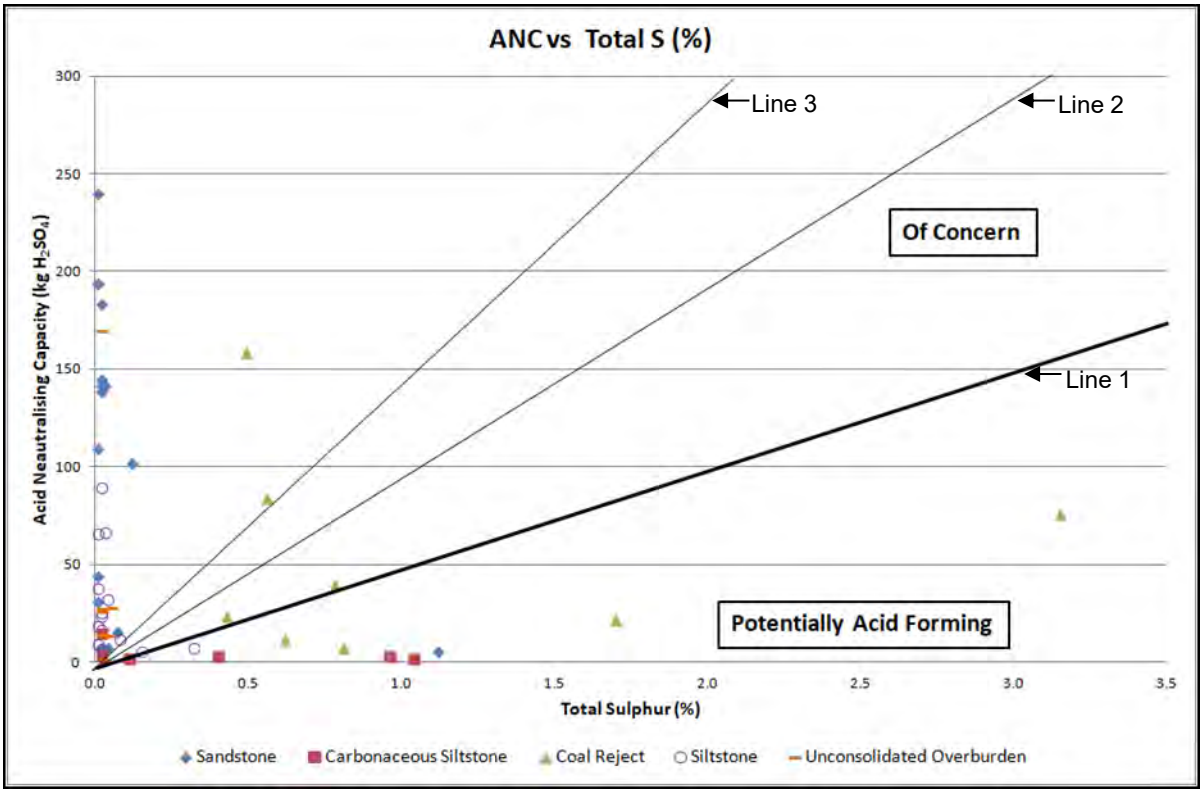

Figure 9: Acid neutralising capacity Vs Total Sulphur (%)

4.2.1 TOTAL AND SOLUBLE METALS

Total metal analysis was performed on mining waste samples collected in both the Ardent (2016) and C&R (2018) sampling rounds on mining waste at IPC. Concentrations of total metals are determined by applying an acid digest to the sample. The Ardent Group report compared results against values for site contamination in the National Environmental Protection Measure (NEPM) Guidelines.

The document "Draft Guideline for the Assessment and Management of Contaminated Land in Queensland" guides the assessment of land contamination in Queensland and is based on the NEPM guideline. Note, the NEPM guideline was amended in 2013. This guideline nominates "Environmental Investigation Levels" (EIL) and "Health Investigation Levels" (HIL). The EIL is the concentration of a contaminant above which further appropriate investigation of the impact on environmental values may be required. The HIL is the concentration of a contaminant, above which further appropriate investigation of the impact on potential human - health risks may be required for the nominated land use. For the purpose of this report, reference has been made to the HIL in the 2013 NEPM guideline.

C&R Consulting have nominated use of the Interim Sediment Quality Guidelines (ISQG) from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality Guidelines (ANZECC 2000) that is part of the National Water Quality Management Strategy. These guidelines relate specifically to the receiving environments that may potentially be affected

by water runoff from mine affected areas and the consequence on aquatic ecology. Therefore, these guidelines provide a more conservative guideline value.

It should be noted that the ISQG are separated into two categories, low and high, with the mean of the "Low" guidelines values equating to that of the EIL values presented within the NEPM Guidelines.

Copper and nickel exceeded the ISQG Low trigger value of 65mg/kg and 21mg/kg respectively. However, the mean value for both metals was below guideline values at 38mg/kg and 18mg/kg.

All five samples collected by Ardent Group from the carbonaceous siltstone, and a single siltstone sample, presented elevated levels of copper, with the highest concentration (74mg/kg) slightly above the ISQG Low trigger value of 65mg/kg.

Elevated nickel levels were recorded within the tertiary overburden mix samples (3) collected by C&R Consulting, and the siltstone (4), unconsolidated overburden (3), and sandstone (1) samples gathered by Ardent Group. Again, the majority of the samples with elevated nickel concentrations recorded values marginally above the trigger value of 21mg/kg, with the maximum value of 40mg/kg recorded within a siltstone sample located within the mining lease of IPE.

In 2017 Terrenus undertook leachate analysis to determine the solubility of metals. This type of analysis is constructive as it provides an insight into the concentration of metals with the potential to become soluble after an extended period of exposure to mining waste materials. Leachate analysis is also used to determine values in 'worse case' scenario and is a more appropriate comparison to seepage (long retention time) than rainfall runoff (short retention time).

The climate at IPC is likely to produce rainfall runoff conditions whereby water is exposed to overburden for shorter periods than those undertaken during laboratory analysis. Terrenus compared results against the water quality guideline values for IPC receiving environments. Elevated levels of soluble aluminium and arsenic were presented within the leachate analyses. However, given the dilution factor and lower water retention rate, it is considered that runoff exposed to overburden would contain soluble metals and metalloids concentrations below the water quality guidelines of the receiving environments at IPC.

4.2.2 DISPERSIVITY

Geochemical summaries of overburden show that it is slightly dispersive (refer Table 1 and Table 2). This suggests that erosion can be expected when overburden is disturbed and placed into out-of-pit spoil dumps.

Tertiary material throughout the Bowen Basin is typically more susceptible to water erosion. Hence the older, generally less dispersive, Permian material should be considered for the surface of the out–of–pit spoil dumps.

In 2017 Terrenus undertook further analysis of the erosive and dispersive natures of overburden materials required for rehabilitation on the IPE mining lease. Analysis was completed on 20 drill core samples including weathered overburden (5), fresh siltstone (8) and fresh sandstone (7).

The Cation Exchange Capacity (CEC) of samples ranged from 4 to 14 meq/100g, with a relatively low median CEC value of 10 meq/100g. This range of CEC values is considered marginal to moderate, indicating a lower than desirable ability to hold nutrients (Terrenus, 2017). These results are consistent with the findings of the annual Rehabilitation Inspections (C&R Consulting, 2017) where it was noted that fertiliser would be required to improve vegetation growth.

The R1 dispersion index is obtained by comparing the proportion of the clay and silt fraction dispersed in water (by shaking), with the amount of clay and silt in the sample obtained by conventional particle size analysis. The range of values obtained from the Terrenus analysis was between 0.2 to 0.8, with an average of 0.6. This suggests that the overburden at IPC will be moderately dispersive, with weathered samples having a greater probability of erosion than unweathered materials. Hence, the unweathered geological medium will provide greater stability during rehabilitation and should be used predominately as the capping material prior to topsoiling.

5. MANAGEMENT STRATEGY

The management and control strategy for Mining Wastes at Isaac Plains must target the following issues:

- Acid Rock Drainage (ARD) of reject under the current management method for rejects (i.e. belt filter press and trucking of rejects to overburden dumps)
- Alkaline and saline seepage through overburden
- Erosion of dispersive overburden; and
- Rehabilitation

5.1 ACID ROCK DRAINAGE

This section describes rejects management under the current management method for rejects (i.e. belt filter press and trucking of rejects to overburden dumps). Management of rejects in the in-pit tailings and coarse reject is described in the Isaac Plains Complex Tailings and Rejects In-pit Disposal Management Plan (Golders Associates, 2018).

As outlined in Section 4.2.2, there is a moderate to low potential for acid rock drainage at IPC as long as coarse and fine rejects are co-disposed. However, once IPE begins operations there is the possibility that some rejects will be Potentially Acid Forming (PAF) and that acid rock drainage could begin to occur.

Typically, in the Bowen Basin where the coal seam is PAF, the coarse rejects and overburden are overwhelmingly Non-Acid-Forming (NAF) with a very high Acid Neutralising Capacity (ANC). This is not the case at IPC where the rejects are expected to be PAF. However, the overburden characteristics for IPM (GEM 2005) show that the overburden has very high levels of Acid Neutralising Capacity (ANC) and will counteract the generation of any acidic material.

Co-disposal of coal rejects and waste rock at IPM suggests that any acidity generated will be neutralised as it seeps through the surrounding waste rock. Rehabilitation inspections at IPC (AXM, 2011; C&R Consulting 2012-2017) do not show any signs of adverse impacts to rehabilitation. All soil results are strongly alkaline (pH 6 to 10). Variations of any other parameter outside the ranges established by reference sites can be explained by other factors. Therefore there are no detrimental impacts evident (to date) from the co-disposal of rejects and waste rock in spoil dumps. Under the current management method for rejects (i.e. belt filter press and trucking of rejects to overburden dumps), the locations of reject co-disposal with spoil should be recorded to ensure that should problems arise, the characteristics of the reject can be investigated and identified.

Material with a very high ANC should be stockpiled for co-disposal with PAF material to neutralise any acidity generated. The method of co-disposal of coal reject and overburden should be sufficient to neutralise any acidity providing that PAF materials can be mixed with NAF materials.

Where practical, co-disposed PAF reject material should:

- Be no more than 10m from the final surface of the dump;
- Be no more than 15m from the toe of any waste rock dump; and
- Be no more than 2m from the base (i.e. natural ground surface) of the waste rock dump

For emergency situations (e.g. unexpected acid generating rejects), a stockpile either/or inventory of agricultural lime <2mm diameter should be kept on-site for immediate treatment of high acid generating material. The maximum liming rate encountered on-site to date has

been 53kg $CaCO_3$ / tonne. It is recommended that sufficient lime be kept on site to dose any PAF material at this rate.

5.2 OVERBURDEN

The overburden characterisation results from mining waste analyses show that the value of pH within the overburden is predominately alkaline within a range of 8.2 – 9.7 (pH soils). Rainfall will seep into the above-ground overburden dumps at IPC. Moisture will slowly move through the overburden dump and will seep out at the toe where the overburden dump meets the natural land surface. Overburden dumps will not be uniform in texture or hydraulic conductivity and therefore there may be several areas up the faces of overburden dumps which emit seepage, a consequence of variable hydraulic conductivity within the dumps and the prevention, or hindrance, of downward water movement.

Moisture residence time within the overburden, and consequently contact time with the surrounding alkaline and/or saline rock, will determine the final alkalinity and/or salinity of seepage emanating from waste rock dumps. This potentially results in alkaline seepage through the dump and into nearby dams over the long-term. Average hydraulic conductivity of spoil throughout the Bowen Basin is approximately 3.16m/yr (Minserve Group et. al., 2004), indicating that seepage through the base of spoil dumps may take many years, if not multiple decades. Short-term rainfall seepage through overburden, as well as groundwater inflow into pits, are the main mechanisms for increased electrical conductivity of waters across the site. This is shown in the high pH 1:5 mixing ratio values for on-site water storage compartments receiving dewatering from pits, seepage through rehabilitated overburden dumps, and non–specific sources.

On-site dams depicted in Figure 10 have a mixing pH1:5 ratio value between 7.2 and 9.89, indicating that alkaline seepage, as well as ongoing reaction between the water in the dam and the surrounding alkaline soils, is impacting water quality (Figure 11). A similar process occurs for electrical conductivity, although the majority of the increases within the dams are the result of pit water dewatering (Figure 12).

IPC are permitted to release waters with a mixing pH1:5 ratio of up to 9.0 into the surrounding stream system based on the natural flow rate in the Isaac River. Releases are governed by the site's Environmental Authority (EA) and are also controlled by the levels of electrical conductivity.

Although monitoring of seepage through overburden dumps at IPC has not been undertaken, it is expected that seepage volumes and concentrations will not be high enough to warrant extensive concern. The soils in the area are naturally alkaline with pH1:5 mixing ratio values averaging between 8.0 and 9.5. Therefore, waters seeping through overburden dumps and entering the water management system, or the environment, will not be any greater than waters in equilibrium with the natural surrounding soil. Similarly, the electrical conductivity (representing salinity) of seepage waters is not considered a concern at Isaac Plains since any seepage waters are contained in the mine site water management system.

Inflows of large volumes of rainfall into pits and dams across the site from intense rainfall events present a much larger risk to the generation of saline waters. The longer the clean water is held in pits and dams, the higher the electrical conductivity and alkalinity will become based on the availability of additional time for ion exchange between the surrounding soil / void and the water.

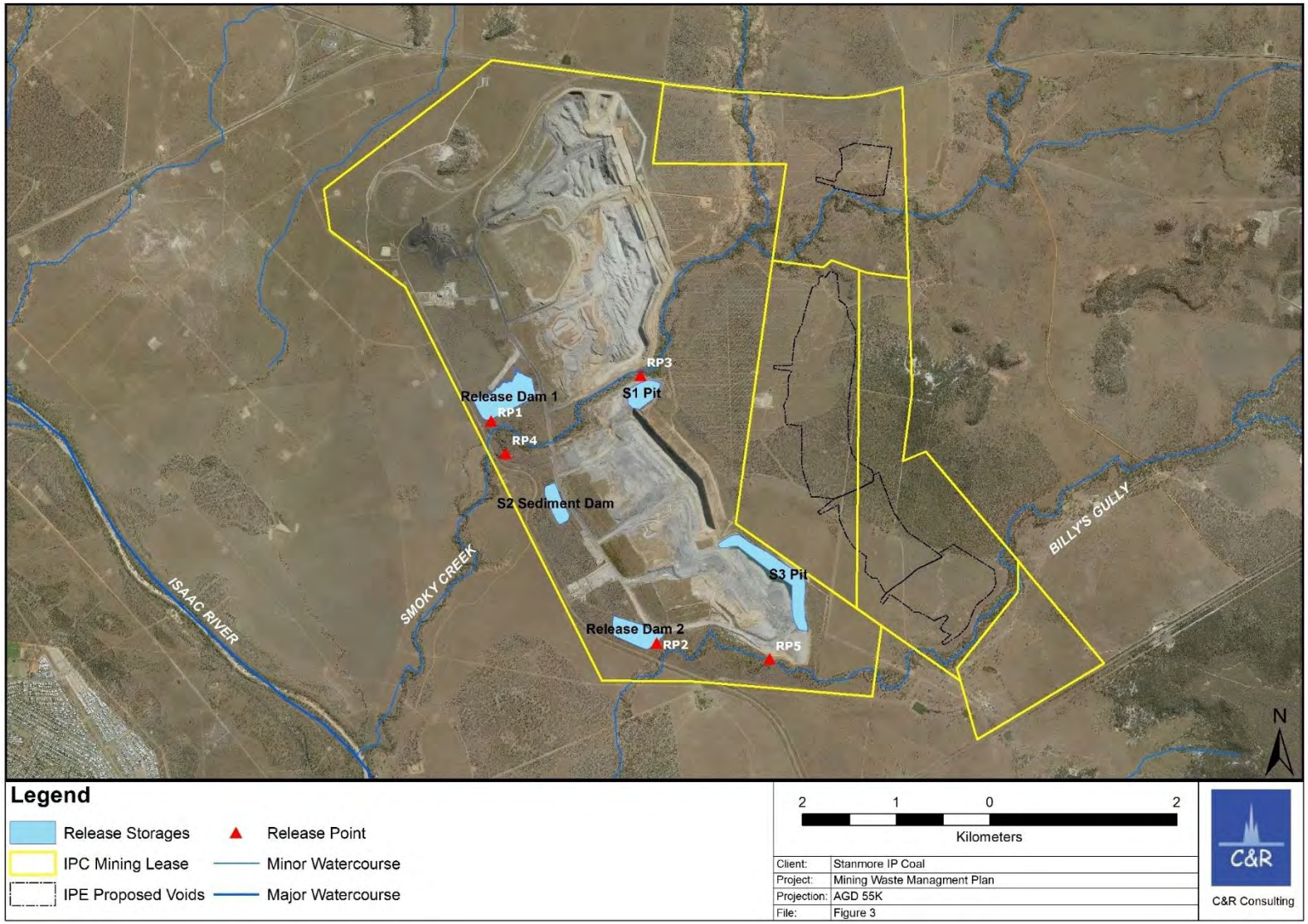

Figure 10: IPC mine affected water storage units

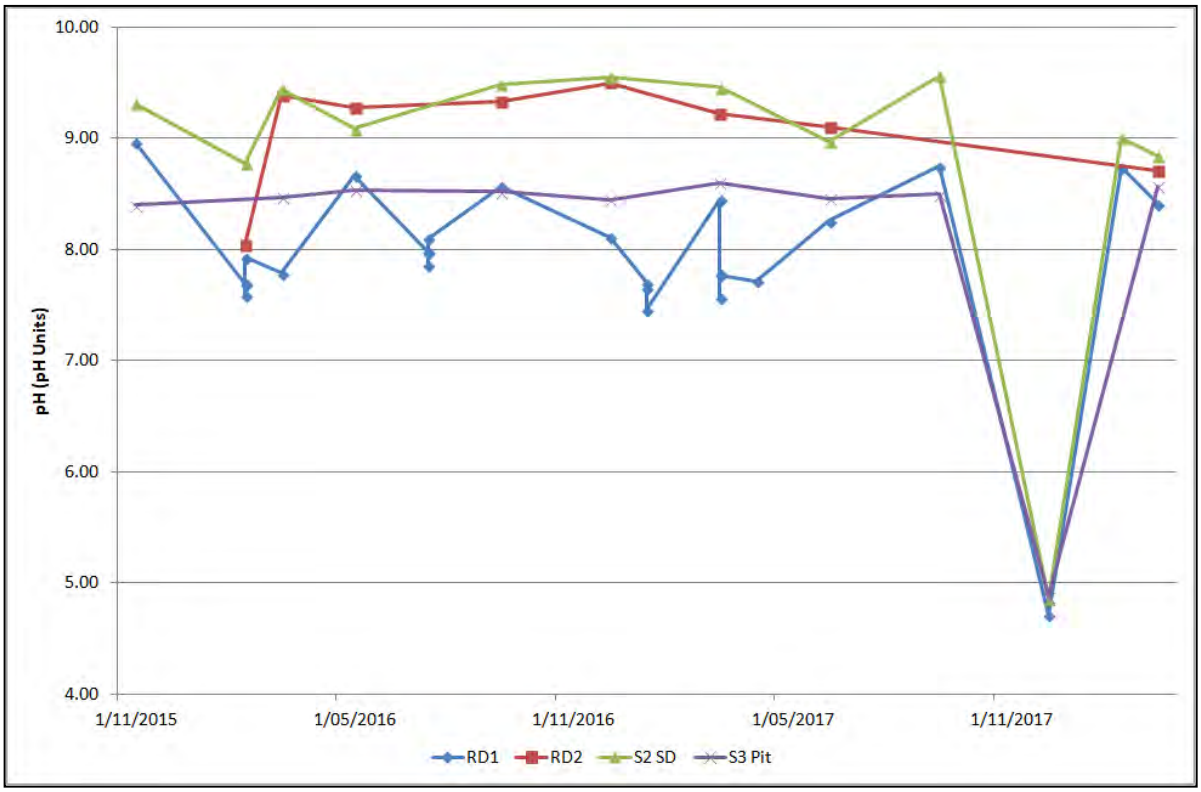

Figure 11: Historical pH range recorded within release points at IPC

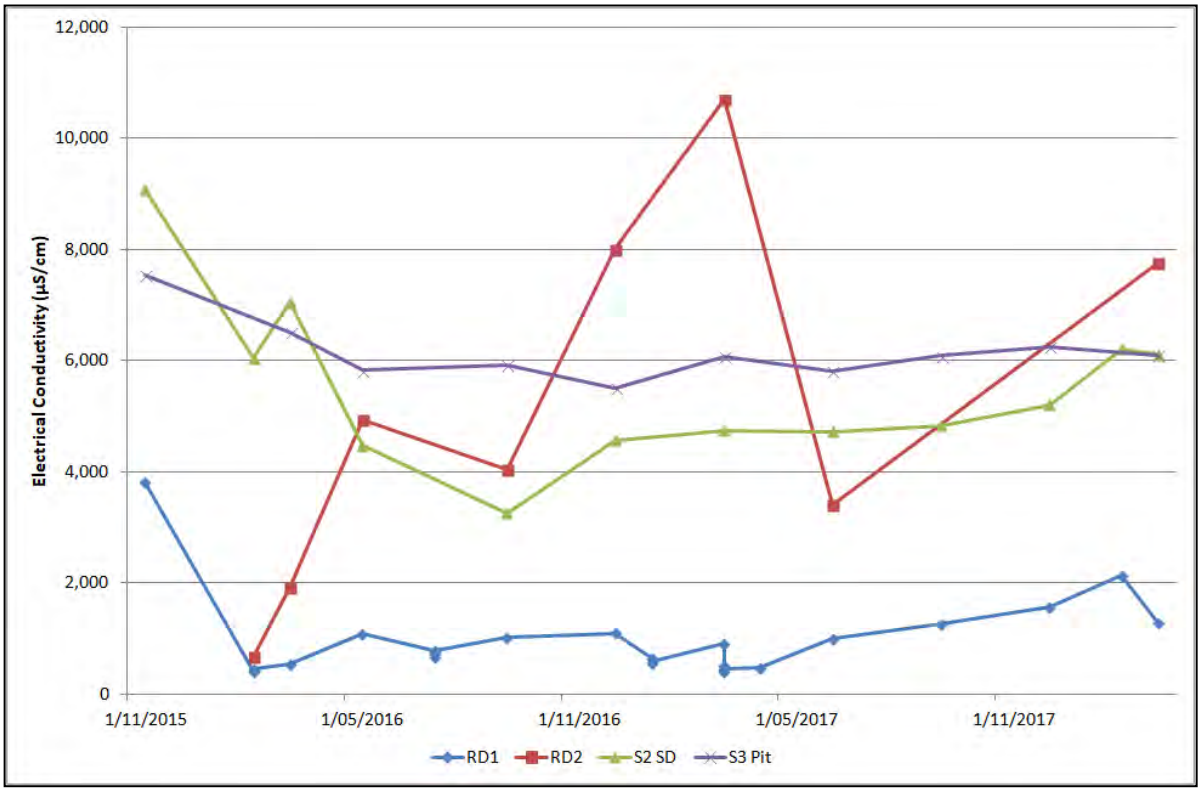

Figure 12: Historical range of EC recorded within release points at IPC

5.2.1 SPOIL DUMP DESIGN

The majority of Completion Criteria for spoil dumps focus on establishing a self-sustaining ground cover that can recover after grazing activities, minimising erosion and maintaining runoff water quality.

The following general principles are of particular concern to the Rehabilitation Management Plan (2018) and Completion Criteria for IPC:

- The effectiveness of benches to slow erosion processes is questionable. Relatively old rehabilitation at some mine sites has resulted in rills eroding through benches and occurring along the entire slope. However, these slopes are at or near the angle of repose (typically 30°);
- The highest erosion is associated with long, uninterrupted, slope lengths;
    - Acceptable slope angles are less than 15% (or 8.53 °) for external spoil slopes, the external slopes at IPC have been designed to be no greater than 8.5 ° ;
    - Where possible dispersive Tertiary spoil should be covered with benign rock cover (such as Permian spoil).
- Spoil dumps must spread water rather than concentrate water down the slope;
- Large rocks are preferred for rock-lined channels to break up water flow and slow velocity. If large rocks are not available, the channel width must be increased; and
- Contour ripping is standard. Areas where contour ripping does not occur are very rare and often seen as 'sub-standard'.

5.3 DISPERSIVE OVERBURDEN

The mining method at IPC will ensure that Tertiary overburden is deposited in the centre of out-of-pit dumps. If Permian (unweathered) material is available, placing Permian overburden over the top of the Tertiary material is an acceptable solution that will minimise exposure of the potentially more dispersive, Tertiary (weathered) overburden. It is recommended that Tertiary overburden be capped with at least 1m of Permian overburden where possible (Minserve et. al. 2004).

The site's Soil Erosion and Sediment Control Plan (C&R Consulting, 2018a) as well as the Rehabilitation Management Plan (C&R Consulting, 2018b) provide additional guidance on the installation of erosion control infrastructure on rehabilitated spoil dumps.

6. MANAGEMENT ACTIONS

6.1 PERIODIC REVIEW

It is proposed that the Mining Waste Management Plan be reviewed on an annual basis to ensure the assessment of final landform's can be addressed as soon as feasibility possible and any concerns can be raised and reconciled.

6.2 CONTINUOUS CHARACTERISATION

Waste rock characterisation should be completed throughout the mining campaign to determine the different growth characteristics and potential interactions to occur as a result of exposing such materials to the elements.

Waste rock characterisation analysis should include testing for the following parameters as per EA **Condition E6**:

- **General**

  pH1:5, EC1:5

- **Acid rock drainage**

  Acid Neutralising Capacity (ANC), Maximum Potential Acid (MPA), Net Acid Capacity (NAC), Net Acid Generation (NAG), NAC and NAG pH after oxidation, Sulphate (total S%), Total Sulphur (S) Chromium Reducible Sulphur ($ScrS_{CR^{-}}$), Net Acidity, ANC Fineness Factor.

- **Metals**

  Aluminium, boron, cadmium, copper, chromium, iron, manganese, zinc, selenium, cobalt, arsenic, molybdenum, antimony

- **Cation / Anion**

  Calcium, magnesium, sodium, potassium, chloride, sulphate (mg/kg), HCO_3, Total alkalinity as $CaCO_3$.

- **Treatment**

  Liming Rate

Samples for waste rock characterisation should be taken from the actual rock that would form the waste in sufficient numbers to provide a statistically valid representation of each geological unit. The characterisation of the excavated waste should be carried out in accordance with the Assessment and Management of Acid Drainage guideline of the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland series (DME, 1995) and any other applicable best practice guidelines.

Sampling should aim to achieve the following understanding:

a) The level of information should be proportionate to the size of the operation;

b) The samples need to be spatially representative both horizontally and vertically of the deposit;

c) The number of samples should be sufficient to represent the variability within each geological unit and material type; and

d) Suggested characterisation sampling frequency is outlined in Table 3.

Table 3: Suggested characterisation sampling frequency

Disturbed Rock (m^3)	Minimum Number of Samples*
<10,000	3
<100,000	3-8
<1,000,000	8-26
<10,000,000	26-80
>10,000,000	100+

* Dependent on the material diversity and prior information availability.

6.3 MINE WASTE TREATMENT

All waste rock characterisation analyses will be managed within a database specifically designed to accurately assess the continuous condition of the waste rock, and highlight potentially concerning conditions. The database will highlight when the application of agricultural lime is required to ensure any potential acid forming waste rock is neutralised appropriately.

To reduce the time lag between sampling, publishing of analysis and treatment application, it is recommended that IPC maintain a minimum volume of agricultural lime on site at all times. Liming rates have been included within the parameter list to be completed when undertaking waste rock characterisation.

7. REFERENCES

- ANZECC, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1. The Guidelines (Chapters 1 – 7).
- Ardent Group, 2016. Isaac Plains East Acid Mine Drainage Assessment, Version 2.
- C&R Consulting. 2012. Isaac Plains Reject Analysis.
- C&R Consulting, 2013. Mining Waste Management Plan 2013.
- C&R Consulting, 2017. Isaac Plains Rehabilitation Inspection 2017.
- C&R Consulting, 2018a. Erosion and Sediment Control Plan for Isaac Plains Complex.
- C&R Consulting, 2018b. Rehabilitation Management Plan for Isaac Plains Complex.
- Department of Mines and Environment, 1995. Assessment and Management of Acid Drainage. Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland series.
- Hansen & Bailey, 2017. Response to information requestion from the Department of Environment and Heritage Protection.
- Terrenus, 2017a. Overburden Geochemistry Report.
- Terrenus, 2017b. Assessment of potential spoil erosion and dispersion characteristics (Isaac Plains East Project).

APPENDIX 1: CERTIFICATION OF ANALYSIS (C&R, 2018)

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1813303**	Page	: 1 of 8
Client	: **C & R CONSULTING PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: SIAN KENNARE	Contact	: Customer Services EB
Address	: 188 ROSS RIVER ROAD AITKENVALE QUEENSLAND 4812	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 47253751	Telephone	: +61-7-3243 7222
Project	: ICPM MWMP	Date Samples Received	: 31-May-2018 09:45
Order number	:	Date Analysis Commenced	: 04-Jun-2018
C-O-C number	: ----	Issue Date	: 08-Jun-2018 13:53
Sampler	: SIAN KENNARE		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 6		
No. of samples analysed	: 6		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Matt Frost	Senior Organic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ED037 (Alkalinity): NATA accreditation does not cover the performance of this service.
- ED038 (Acidity): NATA accreditation does not cover the performance of this service.
- ASS: EA033 (CRS Suite):Retained Acidity not required because pH KCl greater than or equal to 4.5
- EG005T (Total Metals by ICP-AES): Sample EB1813303-001 (IPCM MWMP Tertiary Mix (B)) shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.
- EG005T (Total Metals by ICP-AES): Sample EB1813303-002 (IPCM Medium Reject) shows poor spike recovery due to sample heterogeneity. Confirmed by visual inspection.
- ASS: EA033 (CRS Suite): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime ($CaCO_3$) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- ASS: EA003 (NATA Field and F(ox) screening): pH F(ox) Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Strong; 4 - Extreme

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	IPCM MWMP Tertiary Mix (B)	IPCM Medium Reject	IPCM MWMP Spoil	IPCM MWMP Tertiary (A)	IPCM Course Reject (A)
			Client sampling date / time	24-May-2018 00:00	24-May-2018 00:00	24-May-2018 00:00	24-May-2018 00:00	24-May-2018 00:00
Compound	CAS Number	LOR	Unit	EB1813303-001	EB1813303-002	EB1813303-003	EB1813303-004	EB1813303-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.7	9.2	9.4	9.5	8.8
EA003 :pH (field/fox)								
pH (F)	----	0.1	pH Unit	9.4	8.7	9.4	9.3	8.9
pH (Fox)	----	0.1	pH Unit	6.6	2.7	6.2	9.1	2.8
Reaction Rate	----	1	Reaction Unit	3	4	3	3	3
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-26.6	20.8	-12.5	-25.7	7.2
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	284	173	102	337	109
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	9.2	6.8	8.0	9.9	3.1
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	7.5
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	0.4	<0.1	<0.1	11.8
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	28.1	75.6	13.7	26.3	11.8
ANC as CaCO3	----	0.1	% CaCO3	2.9	7.7	1.4	2.7	1.2
Fizz Rating	----	0	Fizz Unit	1	2	1	1	1
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	8.6	8.8	7.7	8.7	8.4
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.034	1.26	0.018	<0.005	0.543
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	21	789	11	<10	338
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	1.48	6.62	1.11	3.06	1.23
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	296	1320	222	612	246
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	0.47	2.12	0.36	0.98	0.39
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	IPCM MWMP Tertiary Mix (B)	IPCM Medium Reject	IPCM MWMP Spoil	IPCM MWMP Tertiary (A)	IPCM Course Reject (A)
			Client sampling date / time	24-May-2018 00:00	24-May-2018 00:00	24-May-2018 00:00	24-May-2018 00:00	24-May-2018 00:00
Compound	CAS Number	LOR	Unit	EB1813303-001	EB1813303-002	EB1813303-003	EB1813303-004	EB1813303-005
				Result	Result	Result	Result	Result
EA033-E: Acid Base Accounting - Continued								
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	0.28
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	174
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	13
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.03	1.26	<0.02	<0.02	0.54
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	21	789	11	<10	338
Liming Rate excluding ANC	----	1	kg CaCO3/t	2	59	<1	<1	25
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	11.2	15.8	19.5	2.7	5.5
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	1230	360	686	3060	272
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	1060	272	598	2690	255
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	176	88	88	365	18
ED038A: Acidity								
Acidity	----	1	mg/kg	<5	<5	<5	<5	<5
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	140	140	40	40	100
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.05	3.15	0.04	0.02	0.62
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	130	60	30	230	40
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10
Sodium	7440-23-5	10	mg/kg	340	230	140	350	190
Potassium	7440-09-7	10	mg/kg	<10	<10	<10	<10	<10
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	9320	2450	10200	14600	1800
Antimony	7440-36-0	5	mg/kg	<5	<5	<5	<5	<5
Arsenic	7440-38-2	5	mg/kg	<5	6	<5	7	<5
Barium	7440-39-3	10	mg/kg	380	120	30	100	370
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	IPCM MWMP Tertiary Mix (B)	IPCM Medium Reject	IPCM MWMP Spoil	IPCM MWMP Tertiary (A)	IPCM Course Reject (A)
			Client sampling date / time	24-May-2018 00:00	24-May-2018 00:00	24-May-2018 00:00	24-May-2018 00:00	24-May-2018 00:00
Compound	CAS Number	LOR	Unit	EB1813303-001	EB1813303-002	EB1813303-003	EB1813303-004	EB1813303-005
				Result	Result	Result	Result	Result
EG005T: Total Metals by ICP-AES - Continued								
Chromium	7440-47-3	2	mg/kg	10	<2	10	20	<2
Cobalt	7440-48-4	2	mg/kg	13	4	11	15	3
Copper	7440-50-8	5	mg/kg	35	43	39	29	43
Iron	7439-89-6	50	mg/kg	33000	27900	30700	39700	11100
Lead	7439-92-1	5	mg/kg	13	17	10	13	16
Manganese	7439-96-5	5	mg/kg	560	367	238	595	99
Molybdenum	7439-98-7	2	mg/kg	<2	3	<2	<2	<2
Nickel	7440-02-0	2	mg/kg	22	6	21	24	4
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Silver	7440-22-4	2	mg/kg	<2	<2	<2	<2	<2
Vanadium	7440-62-2	5	mg/kg	24	7	22	50	5
Zinc	7440-66-6	5	mg/kg	58	29	66	61	35
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	IPCM Rejects Fines	----	----	----	----
			Client sampling date / time	24-May-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1813303-006	--------	--------	--------	--------
				Result	----	----	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.7	----	----	----	----
EA003 :pH (field/fox)								
pH (F)	----	0.1	pH Unit	8.9	----	----	----	----
pH (Fox)	----	0.1	pH Unit	3.1	----	----	----	----
Reaction Rate	----	1	Reaction Unit	3	----	----	----	----
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-15.5	----	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	209	----	----	----	----
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	7.8	----	----	----	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	----	----	----	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	----	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	39.4	----	----	----	----
ANC as CaCO3	----	0.1	% CaCO3	4.0	----	----	----	----
Fizz Rating	----	0	Fizz Unit	1	----	----	----	----
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	8.9	----	----	----	----
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	----	----	----	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.583	----	----	----	----
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	364	----	----	----	----
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	3.47	----	----	----	----
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	694	----	----	----	----
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	1.11	----	----	----	----
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	IPCM Rejects Fines	----	----	----	----
			Client sampling date / time	24-May-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1813303-006	--------	--------	--------	--------
				Result	----	----	----	----
EA033-E: Acid Base Accounting - Continued								
Net Acidity (sulfur units)	----	0.02	% S	<0.02	----	----	----	----
Net Acidity (acidity units)	----	10	mole H+ / t	<10	----	----	----	----
Liming Rate	----	1	kg CaCO3/t	<1	----	----	----	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.58**	----	----	----	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**364**	----	----	----	----
Liming Rate excluding ANC	----	1	kg CaCO3/t	**27**	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	**33.8**	----	----	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	**3730**	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	**3670**	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	**53**	----	----	----	----
ED038A: Acidity								
Acidity	----	1	mg/kg	<5	----	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**160**	----	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.78**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**120**	----	----	----	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	**50**	----	----	----	----
Magnesium	7439-95-4	10	mg/kg	**20**	----	----	----	----
Sodium	7440-23-5	10	mg/kg	**260**	----	----	----	----
Potassium	7440-09-7	10	mg/kg	**20**	----	----	----	----
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**3920**	----	----	----	----
Antimony	7440-36-0	5	mg/kg	<5	----	----	----	----
Arsenic	7440-38-2	5	mg/kg	<5	----	----	----	----
Barium	7440-39-3	10	mg/kg	**830**	----	----	----	----
Beryllium	7440-41-7	1	mg/kg	<1	----	----	----	----
Boron	7440-42-8	50	mg/kg	<50	----	----	----	----
Cadmium	7440-43-9	1	mg/kg	<1	----	----	----	----
Chromium	7440-47-3	2	mg/kg	**3**	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	IPCM Rejects Fines	----	----	----	----
			Client sampling date / time	24-May-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1813303-006	--------	--------	--------	--------
				Result	----	----	----	----
EG005T: Total Metals by ICP-AES - Continued								
Cobalt	7440-48-4	2	mg/kg	3	----	----	----	----
Copper	7440-50-8	5	mg/kg	39	----	----	----	----
Iron	7439-89-6	50	mg/kg	15700	----	----	----	----
Lead	7439-92-1	5	mg/kg	15	----	----	----	----
Manganese	7439-96-5	5	mg/kg	204	----	----	----	----
Molybdenum	7439-98-7	2	mg/kg	2	----	----	----	----
Nickel	7440-02-0	2	mg/kg	5	----	----	----	----
Selenium	7782-49-2	5	mg/kg	<5	----	----	----	----
Silver	7440-22-4	2	mg/kg	<2	----	----	----	----
Vanadium	7440-62-2	5	mg/kg	11	----	----	----	----
Zinc	7440-66-6	5	mg/kg	38	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	----	----	----	----

APPENDIX L NI TSF MANAGEMENT PLAN

REPORT

STANMORE COAL PTY LTD

Isaac Plains Complex

N1-TSF Mine Waste Management Plan

Date: April 2021

Report Number:119269_01_R01

Document History and Status

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				Author	Reviewer
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Please refer to our Conditions of Investigation and Report

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1 INTRODUCTION

1.1 Purpose

The purpose of this Mine Waste Management Plan (MWMP) is to provide direction in the operation, management and monitoring of the N1 Pit Tailings Storage Facility (N1-TSF) at Isaac Plains Mine (IPM). IPM is owned and operated by Stanmore IP Coal Pty Ltd (Stanmore) and is located some 5km north east of Moranbah, Queensland. IPM comprises the original Isaac Plains Mine (IPM) mining operations on mining lease (ML) 70342, and recently approved Isaac Plains East (IPE) project mining operations on ML 700016, ML 700017, ML 700018 and ML 700019.

This document describes the obligations of the operator with respect to acceptable standards for operation of the N1-TSF, as a means of maintaining the long-term integrity of the facility. In addition, the MWMP is intended to assist with training of staff in matters related to management of the TSF and maintenance of appropriate operating records.

1.2 Regulatory Requirements

This MWMP has been developed in accordance with the following regulatory standards and industry best practice guidelines:

- Environmental Authority (EA) Permit Number EMPL0087181113 (effective 13 March 2018), issued by the Department of Environment and Science (DES);
- Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure (ANCOLD, 2019);
- Guidelines on Consequence Categories for Dams (ANCOLD, 2012);
- Guidelines on Dam Safety Management (ANCOLD, 2003)
- Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (DES, 2016);
- Guidelines on Tailings Dams Planning, Design, Construction, Operation and Closure (ANCOLD, 2019).

Related references include ANCOLD publications addressing guidelines for earthquakes (ANCOLD, 2019) and guidelines on risk assessment (ANCOLD, 2003).

1.3 Associated Documentation

This MWMP should be read in conjunction with the following documents:

- Isaac Plains Mine N1 Pit Tailings Cells Basis of Design Report
- Isaac Plains Complex Risk Management System

1.4 EA Conditions

The IPC Environmental Authority EPML00932713, effective of 24 January 2018 (the EA), Condition E6, requires that a Mine Waste Management Plan (MWMP) be prepared. A summary of the EA applicable to the MWMP for tailings and coarse rejects and the sections in which they are addressed in this document are outlined in Table 1.

Table 1
EA Conditions

Clause	Requirement	Addressed in this Management Plan
E6 a)	Characterisation programs to ensure that all mining waste is progressively characterised during disposal for net acid producing potential, salinity and the following contaminants: pH, Electrical Conductivity (EC), Acid Neutralising Capacity (ANC), Net Acid Generation (NAG) (reporting NAG capacity and NAG pH after oxidation), Total Sulphur (S), Chromium Reducible Sulphur (Scr), Boron (B) Cadmium (Cd), Iron (Fe), Aluminium (Al), Copper (Cu), Magnesium (Mg), Manganese (Mn), Calcium (Ca), Sodium (Na), Zinc (Zn) and Sulphate (SO4);	Section 2, Section 5
E6 b)	Characterisation programs to ensure that the physical properties of the mining waste is progressively characterised during disposal;	Section 5
E6 c)	The availability or leachability of metals from the mining waste;	Section 2.3
E6 d)	Quantification of PAF from mining waste present;	Section 2.3
E6 e)	Review impacts of the PAF mining waste on the rehabilitation;	Section 6
E6 f)	Management actions for mining waste that has been identified as having a high availability or leachability of metals;	Section 4
E6 g)	Management actions for mining waste that has been defined as PAF;	Section 4
E6 h)	Identification of environmental impacts and potential environmental impacts;	Section 4
E6 i)	Control measures for routine operations to minimise likelihood of environmental harm;	Isaac Plains Complex Risk Management System
E6 j)	Contingency plans and emergency procedures for non-routine situations;	Isaac Plains Complex Risk Management System and Emergency Management Plan
E6 k)	Periodic review of environmental performance and continual improvement;	Section 5
E6 l)	Containment of tailings;	Section 3
E6 m)	Records to indicate locations and characteristics of tailings stored within the tailings storage facility;	Section 5
E6 n)	The management of seepage and leachate from tailings storages both during operation and the foreseeable future	Section 3.5
E6 o)	The control of fugitive emissions to air; and	Not Applicable
E6 p)	A program for progressive sampling and characterisation to identify acid producing potential and metal concentrations of tailings.	Section 5

1.5 Updates to MWMP

The MWMP is a working document, with the operating and monitoring practices subject to periodic review and updates to reflect modifications to the conditions on which the document is based. The timing for such updates includes, but is not necessarily limited to the following:

i) Alteration (either increase or decrease) of the capacity of the TSF.
ii) Following a significant incident with respect to the operation and/or performance of the facility.

iii) Following revisions to the Environmental Authority.

Notwithstanding these conditions, review and updating of the OMP should be completed every 2 years, as a minimum, should the life of the facility extend beyond this timeframe.

1.6 Key Personnel for Tailings Cell Management

The roles and responsibilities pf IPC staff in respect of this MWMP are summarised in Table 2.

Table 2
Roles and responsibilities

Role	Responsibility
General Manager Operations	Ensure adequate resources are available to enable implementation of the MWMP
Site Superintendent	Responsible for the overall management of the N1-TSF
Site Superintendent	Responsible for overseeing the management of the N1-TSF and associated pumps and piping
CHPP operations and maintenance personnel	Conduct the general duties/activities associated with the daily functioning of the tailings discharge
Environmental Officer	Responsible for monitoring the functioning of the N1-TSF for environmental compliance
Environmental Officer	Responsible for environmental compliance issues
Site Superintendent	Responsible for providing operational/logistical support to the CHPP Superintendent through the provision of specific machinery and earthworks functions required for the proper functioning of the N1-TSF
Surveyor	Conduct survey and technical monitoring functions
Off-site specialists or consultancy services	Will be utilised as required for technical assistance and specific monitoring/audit functions

1.7 Document Structure

Section 1: Includes background, statutory requirements and objectives of the MWMP and the structure of the document.

Section 2: Summarises N1 Pit and N1-TSF background, geotechnical and geochemical characteristics of the tailings and rejects.

Section 3: Outlines operational objectives, design criteria and consequence category assessment.

Section 4: Discussed tailings management objectives and procedures.

Section 5: Provides a summary of the proposed monitoring, inspection, and review schedule.

Section 6: Decommissioning and Rehabilitation Strategy.

Section 7: Emergency Action Planning Summary and Reference.

Section 8: Provides a glossary of terms used in the management plan.

2 BACKGROUND

2.1 Operations Description

IPM is a coking and thermal coal mine. The mining method is open cut using a combination of truck and shovel/excavator, and draglines. Overburden is excavated and deposited in mined out strips and ROM coal is hauled by truck from the open cut pits to the Coal Handling and Preparation Plant (CHPP) for washing and processing. The coal washing wastes includes rejects and tailings. Currently, tailings are pumped from the CHPP to the N1-TSF via a series of HDPE pipelines.

The N1 Pit void is an inactive void that functions as the primary mine-affected water storage facility for IPM. It receives pumped transfers from all the mine voids and the CHPP, up to a maximum operating water level of 217mAHD. The N1-TSF is located within the partially-backfilled void spoil dumps located to the west of the main void, with the spoil comprising waste rock and course rejects materials.

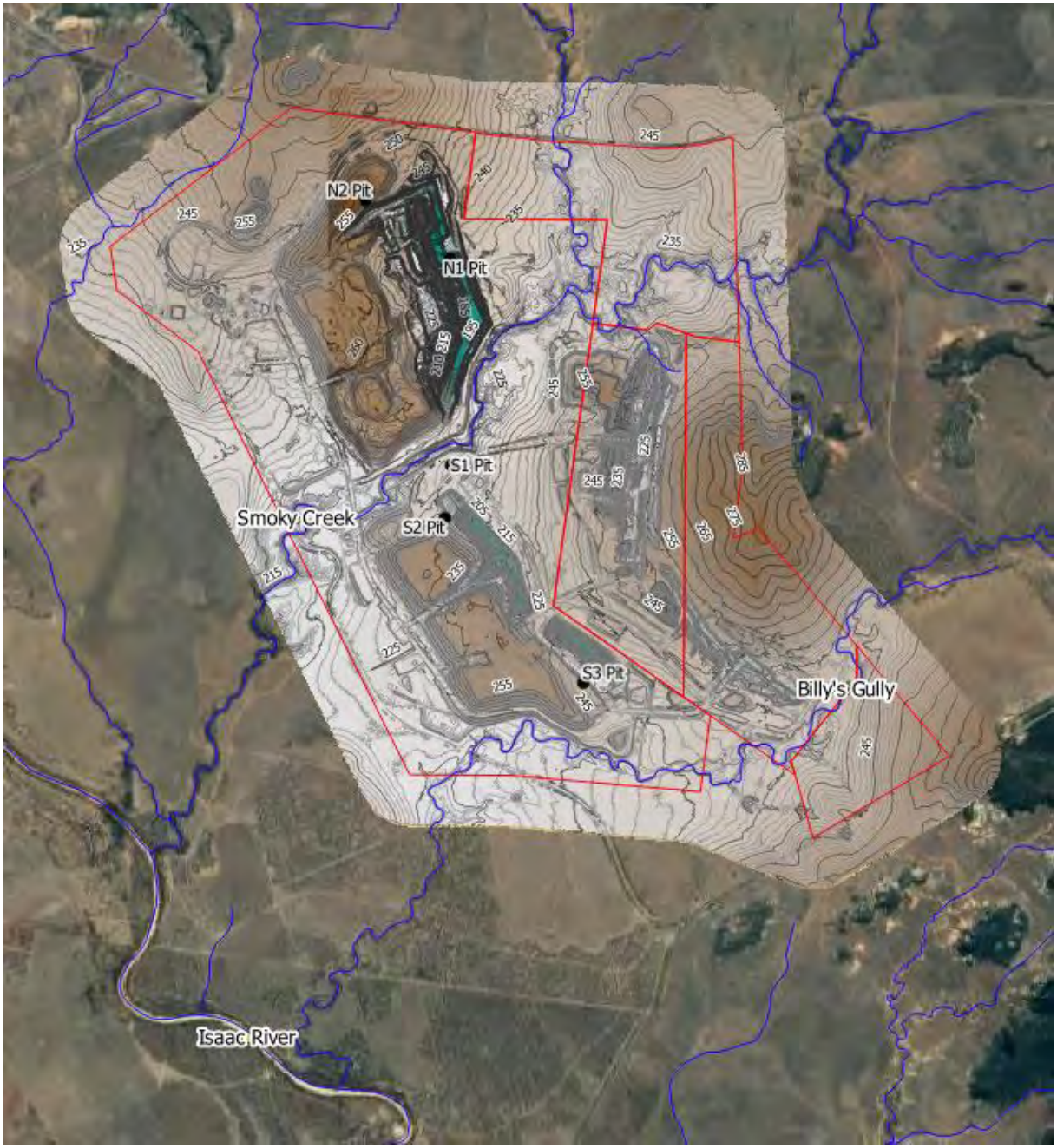
The N1-TSF comprises 5 cells, referred to as Cell 1 to 5. The extents of each cell are depicted in Drawing 001.

2.2 Site Topography and Drainage

The site is located on generally north to south sloping topography. Locally, the topography rises to the north of the N1 Pit. The surrounding area is predominantly used for grazing. IPM is traversed by Smoky Creek, its northern tributary and several minor drainage lines and Billy's Gully. Surface water flow within Smoky Creek flows in a south westerly direction joining the Isaac River approximately 7km downstream of the project mining lease boundary as depicted in Map *1*.

Billy's Gully flows in a west-south westerly direction and is located to the south east of the IPM. The IPM comprises undulating terrain. Within the northern region of the project mining area, the land slopes towards the creek channels with the remaining topography sloping in a westerly direction.

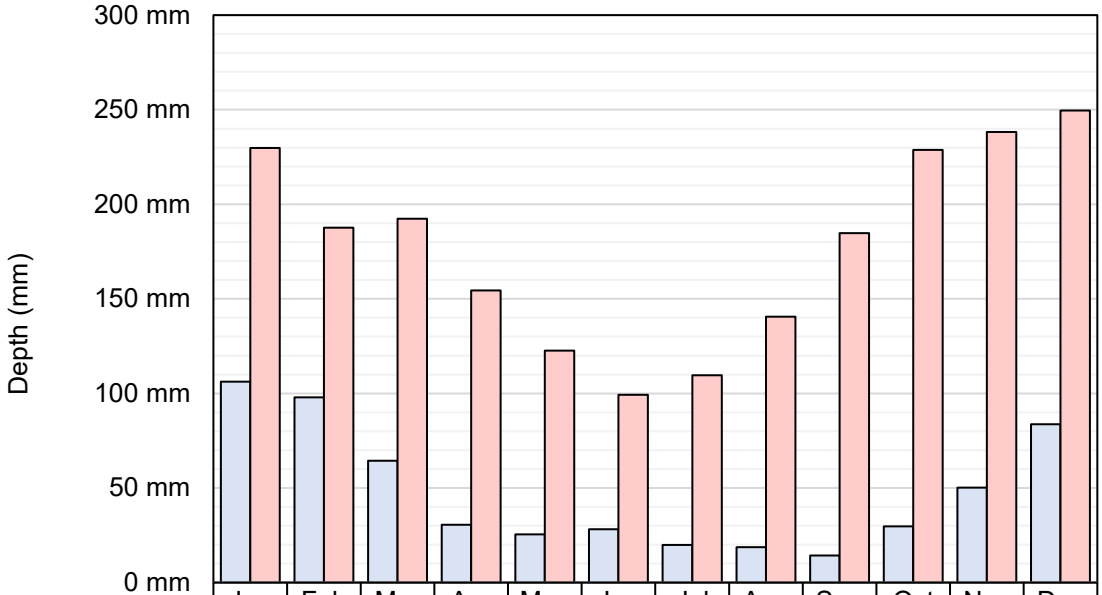
Map 1 - Local Topography and Drainage



2.3 Climate - Rainfall and Evaporation

IPM is located within the Burdekin River Basin, in northern Queensland. The region typically experiences the greatest rainfall during the summer months, between December through to March. The mean annual rainfall is approximately 570mm (Silo Data drill - Moranbah Water Treatment Plant). The Mean annual precipitation and evaporation is shown in Graph 1.

Graph 1 - Average rainfall and evaporation



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation (mm)	106.2	98.0	64.4	30.6	25.6	28.1	20.0	18.7	14.4	29.7	50.1	83.7
Evaporation (mm)	229.7	187.6	192.4	154.4	122.7	99.3	109.6	140.5	184.8	228.7	238.3	249.6

Source: Long-Paddock Silo Data Drill, https://www.longpaddock.qld.gov.au/silo/point-data/. Station Number: 34038 Moranbah Water Treatment Plant.

2.4 Geology

The majority of surface geology comprises deeply weathered profiles of the Permo-Triassic rock within situ weathering and soil development and minor alluvium that, for the most part, conceal these rocks across the lease.

Tertiary-aged, poorly consolidated, sandstone forms part of an earlier thin sequence that covered much of the district. This sequence and older lithologies were eroded down to a flat surface (peneplain) that is capped with duricrust (ferricrete) or carbonate laterites. Locally the sequence has been eroded back to a table top to the north leaving behind mesas of sandstone on and around the lease.

Prior to and during this erosion period in the Tertiary, volcanic activity produced widespread basalt lava flows. At least two basalt flows have taken advantage of an earlier deep river passing down the eastern length of the lease. Remnants of the lava flows persist in mesas east of the lease and part of the northern table top while the remainder has been weathered down to the current alluvial flat developing across the site.

The coal beds exist as layers in packages of sedimentary beds called 'Coal Measures' which reflect the fact that coal seams split, thicken and thin, and are interfingered with other sediments at their time of formation. These sediments can include relatively porous sandstones conducive to groundwater flow. The coal beds themselves are frequently significant conduits to groundwater and provide local aquifer systems.

The economic coal measures at Isaac Plains are the Rangal Coal Measures which is part of the Late Permian Blackwater Group. This group of rocks extends throughout the western half of the Bowen Basin.

2.5 Hydrogeology

There are five principal hydrostratigraphic units within the IPC tenement areas:

1. Quarternary Alluvium;
2. Tertiary Sediments;
3. Cenozoic (Tertiary Basalt);
4. Triassic Rewan Group; and
5. Late Permian Rangal and Fort Cooper Coal Measures: sandstone, siltstone and coal.

The Quaternary Alluvium and Tertiary Sediments are associated with channel deposits of Smoky Creek and the Isaac River. In 2018, KCB completed in field investigations to assess the extent of the Quaternary Alluvium in relation to Smoky Creek. This followed instruction from the Department of Environment and Science that one monitoring bore must be installed to monitor the Alluvium although when drilling occurred, no Alluvium was present. The selection of this target lithology for this monitoring bore location was based on the mapped alluvium presented in the Mount Coolon 1:250,000 map sheet that is mapped as having an extent of up to ~500 m adjacent to Smoky Creek. As per the findings from the field investigation, KCB reported:

The extent of the sediments was identified to be limited to the water course channel as the channel is deeply incised, with the creek banks comprising weathered bedrock. Furthermore, outcrops of weathered bedrock occur within the channel of Smoky Creek, identifying the limited depth of unconsolidated sediments. (KCB, 2018)

Cenozoic basalt crops out to the north-east of tenement ML70342 and particular basalt flows constitute aquifers in several surrounding areas. Confinement of the Late Permian strata is variable locally, depending on pressure distribution and depth. Surface distribution of each unit is complicated by several regional structures, including at least one syncline and thrust faults truncating the eastward-dipping target beds. The aquifers of the Isaac Plains area are described in the following sections, with reference made to aquifer characteristics, groundwater flow and groundwater quality for each unit.

2.6 Characteristics of Tailings and Rejects

2.6.1 Summary

Terrenus Earth Sciences undertook hydro-geochemical analysis of tailings between 2016 and 2018 and the relevant parts of this assessment are reproduced in Section 2.7. A summary of investigation outcomes is provided as follows:

- All except one rejects sample had total sulfur concentrations below 1% by mass and about half of all samples had sulfur concentrations below 0.5%. The relative low sulfur concentrations (for Permian coal rejects) suggest that rejects (as a bulk material) is regarded as relatively low risk but has some potential to generate acidity and relatively low concentrations of sulfate in an unmitigated environment (i.e. prior to management/disposal methods being adopted).

- Around 70% of rejects samples tested were classified as non-acid forming (NAF), with some 10% classified as potentially acid forming (PAF), with a relatively low capacity to generate significant acidity. The remaining 20% of samples were classified as 'Uncertain', primarily due to uncertainty around the availability of sufficient neutralising material and conflict between the net acid producing potential (NAPP) and net acid generation (NAG) test results.

Despite this uncertainty, these 'Uncertain' samples are conservatively assumed to be PAF from a materials management perspective. It can be assumed that up to 30% of rejects may be PAF, with the remaining 70% being NAF.

- Total metal and metalloid concentrations in rejects samples are low compared to average element abundance in soil in the earth's crust. No samples were enriched in any measured element with respect to average crustal abundance in soil.

- The sequential leachate assessment, over four stages, found that rejects (current and potential) are expected to generate pH-neutral to alkaline, low-salinity leachate when emplaced within the pit. Some rejects could produce leachate in seepage/groundwater containing slightly elevated concentrations of soluble Al and/or As, as is common from Permian coal measures in the Bowen Basin.

- Rejects samples from individual and discrete streams (e.g. fine versus coarse and current rejects versus potential rejects) display subtle geochemical variations; however, the differences are insignificant and do not warrant selective handling and processing (such as fine vs coarse, or IPE versus IPM).

2.6.2 Assessment Methodology

Representative samples were taken from the belt press filter (tailings) and the dense medium circuit (rejects) in 2016, 2017 and 2018 for testing by NATA accredited laboratory ALS Limited (ALS) Brisbane. Additionally, four samples of tailings liquor were collected during the sampling period between late-February 2018 to mid-March 2018 from the CHPP thickener. Sample collection was undertaken randomly to capture the different ROM coal being processed. Coal seam roof and floor samples were also collected from drill-core from four drill holes located across the IPC mine lease area and one sample from the IPE Project area. Rejects samples collected in 2016 and 2017 comprised 'mixed' fine and coarse rejects, collected from various locations within the CHPP over a one-month period.

An environmental geochemical assessment of current and potential future reject material was undertaken based on the characterisation of samples using static geochemical test methods. Samples were tested for a range of parameters considered important for characterising the material for management. The maximum potential acidity (MPA) and NAPP was calculated from the total sulfur or Scr and acid neutralisation capacity (ANC) results.

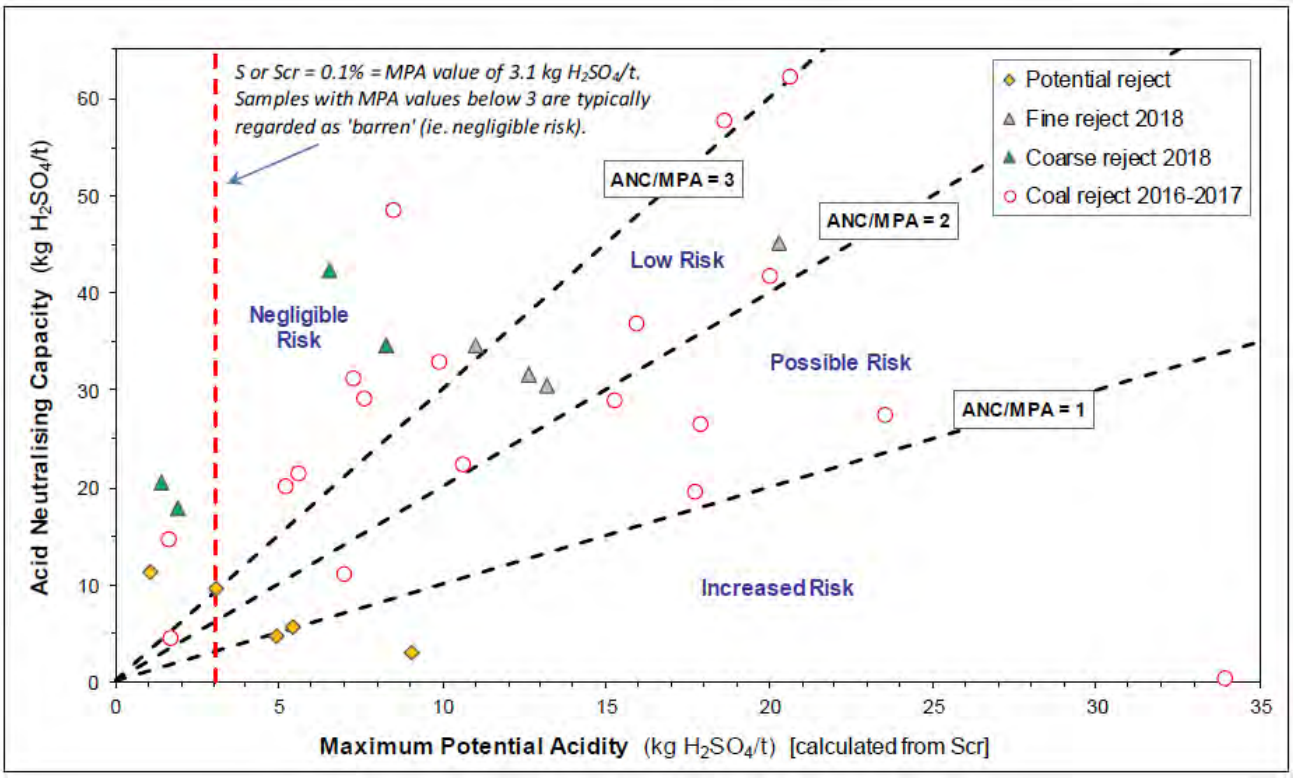
2.6.3 Acid-Base Account

Acid-Base Account results for the 2016 and 2017 rejects samples, 2018 rejects samples and IPE potential rejects samples (32 samples in total) that were geochemically analysed are summarised in Table 3.

The median total sulfur concentration of all samples was relatively low (0.5% S), with 9 out of 10 samples below 0.93% S. Sulfide-sulfur (as Scr) concentration in all 32 samples ranged from 0.03% to 1.11%, with a median value of 0.29% and a 90th percentile value of 0.66%. Total sulfate was measured on the 2018 rejects and IPE potential rejects samples and found that sulfur as sulfate (SO_4-S) was a relatively small proportion of total sulfur in these samples (SO_4-S <0.07% in all samples). There was little significant difference between the sulfur concentration of tailings samples compared with coarse reject samples.

The MPA values are generally low, with a median MPA of 9 kg H_2SO_4/t and relatively low 75th percentile value of 16 kg H_2SO_4/t, but MPA values are widely distributed. The median ANC of the samples are modest at 27 kg H_2SO_4/t. This value indicates that the tailings and rejects have typically some acid buffering capacity. As a 'bulk' material, the rejects are expected to have sufficient neutralising capacity to buffer any generated acidity – or in the event of acidity generated, the significance would be low due to the relatively low sulfide concentrations. This is highlighted by the ANC/MPA ratios shown in Diagram 1 and the NAPP values discussed below. Some samples display a greater level of 'risk' compared to other rejects and potential rejects samples; however, there is generally little significant difference between the sample types (potential rejects versus actual rejects).

Diagram 1
Maximum Potential Acidity (MPA) and Acid Neutralising Capacity (ANC). Source: Terrenus, 2018



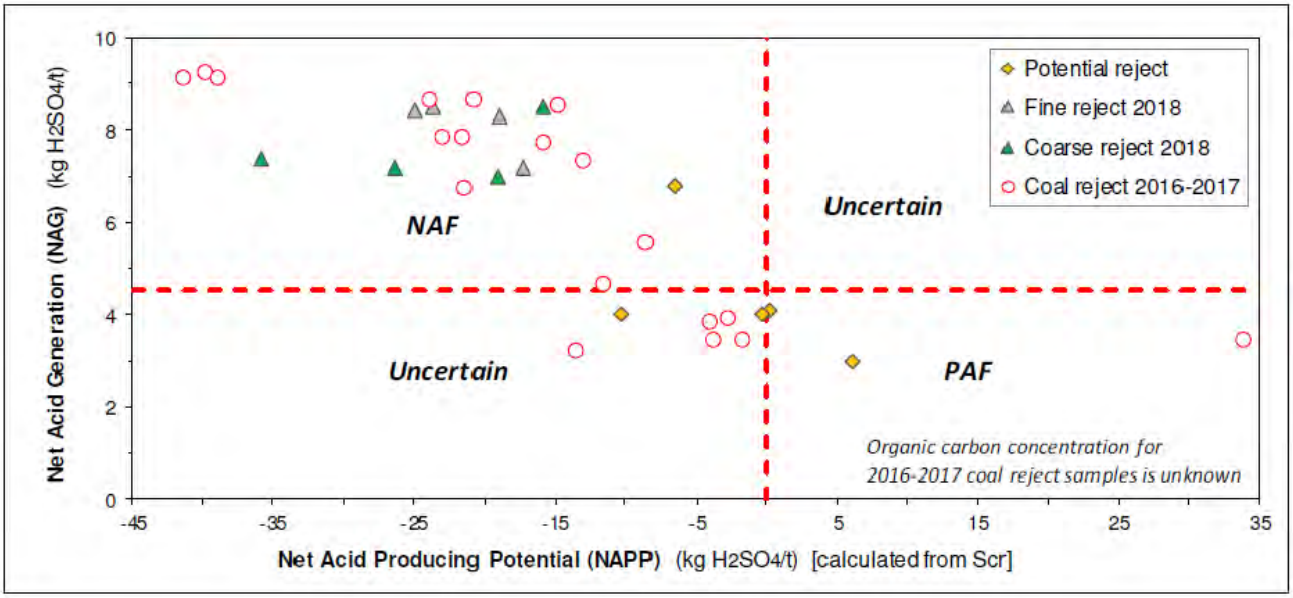
The net acid producing potential (NAPP) is typically negative, with a relatively low median NAPP of -16 kg H_2SO_4/t. Of the 32 samples, two samples had clearly positive NAPP values. A potential reject sample also had a marginally positive NAPP value (+0.2 kg H_2SO_4/t).

Table 3
Summary statistics of acid-base account parameters

Parameter	Unit	Minimum/Maximum	Median	25th / 75th / 90th Percentile	Comments
Total Sulfur	% mass	0.1 / 1.35	0.52	- / 0.77 / 0.93	
Sulfide-sulfur (as Scr)	% mass	0.03 / 1.11	0.29	- / 0.54 / 0.66	
MPA	kg H2SO4/t	1 / 34	9	5 / 16 / 20	Generally low to moderate
ANC	kg H2SO4/t	<1 / 62	27	14 / 35 / 45	Generally moderate
NAPP	kg H2SO4/t	-41 / 34	-16	-23 / -6 / -0.4	Generally negative NAPP values
NAGpH	-	3.0 / 9.2	7.2	- /- /	
NAG	kg H2SO4/t				

NAG test results confirmed that most of the samples were classified NAF, with only ten out of 32 samples having NAGpH values below pH 4.5 and having NAG capacities ranging from 5 to 34 kg H_2SO_4/t. Of these, three are classified as PAF, and the remaining seven have an uncertain classification due to conflicting NAPP/NAG results (refer Diagram 2). Terrenus concluded that there is no significant difference in the NAGpH values of the tailings samples compared with the coarse reject samples.

Diagram 2
Net Acid Generation (NAG) pH After Oxidation versus Net Acid Producing Potential (NAPP).
Source: Terrenus, 2018



The results of the acid-base account have been used to classify the acid forming nature of the rejects and potential rejects samples. The geochemical classification (acid forming nature) of these samples is summarised in Table 4.

Table 4
Geochemical classification of rejects and potential rejects samples. Source: Terrenus, 2018

	NAF-Barren[1]	NAF-Lows	NAF	Uncertain	PAF
No. and (%) of IPE potential rejects samples (n=5)	-	1 (20%)	-	2 (40%)[2]	2 (40%)
No. and (%) of 2018 rejects samples (n=8)	-	2 (25%)	6 (75%)	-	-
No. and (%) of 2016-2017 rejects samples (n=19)	-	1 (~6%)	12 (63%)	5 (26%)	1 (~6%)
No. and (%) of all samples (n=32)	-	4 (13%)	18 (56%)	7 (22%)	3 (9%)
% of all samples (n=32)	69%			22%	9%

1: Samples have been classified as NAF-Barren where total sulfur concentration is less than 0.1%.
2: Two potential rejects samples are classified as 'Uncertain'; however one sample is expected to be PAF and the other sample NAF-LowS.
Note: Percentages may have minor discrepancies due to rounding.

From a rejects management point of view, it is conservatively assumed that up to 30% of rejects could have some likelihood of generating acid (with no management controls in place). But the magnitude of any acidity generated (if at all) would be expected to be relatively low due to the low sulfur and sulfide concentrations.

2.6.4 Total Metals and Metalloids

Total metals and metalloids concentrations have been determined from samples taken in 2018 (five potential rejects and eight rejects) and 2016 to 2017 samples (19 rejects samples).

Due to different sample preparation and analysis methods used for the different years, only the 2018 samples are discussed. Total element concentrations of coarse rejects and tailings and potential rejects (2018 sampling) are very similar except for manganese. Rejects samples from the CHPP have an order of magnitude higher concentrations in manganese when compared to the seam roof and floor samples of the IPE Project (potential rejects). When compared to background concentrations the test results show that no samples are enriched in any measured element with respect to average elemental abundance in soil in the earth's crust.

2.6.5 Leaching Characteristics of Rejects and Potential Rejects

To evaluate the salinity, pH and the solubility of multi-elements in solids, single-stage water extract tests were completed on the 2016 and 2017 rejects samples and sequential water extract tests on five potential rejects samples and eight rejects samples collected in 2018.

The pH of sequential bottle leachate is generally pH-neutral to mildly alkaline. The potential rejects samples have slightly lower pH compared to the rejects samples. Alkalinity ranges between 120 and 30 mg $CaCO_3$/L with highest values for the first of the 4 sequential leach tests suggesting small amount of excess neutralisation capacity of the samples.

Electric conductivity recorded during sequential leaching suggest that concentrations of leachable salts present in rejects and potential rejects materials are low and be easily liberated. Multi-element scans of water extracts were conducted to identify those elements that were water soluble and therefore potentially mobile if leached and could emanate from the tailings and rejects. Many elements were present at concentrations less than or marginally above the laboratory LOR. Soluble metals concentrations for elements with values generally above the laboratory LOR are summarised in Table 5. For comparison, the concentration for each element were compared to the water quality of the Isaac's groundwater, water chemistry Zone 34, and average background concentration in groundwater of the various aquifers known to exists near IPC.

Table 5 Statistical summary of CHPP rejects and bottle leach test results and comparison with groundwater quality objectives and background data

Parameters	LOR[B]	Rejects Liquor Percentiles [B]	Bottle Leach Test Percentiles [B, C]	Isaac groundwaters: water quality objectives, water chemistry Zone 34 [B]		Deep Aquifers (> 40m depth), confined Groundwater [A, B]			Shallow Aquifers (< 40m depth), Confined or Unconfined Groundwater [A, B]	
				Shallow Aquifers	Deep Aquifers	Moranbah Coal Measures	Rangal Coal Measures	Rewan Group	Tertiary Basalt	Tertiary Sediments
pH (site)	0.01	7.51 / 7.71 / 8.59	8.0 / 8.4 / 9.0	7.10 / 7.75 / 8.10	7.40 / 7.80 / 8.03	7.4 / 7.7 / 8.2	7.4 / 8.0 / 8.2	6.8 / 7.2 / 8.0	8.2 / 8.4 /8.6	3.9 / 7.3 / 7.8
EC (site)	1	646 / 836 / 1275	76 / 120 / 271	498 / 2150 / 8910	3419 / 6100 / 16000			1959 / 5840 / 9319	9612 / 1211 / 3154	
EC (lab)	1	833 / 1082 / 1340				6900 / 9190 / 15000	4202 / 18400 / 23880	2000 / 5730 / 9344	1100 / 4800/ 16540	6600/ 13000/ 23000
Total Alkalinity	1	1780 / 3455 / 5460	38 / 61 / 87	154 / 435 / 752	156 /275 / 536	315 / 662 / 1510	486 / 603 / 769	73/ 704 / 760	140 / 284 / 642	260/ 520/ 700
Sulfate	1	40 / 62.5 / 86	5 / 10 / 31	12 / 140 / 318	25 / 138 / 398	2 / 95 / 314.8	51.5 / 528.5 / 955.2	36.4 / 114 / 1368	23.8 / 40 / 1200	85/ 500/ 1700
Chloride	1	208 / 309 / 354	1 / 3 / 10	171 / 1309 / 3185	753 / 1900 / 5905	1800 / 2824 / 4730	1192 / 5085 / 8161	228/ 1340/ 3376	200/ 1705/ 5600	1920/ 4300/ 7760
Calcium	1	13 / 19.5 / 21	0.5 / 3 / 8	18 / 84 / 215	46 / 145 / 442	16 / 69 / 240	120.4 / 237 / 382.1	20 / 503 / 1965.7	3.48/ 64.5/220	15/ 233/652.6
Magnesium	1	5 / 6.5 / 10	0.5 / 1 / 1	27 / 108 / 389	35 / 115 / 491	6 / 46 / 300	130.7 / 318 / 623.1	113.4 / 527 /2859.4	4.99/73/378.2	163.2 / 280 / 836
Sodium	1	280 / 297.5 / 307	6.4 / 16 / 45	135 / 747 / 1500	480 / 1100 / 2565	1150 / 1830 / 2630	476.4 / 612 /4051	697 / 4680 /25456	210/748/ 2900	954 / 2100 / 3230
Potassium	1	4 / 4.5 / 8	1 / 2 / 4			8 / 15 / 33	3.7 / 19 / 39.9	5 / 54.2 /297.2	1 / 4 / 7.86	2.97 / 9.4 / 30.1
Aluminium	0.01	<0.01 / 0.01 / 0.01	0.13 /0.4 / 0.67			0.0075 / 0.0125 / 0.0275	<0.01 / <0.01/ <0.01	0.003 / 0.003 / 0.003	0.006 / 0.013 / 0.058	0.007 / 0.014 / 2.94
Arsenic	0.001	0.007 / 0.009 / 0.011	0.005/0.01/ 0.04			0.0033 / 0.0045 / 0.0057	0.003 / 0.012 / 0.0232	0.001 / 2 / 4	0.002 / 0.006 / 0.0073	0.001 / 0.004 / 0.0069

Barium	0.001	0.072 / 0.1565 / 0.205	0.008/0.074/ 0.176			3.47 / 6.8 / 11.81		0.0712 / 0.179 / 0.594	0.071 / 0.107 / 0.143	
Beryllium	0.001	<0.001 / <0.001 / <0.001	< LOR				0.003 / 0.012 / 0.0232			
Boron	0.05	0.06 / 0.065 / 0.08	< LOR			0.384 / 0.56 / 0.624	0.164 / 3.12 / 4.57			0.258 / 0.37 / 0.482
Cadmium	0.0001	LOR	< LOR			0.0001 / 0.0001 / 0.0001	0.0605 / 0.072 / 0.0977			<0.0001 / <0.0001 / <0.0001
Cobalt	0.001	0.001 / 0.0015 / 0.002	< LOR			0.022 / 0.022 / 0.022				<0.001 / 0.008 / 0.008
Chromium	0.001	<0.001 / <0.001 / <0.001	0.0005/0.0005/ 0.001			0.001 / 0.001 / 0.001				0.0011 / 0.0015 / 0.0019
Copper	0.001	<0.001 / <0.001 / <0.001	< LOR	0.000/0.010/ 0.030	0.017 / 0.030 / 0.030	0.002 / 0.002 / 0.002				0.002 / 0.002 / 0.002
Iron	0.05	<0.001 / <0.001 / <0.001	0.025/0.025/ 0.025	0.000/0.030/ 0.140	0.000 / 0.050 / 0.246	0.056 / 0.26 / 10.52		0.084 / 0.46 / 904	0.061 / 0.235 / 2560	0.08/ 0.28 / 5.1
Mercury	0.0001	< LOR	< LOR			0.00013 / 0.0004 / 0.00081	<0.0001 / <0.0002 / <0.0003	<0.0001 / <0.0001 / <0.0001	0.0001 / 0.0002 / 0.00036	0.0001 / 0.0023 / 0.00446
Manganese	0.001	0.009 / 0.0215 / 0.032	0.0005/0.0005/ 0.002	0.000/0.010/ 0.160	0.000 / 0.050 / 0.291	0.02 / 0.035 / 0.1133				0.1231 / 0.5795 / 1.0359
Nickel	0.001	0.001 / 0.0015 / 0.005	< LOR			0.0054 / 0.023 / 0.0406				0.0014 / 0.003 / 0.0046
Lead	0.001	<0.001 / <0.001 / <0.001	< LOR			<0.001 / <0.001 / <0.001				<0.001 / <0.002 / <0.003
Selenium	0.01	<0.01 / 0.01 / 0.01	0.005/0.005/ 0.005			0.02 / 0.02 / 0.02		<0.01 / <0.02 / <0.03	0.0022 / 0.003 / 0.0038	0.0025 / 0.0065 / 0.007
Strontium	0.001	0.576 / 1.165 / 2.82	0.0042/0.0965/ 0.3092							
Vanadium	0.01	<0.01 / <0.01 / <0.01	0.005/0.02/0.03			<0.01 / <0.01 / <0.01				0.01 / 0.01 / 0.01
Zinc	0.005	<0.005 / <0.005 / <0.005	< LOR	0.000/ 0.015/ 0.060	0.01/ 0.025 / 0.317	0.0054 / 0.007 / 0.0398				0.0241 / 0.0245 / 0.0249

Notes: Values provided in the table are the 20th Percentile / Median / 80th Percentile except for values for Deep and Shallow Aquifers which are the 10th Percentile
/ Median / 90th Percentile

[A] Data sourced from groundwater monitoring records of IPM, IPE and adjacent mine sites and project sites including, Moranbah North Mine, Grosvenor Mine, Moranbah South Project.

[B] All values mg/L, except pH (pH-value) and EC (µS/cm)

[C] Percentile were calculated using data from four leach tests

2.6.6 Reject Liquor Chemistry

Four samples of rejects liquor were collected from the thickener tank at IPC on the same dates as the collection of the fine and coarse rejects solid samples. The chemical composition of liquor is expected to be similar to the pore water chemistry of the wet tailings at time of deposition in the N1-TSF.

The liquor samples underwent analysis for a broad suite of water quality parameters, including pH and EC at time of sample collection, and then EC, major ions and soluble metals and metalloids analysed at the laboratory.

The results show that liquor is pH neutral to alkaline (approximately 7.5 to 8.6), generally has low to moderate salinity (approximately 650 to 1300 µS/cm) and has low concentrations of metals and metalloids. A summary table with results are presented in Table 6.

Table 6
Soluble parameter concentrations in rejects liquor

Parameters	Laboratory LOR	Isaac deep aquifers	Rangal Coal Measures	Reject liquor, N1N45-LH full seam	Reject liquor, N1S45-LH full seam	Reject liquor, N1S45-LH full seam	Reject liquor, N1N45-LH upper
	All values mg/L, except pH (pH units) and EC (µS/cm)						
pH (site)	0.01	7.40-8.03	7.40-8.20	7.51	7.76	7.66	8.59
EC (site)	1	16, 000	23, 880	646	991	1275	681
EC (lab)	1			854	1340	1310	833
Total Alkalinity	1	536	769	5110	1800	1780	5460
Sulfate	1	398	995	40	54	71	86
Chloride	1	5,905	8, 161	208	295	354	323
Calcium	1	442	382	21	20	19	13
Magnesium	1	491	623	10	8	5	5
Sodium	1	2.565	4, 051	299	307	280	296
Potassium	1	-	39.9	8	5	4	4
Aluminium	0.01	-	<0.01	<0.01	0.01	0.01	<0.01
Arsenic	0.001	-	0.0232	0.009	0.007	0.009	0.011
Barium	0.001	-	-	0.11	0.205	0.203	0.072

Beryllium	0.001	-	0.0232	<0.001	<0.001	<0.001	<0.001
Boron	0.05	-	4.57	0.07	0.08	0.06	0.06
Cadmium	0.0001	-	0.0977	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	0.001	-	0.022	0.002	0.001	0.002	0.0101
Chromium	0.001	-	0.001	<0.001	<0.001	<0.001	<0.001
Copper	0.001	0.030	0.002	<0.001	<0.001	<0.001	<0.001
Iron	0.05	0.246	10.52	<0.05	<0.05	<0.05	<0.05
Mercury	0.0001	-	<0.0003	<0.0001	<0.0001	<0.0001	<0.0001
Manganese	0.001	0.291	0.1133	0.016	0.027	0.032	0.009
Nickel	0.001	-	0.0406	0.005	0.001	0.002	0.001
Lead	0.001	-	-	<0.001	<0.001	<0.001	<0.001
Selenium	0.01	-	-	<0.01	<0.01	<0.01	0.01
Strontium	0.001	-	-	2.82	1.17	1.16	0.576
Vanadium	0.01	-	-	<0.01	<0.01	<0.01	<0.01
Zinc	0.005	0.317	0.0398	<0.005	<0.005	<0.005	<0.005

Alkalinity expressed as mg CaCO3/L. pH (site) and EC (site) measured on sample at time of collection. EC (lab) measured on 'as received' sample. All other elements analysed after filtering. Shaded cells = values that exceed one or more of the applied groundwater values.

2.6.7 Potential Groundwater Impacts and Risk Assessment

An impact and risk assessment was completed, as part of the MWMP for tailings and rejects, that documents potential risks to the environmental values of groundwater that seepage of leachate from the N1-TSF would pose to sensitive features or receptors near the facility.

The assessment is based on the current knowledge of the chemical constituents of the rejects and washing water that potentially could harm the environment or adversely affect its value (Contaminants of Potential Concern or COPC), the characteristics of the environmental receptors that may be at risk from the COPC and the means, or pathway, by which the receptors may be affected by the COPC.

The assessment is proportionate to the level of risk posed by the N1-TSF, and therefore the assessment has adopted a factual, evidentiary approach. Consideration has been given to the following:

- Source – COPC in the rejects solids that may become available (i.e.by oxidisation of sulphide minerals) or are leachable (i.e. metals) and COPC in rejects liquor

- Environment – i.e. the entity (e.g. human, stock, water resource, ecosystem, etc) that is vulnerable to the adverse effects of the COPC
- Identified or plausible pathways – i.e. the mechanism by which the environment and COPC in the rejects solids and liquor can come into contact (e.g. migration pathways through groundwater); and barriers that inhibit the release and/or impede the migration of the COPC.

The Queensland Environmental Protection Act 1994 defines environmental harm of an activity by its adverse effect or potential adverse effect (whether temporary or permanent and of whatever magnitude, duration or frequency) on an environmental value. Therefore, the environmental values near the N1-TSF have been investigated to establish an understanding of the potential for any seepage and COPC from the facility to adversely affect environmental values.

The IPC lies in Zone 34 of the "Isaac Groundwaters", as defined in the Fitzroy River Sub-basin Environmental Values and Water Quality Objectives.

The environmental values for the "Isaac Groundwater" are:

- Aquatic ecosystems
- Irrigation
- Farm water supply/use
- Stock watering
- Primary recreation
- Drinking water
- Cultural and spiritual values.

Three out of the seven values are considered relevant or potentially relevant for the IPC (aquatic ecosystems, farm water supply / use, and stock watering). No recreation activities (e.g. swimming in water holes feed by groundwater) relying on groundwater or groundwater that holds cultural and spiritual importance are known in the vicinity of the N1-TSF, and as such, are not considered relevant environmental values that could adversely be affected by seepage and COPC from the N1-TSF. The low quality of all shallow and deep groundwater near to N1-TSF render the water unsuitable for human consumption or long-term irrigation without significant treatment. Other groundwater uses in addition to the environmental values listed above are associated water from open cut pit dewatering and from a water supply scheme at Brodlea Mine that is used for coal washing and dust suppression and has therefore an industrial value.

A plausible pathway for a COPC is how the COPC could be transferred into the environment, and thence to any defined receptors in the environment. For a risk of environmental harm to exist due to the deposition of rejects in the N1 pit void, there must be a plausible pathway between the COPC in the rejects solids and liquor of the N1-TSF and environmental receptors whose relevant or potentially relevant values listed above could adversely be impacted by the COPC.

Barriers impede or slow down the migration of COPCs along a pathway and if multiple barriers effectively prevent the migration of COPC the likelihood of a COPC to impact on the environmental value of a receptor becomes negligible and the pathway implausible.

Barriers can be of natural or engineered nature including:

- a large distance between the source and receptor
- low permeable confining geological formation disconnecting pathways

- complete saturation of tailings and rejects beneath the water table creating anoxic condition and inhibiting the release of metals and metalloids from the tailings solids
- vadose zone preventing contaminant migration into or from the groundwater system enclosure of COPC in a low permeable mine waste deposit
- acid neutralisation capacity of the mine waste material or geological material enclosing the waste material
- an engineered vertical or horizontal reactive barrier separating the mine waste material form the environment.

The conceptual hydrogeological model for the IPE Project area and its surround presented in KCB (2016) was reviewed and interrogated for COPC plausible pathways in the environment and barriers that could inhibit the release or migration of the COPCs.

Two plausible pathways with COPC to potentially impact receptors were identified and the potential impacts to environmental values related to the source – pathway – receptor combination were carried forward into a qualitative risk assessment. The receptors and environmental values potentially affected are:

- The value of rehabilitated N1-TSF land as grazing land due to salinity and sodicity of soil cover
- Potential farmers using groundwater from the Rangal Coal Measures that is adversely affected by acid mine drainage seepage from the N1-TSF.

Qualitative risk assessment was used to assess the likelihood of harm to the environment as the result of exposure to COPC migrating along the plausible pathways from the N1-TSF to environmental receptors, and the consequence of those impacts on receptors, the environment and specifically its relevant or potentially relevant values. Health and safety risks during mine operation and post closure were not considered as part of this assessment. Mine operational health and safety risks are addressed in the IPC Safety Health and Environment Risk Management System. Mine closure risks are addressed in the IPC Rehabilitation Management Plan.

While a number of potential environmental impacts and risks were identified and assessed, all:

- Were of low risk considered to be acceptable with respect to adverse effects to receptors and the impact to environmental values due to:
    - low potential of COPC in tailings seepage and water ponding on rehabilitated surfaces of the N1-TSF to harm the environment and
    - multiple barriers providing safeguard against COPC adversely impacting on receptors and environmental values in the long-term.
- Would not require the adoption of control measures or compliance criteria that are not already required by the EA.
- Can be mitigated by a sampling and monitoring strategy to test the robustness of leachate containment by the multiple barriers.

3 BASIS FOR SYSTEM DEVELOPMENT AND OPERATION

3.1 Operational Objectives

High level operational objectives to optimise the performance of the Tailings Cells are as follows (ANCOLD, 2019):

- Control distribution of the tailings to achieve the required geometric shape of the deposit, to maintain the water pool within the specified position and to ensure that segregation does not compromise the structural integrity of the deposit.
- Control the deposition cycle to ensure that settlement and drying of tailings conforms with the design intent.
- Control the level and position of the water pool to maintain a specified water cover or maintain freeboard to prevent the risk of overtopping.
- Control the flow and discharge of storm water which accumulates on the storage in such a way as to prevent damage.
- Control access so that only those persons authorised to gain access for the purpose of operation and supervisory management can do so.
- Optimise the recycle of water from the storage where appropriate. Discharge of water to the environment should not occur except for extreme, prolonged rainfall events.
- Keep uncontaminated water separate from contaminated water.
- Control dust during windy conditions by more frequent deposition to create maximum area of wet beaches and by control of traffic in the area.

3.2 Key Design References

The design benchmarks are as follows:

- *Guideline on Tailings Dams - Planning, Design, Construction, Operation and Closure (ANCOLD, 2019)*
- *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (DES, 2016)*
- *Guidelines on the Consequence Categories for Dams (ANCOLD, 2012)*
- *Guidelines on Selection of Acceptable Flood Capacity for Dams (ANCOLD, 2000)*
- *Guidelines for Design of Dams for Earthquakes (ANCOLD, 1998)*

3.3 Consequence Category Assessment

Dams, water storages and other hydraulic structures associated with environmentally relevant activities under the *Environmental Protection (EP) Act 1994*, are subject to assessment of consequence category. The benchmark reference relevant to consequence assessment and definition for design criteria is the manual for assessing the consequence category and hydraulic performance of structures ESR/2016/933 (DES, 2016).

Assessment criteria for Consequence Category assessments are based on the following failure scenarios:

(a)	'Failure to contain – seepage'	Spills or releases to ground and/or groundwater via seepage from the floor and/or sides of the structure.
(b)	'Failure to contain – overtopping'	Spills or releases from the structure that result from loss of containment due to overtopping of the structure.

(c) 'Dam Break' Collapse of the structure due to any possible cause.

In accordance with the EA (*Condition D1*), the consequence category must be assessed at the following times:

- Prior to the design or construction of the dam; or,
- Prior to any changes in its purpose or the nature of its stored contents.

The consequence category for the Tailings Cells was assessed in the N1-TSF Basis of Design Document (ATCW, 2020). The assessed consequence category of the tailings cells is 'Low'.

3.4 Design Criteria

3.4.1 General

Key design assumptions applicable to the N1-TSF are outlined in the Basis of Design (BOD) Report (ATCW, 2020). Design criteria relates to seepage, stability and hydraulic aspects which are summarised below.

3.4.2 Geotechnical Stability

With respect to tailings cells, two embankment zones are considered as follows:

1. Insitu waste rock
2. Constructed embankments

Insitu waste rock comprised of dragline spoil heaps has been dumped without compaction. Embankments will be constructed with rockfill, sourced from the N1 dump. Generally waste rock would be dozer pushed or placed with excavator and truck with final trimming undertaken by excavator. Waste rock used in embankment construction shall be spread in layers not exceeding 500mm and compacted with a minimum 5 passes with the spreading plant. No specific criteria applies to the construction materials, however it is assumed that the material would be consistent with characteristics described in the BOD report (ATCW, 2020).

The stability of the insitu waste rock and the constructed embankments have been assessed separately as detailed in the BOD report (ATCW, 2020). Limit equilibrium approaches were adopted with factors of safety required based on ANCOLD (2019). These design factors are provided in Table 7, below.

Table 7
Summary Results of Slope Stability Factors of Safety

Condition	Minimum Factor of Safety
Long Term/Steady State Seepage (at a maximum storage level)	1.5
End of Construction	1.3
Seismic Conditions*	
• Pseudo static (OBE)	1.2
• Pseudo static (SEE)	1.0
• Post-Seismic (Liquefied Shear Strength of Tailings)	1.0

** OBE: Operating Base Earthquake, producing a level of ground motion which will cause only minor and repairable damage to the structure.*
SEE: *Safety Evaluation Earthquake (SEE), under the SEE, damage could be more extensive and may disrupt operations but the facility should maintain its integrity and uncontrolled release of water should not occur.*

3.4.3 Seepage Management

No quantifiable criteria with respect to seepage management would generally apply, other than inference against the following:

- In accordance with the EA, contaminants that have the potential to cause environmental harm shall not be released directly or indirectly to any waters or land;
- excessive surface expression of seepage discharge downstream from the embankment should not occur; and
- a significant impact on the environmental status of receiving waters should not result.

3.4.4 Hydraulic Performance Criteria

the Manual for assessing the consequence category and hydraulic performance of structures (DEHP, 2016) specifies hydraulic performance criteria for regulated structures, summarised as follows:

- Spillway design
- Freeboard criteria (Design storage allowance, Extreme Storm Storage)

The consequence category of tailings cells has been assessed as low and as such no hydraulic performance criteria applies. Notwithstanding, the following operational objectives are applicable:

- Overtopping of tailings cells is to be avoided for all but extreme weather events. Minimising the spill risk is achieved though ensuring the storages levels does not exceed maximum levels specified in Section 4.

- No formalised spillways have been included for the tailings cells noting embankments are constructed with waste rock and as such, the probability of failure through overtopping is considered low. The above notwithstanding, nominal discharge points have been identified as depicted in Drawing 001 for discharge during extreme rainfall events.

4 REJECTS AND TAILINGS MANAGEMENT

4.1 General

The N1-TSF is to be maintained such that legislative requirements and company standards are met. It is important that the management team are aware of the consequence of failure of the dam, and their legal responsibilities to ensure that proper and adequate attention is given to the management of risks.

In addition to the operational objectives outlined in Section 3, the N1-TSF is to be managed in accordance with the following (ANCOLD, 2019):

- Maintained in a safe and stable state an in accordance with prescribed risk management specifications
- Operated in accordance with the requirements of the design report and operations manual (this document)
- Operated in accordance with legal requirements
- Operated to achieve prescribed environmental objectives; and
- Operated in accordance with the closure plan and intended use after closure. Maintenance of work-related records as well as accomplishment reports.

4.2 LOM Rejects and Tailings

The anticipated Life-of-Mine (LOM) rejects and tailings tonnages and predicted storage volumes for these materials are shown in Table 8.

The volumes were calculated assuming the following settled density values:

- Tailings 0.75 t/m^3
- Rejects 1.35 t/m^3

Table 8
Tailings and rejects tonnages and volumes

Year	Tailings (tpa)	Cumulative Tailings Volume (m^3)	Rejects (tpa)	Cumulative Rejects Volume (m^3)
2019	150 000	200 000	500 000	370 370
2020	150 000	400 000	500 000	740 741
2021	250 000	733 333	800 000	1 333 333
2022	250 000	1 066 667	800 000	1 925 926
2023	250 000	1 400 000	800 000	2 518 519
2024	250 000	1 733 333	800 000	3 111 111
2025	250 000	2 066 667	800 000	1 703 704
2026	250 000	2 400 000	800 000	4 296 296
2027	250 000	2 733 333	800 000	4 888 889
2028	250 000	3 066 667	800 000	5 481 481

4.3 PAF Tailings Disposal

Results of hydro-geochemical analysis of IPM tailings and rejects and IPC potential rejects summarised in Section 2 suggest that acid and metalliferous drainage from tailings and rejects present a low risk and will be manageable. The management can be carried out by isolation of any PAF tailings and rejects in an anoxic environment, which has been shown to inhibit acid generation and the release of soluble metals and metalloids. This will be achieved by:

- Adequate dispersion of PAF material within the low-permeability tailings
- Permanent submersion of PAF material below water table
- Provision of sufficient NAF cover material to avoid interaction of mineral waste material with rainwater as a precautionary measure.

To ensure the effective management of PAF tailings and rejects the following protocols will be adhered to and monitored.

- No reject materials will be placed above the pre-mining groundwater table and any closer than 3 m to the rock head; this will be managed by survey limit pegs.
- PAF materials will not be placed within 2 m of the minimum expected post closure pit water level to remain saturated; survey control will be used to ensure documented evidence of distance from the predictive estimate of the minimum waterline to the upper PAF mineral waste line is recorded.
- Mineral waste materials in planned disturbance areas of the IPC will be geochemical characterised ahead of mining to confirm the expected geochemical characteristics of these materials.
- Rejects liquor rejects and tailings will be regularly sampled and analysed to confirm their hydrogeochemical characteristics and to re-evaluate and update the management and disposal strategies for PAF rejects and tailings.

As a contingency, in the unlikely event that larger volumes of PAF tailings and rejects material is produced by the CHPP and cannot be accommodated in the active disposal cell, systems will be in place to pump tailings slurry away from any coal face at the bottom of the next downstream disposal cell. As this is expected to be required infrequently, the N1-TSF has enough capacity to accommodate PAF tailings and rejects generated that cannot be disposed in the active cell. Where necessary, PAF tailings and rejects will be treated as a precautionary measure with small amount of alkaline material. This treatment is to ensure the potential for acidity to impact upon supernatant water quality is minimised prior to covering the PAF material with NAF tailings material.

4.4 Pumping and Piping Systems

The pumping and pipeline system for the TSF comprises the tailings delivery line and the return water line to the process pond. General surveillance of pumping and pipeline systems is to be undertaken to confirm effective operability of these systems. Such inspections are covered under Section 5.

In addition to inspection requirements for pumping and piping systems, a general procedure for repair of faults or small leaks within pipelines is to be adopted as described below:

- Maintain an inspection program to check for faults or leaks (refer Section 5)
- Where a leak is detected, this area shall be marked to assist maintenance personnel to locate the fault.
- As a temporary measure, Linatex bandages, fibreglass tape, Bielzona or insertion of timber plugs may be used to repair leaks.
- In the event that a significant fault or leak is encountered (i.e. cannot be managed by temporary measures), the system shall be shut down, and effective repairs, which may include replacement of pipe sections, is to be undertaken.

4.5 Return Water Management

Typically, tailings would be deposited from a single discharge point with a decant pond formed at the opposite end of the cell. A floating pump arrangement utilised to remove the supernatant water and pump it into the return water pipeline. Flocculent may be added to the tailings discharge pipe to assist the recovery of water and tailings consolidation.

The water return pipeline will be positioned above ground to allow ease of inspection. As required, small sections of the pipeline may be buried and/or protected by steel/concrete casing to allow for heavy vehicle crossings over the pipeline.

4.6 Seepage Management

Seepage of the N1-TSF is anticipated to have typically metal concentrations similar or below background concentrations of deep groundwater as defined by:

a) The water quality objectives of the Isaac Groundwaters, water chemistry Zone 34
b) The long-term groundwater monitoring at locations within and adjacent to the IPC mining leases.

Seepage is expected to be contained within the N1 void bounds due to the low permeability of the tailings material itself, the natural low pervious geological barriers (confining mudstone and siltstone beds of the Rangal Coal Measures and the Rewan Group) and the natural groundwater levels that are higher compared to the levels of water in the final void. A leachate and groundwater sampling and monitoring strategy will be implemented to test the robustness of leachate containment by the multiple barriers. Details of the monitoring program are provided in Section 5.

4.7 Final Void Water Balance

Upon filling of the N1-TSF cells, it is expected that the N1 pit would be used for tailings deposition, however details for the deposition strategy have not yet been finalised. The final water balance within the final void would need to be assessed once a deposition plan and closure plan is finalised for the N1 void.

5 MONITORING, REPORTING AND REVIEW

5.1 General

Dam monitoring is to be used to determine trends in the stability performance of the N1-TSF. This process consists of the collection, recording, analysis and devices installed at or near dams (ANCOLD, 2003). Key aspects for monitoring, beneficial for assessing the performance of the TSF are as follows:

- Reservoir water level
- Seepage which way be measured at any point on the dam abutments or reservoir
- Rainfall
- Embankment porewater pressure
- Surface and internal movements
- Seismic events which may be measured on a regional or local basis

Existing and recommended monitoring for the TSF is detailed below.

5.2 Embankment Stability

Currently no instrumentation is installed for monitoring the geotechnical stability of the structure. As a minimum the following would be recommended:

- Survey monuments; and,
- Piezometers.

Details of recommended instrumentation is as follows:

<u>Survey Monuments</u>

Survey monuments generally comprise permanent benchmarks located around the TSF used to monitor vertical and horizontal displacement. As a minimum, survey monuments should be established on the crest of all embankments. In siting monuments, consideration should be given to traffic movements around the TSF such that they are not disturbed. Additional settlement monitoring sites need to be established where any monitored or observed settlement of displacement occurs.

Quantifying normal settlement versus abnormal settlement is difficult. Various empirical predictive methods are available, however factors such as construction materials and techniques, moisture content in construction material, nature of stored contents, phreatic surface, foundation conditions all contribute to the settlement rate. On this basis, it would be required to establish a baseline of 'normal' settlement with particular attention paid to settlement rates when monuments are first installed, to establish if settlement rates are increasing or exceptionally high.

As a minimum, survey monitoring shall be carried out on a quarterly basis. The results of survey from each site would need to be plotted, with a broad assessment of the rate of settlement to be undertaken. Any significant increase to this rate the settlement data shall be reviewed by a suitably qualified dam engineer (unless otherwise covered by the Annual Dam Safety Review). All settlement results shall be analysed regardless as part of the annual dam safety review/operational audit (refer Section 8.1).

Piezometers

Monitoring of peizometric level is required to measure embankment phreatic surface, which provides a basic and efficient means for assessing geotechnical stability of the embankment. Both sudden or gradual changes (increase or decrease) in the phreatic surface can be indicative of embankment instability.

As a minimum, it would be recommended to install piezometers on each embankment. Measurement of piezometric level is to be carried out monthly. The results of the monitoring are to be plotted, with a broad assessment of the rate of water level movement being made.

Any significant change in the rate, the monitoring data should be reviewed by a suitably qualified dam engineer. Otherwise, review and analysis of the monitoring should be carried out as part of the annual dam safety review/operational audit.

5.3 Environmental Monitoring Schedule

Monitoring schedules, programs and site Operation Management Procedures have been developed to ensure that all aspects of environmental management are incorporated into the TSF and related activities. Environmental monitoring is to be undertaken in accordance with the Receiving Environment Monitoring Plan (REMP).

5.4 Incident Reporting

All operational activities from tailings management that results in an impact to the environment must be reported to the Environmental Superintendent and notification to the Department of Environment and Science (DES) must occur.

Examples of incidents include the following:

- Exceedance of MRL
- Chemical spill;
- Tailings/slurry spill, including spillage from ruptured pipelines; and,
- Discharge of process water to land, including spillage from ruptured pipelines.

Where such incidents occur, an action plan may be required to define rectification/remediation measures.

5.5 Inspection and Monitoring Summary

A schedule for inspections and monitoring for the TSF is provided in Table 9. This schedule is based on the inspection and monitoring requirements as outlined above.

Table 9
N1-TSF monitoring, inspection and review schedule

Frequency	Action
Weekly	Record daily total rainfall and pan evaporation depth.
Monthly	Record total volume pumped and average flow rates of tailings slurry to N1-TSF and return water CHPP
Monthly	Monitor percentage solids and slurry density of tailings
Monthly	Assess actual tailings and coarse reject volumes against predicted volumes to track performance.
Monthly	Record spigots and decant locations
Monthly	Inspect tailings discharge lines, process water pipeline and discharge points.
Monthly	Record tailings decant water levels
Monthly	Inspect wall for any signs of seepage and instability
Quarterly	Summarise impoundment elevation levels and plot data graphically.
As Specified in the EA	Monitor the Standing Water Level (SWL) at the locations specified in Table 13 of the EA. IPC may consider monitoring SWL at additional locations to supplement information gained from the current environmental monitoring program.
As Specified in the EA	Monitor the quality of the receiving waters at the locations specified in Table 8 and depicted in Figure 2 of the EA for each quality characteristic stated in Table 7 of the EA.
As Specified in the EA	Monitor the quality of groundwater at the locations specified in Table 11 and for each quality characteristic listed in Table 12 of the EA. IPC may consider monitoring groundwater quality at additional locations to supplement information gained from the current environmental monitoring program.
Annually	Collect, characterise and assess actual physical properties of rejects during placement, and specifically analyse selected samples for the following suite of parameters: • Bulk density • Dry density • Water content • Hydraulic conductivity Record beach slope at all tailings discharge locations.
Annually	Collect, characterise and assess actual rejects from the CHPPs and the rejects disposal area(s) to confirm the expected geochemical properties of these materials described in Section 2.0 and APPENDIX A. Specifically analyse selected CHPP samples and samples from the N1-TSF rejects disposal area at a NATA registered laboratory for the following suite of parameters: • net acid producing potential • salinity • pH

	• Electrical Conductivity (EC) • Acid Neutralising Capacity (ANC) • Net Acid Generation (NAG) (reporting NAG capacity and NAG pH after oxidation) • Total Sulphur (S) • Chromium Reducible Sulphur (Scr) • Boron (B) • Cadmium (Cd) • Iron (Fe) • Aluminium (Al) • Copper (Cu) • Magnesium (Mg) • Manganese (Mn) • Calcium (Ca) • Sodium (Na) • Zinc (Zn) • Sulphate (SO4)
Annually	Complete detailed facility inspection including all exposed slopes, embankments, piping, valves and pumps.
Every two years	Review N1-TSF water balance model and update if necessary
Every two years	Review and update the Mine Waste Management Plan if necessary

6 DECOMMISSIONING AND REHABILITATION STRATEGY

The N1-TSF and N1 residual void will be rehabilitated in accordance with conditions set out in the EA. Condition F4 requires that:

Land disturbed by the authorised mining activities will be rehabilitated to a safe, stable and non-polluting landform, with a self-sustaining vegetation cover in accordance with:

a) Appendix 2, Table 1: Rehabilitation Requirements
b) Table 18: Residual Void Design
c) Table 19: Rehabilitation Schedule
d) The rehabilitation management plan required by Condition F7.

A separate document will be developed as part of the mine rehabilitation management planning. This document will provide details of the decommissioning and rehabilitation works to be undertaken for N1-TSF and N1 residual void.

Future staged rehabilitation activities of IPC's decommissioning and rehabilitation strategy for N1-TSF are anticipated to include:

- Identifying required volumes of suitable cover materials and stockpile material close to the facility for construction use.
- Placement of an appropriate cover system to:
    - control seasonal drying and wetting of the underlying tailings and therefore reducing the risk of cracks developing in the tailings deposition
    - provide an oxygen ingress barrier for the underlying tailings material and which reduces potential of acid generation
    - increase depth to water table resulting in a reduction of an upwards migration of salts, the potential for soil salinization and reduced run-off water quality
    - provide a stable ground for human, livestock or wildlife to safely access the rehabilitated area.
- Assess the long-term safety, stability and management of the residual void which may include:
    - geotechnical investigations to confirm material characteristics and structural integrity of the pit walls
    - scaling and profiling low wall and soil slopes to a uniform batter slope
    - construction of drainage control structures to reduce drainage on and over the low wall
    - promoting natural re-growth of vegetation that will provide some ground cover to reduce low wall erosion
    - fencing and barricading rejects deposition areas that in long-term may remain inundated to restrict access for human, cattle and wildlife.
- Topsoiling and seeding with appropriate native and exotic pasture species.
- Ongoing monitoring of rehabilitation to determine success in terms of erosion, stability, groundcover, sustainability and crust penetration.

All soils to be used for rehabilitation will be NAF and will support post mining grazing land use. IPC will implement closure trials that involve current best practice, continue to investigate alternative rehabilitation strategies for the N1-TSF while consulting with DES.

7 EMERGENCY ACTION PLANNING

The purpose of the EAP is to reduce the risk of human life loss and injury, to minimise property damage and environmental harm during an unplanned or emergency event arising from failure of the TSF. The EAP defines the procedures to identify emergency conditions that could endanger the integrity of the storage and that would require immediate action. The EAP also prescribes procedures that should be followed by operating personnel in the event of an emergency including timely warning to appropriate emergency management agencies for implementation of community protection measures, if deemed necessary.

Emergency response procedures are outlined in the Isaac Plains Complex Risk Management System and Emergency Management Plan.

8 GLOSSARY OF TERMS AND ACRONYMS

Table 10
Glossary of terms and acronyms

Term/Acronym	Description
Acid	A measure of hydrogen ion (H+) concentration; generally expressed as pH
Acid-Base Account	Evaluation of the balance between acid generation and acid neutralisation processes. Generally determined by the maximum potential acidity (MPA) and the inherent acid neutralising capacity (ANC), as defined below. See also "MPA" and "ANC"
Adaptive Management	Adaptive management allows for contingency planning and remediation if unacceptable impacts on the receiving environment are predicted or measured
AHD	Australian Height Datum
ANC	Acid Neutralising Capacity, expressed as kg H2SO4 per tonne of rock/material. A measure of a sample's maximum potential ability to neutralise acid
ANC/MPA ratio	Ratio of the acid neutralising capacity (ANC) to the maximum potential acidity (MPA) of a sample. Used to assess the risk of a sample generating acid conditions. See also "ANC" and "MPA"
ANZEEC	New Zealand Environment and Conservation Council
Aquatic ecosystem	Distinct community of organisms that exists in a watery environment and depend on that environment
Barrier	Imped or slow down the migration of contaminants along a pathway and can be of natural or engineered nature
CHPP	Coal Handling and Preparation Plant
Coarse Reject	Coarse mineral waste materials (typically greater than 1.5 mm grain size) produced from the CHPP as part of the processing of coal.
Consequences	The effects (or impacts) of a particular situation, action or event. Impacts may be positive (benefits) or negative (costs, or harms). Risk assessments usually focus on assessing the potential negative consequences (the harm) that may result from the realisation of identified hazards
COPC	Contaminants of Potential Concern
DES	Queensland Department of Environment and Science
EA	Environmental Authority; in this report refers to the Environmental Authority EPML00932713 effective of 24 January 2018
EC	Electrical conductivity
Environmental Impact	The effect that the activities of people and businesses have on the environment
EPA	Queensland Environmental Protection Act 1994
EPP	Queensland Environmental Protection (Water) Policy, 2009

DNRM	Queensland Government of Natural Resources and Mining, now Queensland Government Department of Natural Resources, Mines and Energy
Final Void	Area of excavation that is not backfilled after mining is complete
Fine Reject	Fine-grained mineral waste materials (typically less than 1.5 mm grain-size) produced from the CHPP as part of the processing and washing of coal. Fine reject typically comprises mud/clay and silt present in CHPP wastewater and is also known as "Tailings".
Harm	The damage to a receptor that results when a hazard is realised.
Hazard	A property or situation that in particular circumstances could lead to harm.
IPC	Isaac Plains Complex operation
IPE	Isaac Plains East mining project on ML 700016, ML 700017, ML 700018 and ML 700019
IPM	Isaac Plains Mine on ML 70342
Leachate	Leachate is this report is water that, in the course of passing through mineral waste, extracts soluble or suspended solids.
LOM	Life-of-Mine; the time in which the ore reserves will be extracted.
LOR	Limit of Reporting
Mineral Waste	Overburden, interburden and similar 'waste rock' (spoil) material mined and disposed during extraction of coal. In this report, the definition of Mineral Waste also extends to rejects from the CHPP. See "Rejects".
MPA	Maximum Potential Acidity. Calculated by multiplying the total sulfur (S) or sulfidesulfur (Scr) content of a sample by 30.6 (stoichiometric factor) and expressed as kg H2SO4 per tonne of rock/material.
µS/cm	Micro-Siemens per centimetre
MWMP	Mine Waste Management Plan
NAF	Non-Acid Forming. Geochemical classification criterion for a sample that will not generate acid conditions. A sample classified as NAF may, or may not, have a significant sulfur content but the availability of neutralising material within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any contained sulfide minerals. As such, material classified as NAF is considered unlikely to be a source of acidic drainage.
NAG	Net Acid Generation
NAPP	Net Acid Producing Potential expressed as kg H2SO4 per tonne of rock/material. Calculated by subtracting the ANC from the MPA.
NATA	National Association of Testing Authorities (Australia)
Overburden	Waste rock material overlying the uppermost mined (economic) coal seam.
PAF	Potentially Acid Forming. Geochemical classification criterion for a sample that has the potential to generate acid conditions. A sample classified as PAF almost always has a significant sulfur content, the acid generating potential (MPA) of which exceeds the inherent acid neutralising capacity (ANC) of the material. This means there is a

	high risk that such a material, even if pH circum-neutral when freshly mined or processed, could oxidise and generate acidic drainage if exposed to atmospheric conditions.
Pathways	The routes or means by which defined hazards may potentially realise their consequences at the receptors.
Ramp	Moderately inclined accessways from the surface to mining levels for haulage of ore, materials, waste, workers, and equipment.
Receptors	Identified individuals, environmental populations or components, structures, assets and property that may potentially be exposed to an identified hazard, and that may consequently suffer harm
Rejects	Mineral waste produced during the processing of coal, typically from a CHPP; rejects typically comprises crushed siltstone, mudstone and fine-grained sandstone, which is mined as coal seam roof, parting or floor material during the extraction of ROM coal. Rejects is commonly produced in different size fractions – fine and coarse reject.
Risk	A combination of the probability, or frequency, of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.
Rock head	Surface between overlying unconsolidated material and solid bedrock below.
ROM	Run of Mine; Coal as it comes from the mine prior to screening or processing.
Scr	Chromium reducible sulfur; analytical procedure to determine the sulfide-sulfur concentration in a sample.
Seepage	The act or process involving the slow flow of a water or other liquid through a porous material such as soil or rock.
SO4	Sulfate
Source	The activity or operation taking place on the site from which a particular hazard may arise.
Spoil	Waste rock material overlying and between coal seams.
Stygofauna	Subterranean fauna that live in groundwater systems or aquifers, such as caves, fissures and vugs.
Supernatant water	The water ponded on a tailings surface following the sedimentation of the deposited tailings slurry.
SWL	Standing Water Level
Tailings	Fine-grained mineral waste materials (typically less than 1.5 mm grain-size) produced from the CHPP as part of the processing and washing of coal. Fine reject typically comprises mud/clay and silt present in CHPP wastewater and is also known as "Fine Rejects".
Tpa	Tonnes per annum
TSF	Tailings Storage Facility
Vadose Zone	A subsurface zone containing water under pressure less than that of the atmosphere, including water held by capillary; and containing air or gases generally under atmospheric pressure.
Water Extract	A method to determine the water soluble parameters in soil. Solutes are leached from a soil sample by the continuous suspension and agitation.
Water quality objective	Specific water quality targets agreed between stakeholders, or set by local jurisdictions, that become the indicators of management performance

APPENDIX M VOID WASTE BALANCE

Isaac Plains Complex

Water Balance Model Update 2021

Stanmore IP Coal Pty Ltd
0476-48-B1, 30 November 2021

Report Title	Isaac Plains Complex, Water Balance Model Update 2021
Client	Stanmore IP Coal Pty Ltd
Report Number	0476-48-B1

Revision Number	Report Date	Report Author	Reviewer
DRAFT	25 October 2021	KO	AMC/MGB
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For and on behalf of WRM Water & Environment Pty Ltd
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1 Introduction

WRM Water & Environment (WRM) have been engaged by Stanmore IP Coal (Stanmore) to update the water balance model for the Isaac Plains Complex (IPC), which includes the Isaac Plains Mine (IPM) and Isaac Plains East Extension (IPEE), to reflect current and proposed conditions at the mine.

Sections C29, C30 and C31 of the IPC Environmental Authority (EA) (EPML00932713), which relate to the development of a Water Management Plan (WMP), states that the WMP must include a water balance model and appropriate documentation. The scope of work completed by WRM for this assessment includes:

- Review and interpretation of project data provided by IPC;
- Update of the existing OPSIM water balance model;
- Assessment of the current status of the IPC water management system (WMS) using the updated model; and
- Preparation of a standalone report summarising the investigation outcomes.

The primary purpose of the IPC water balance model is to provide Stanmore with a management tool which allows strategic review of the WMS, and quantitatively assess potential changes to this system. Although the model incorporates all the key components of the IPC WMS in significant detail, it is not intended to be utilised as a daily operational water management tool.

2 Climate data and simulation methodology

2.1 OVERVIEW

An OPSIM water balance model has been developed for the existing and proposed IPC water management system (WMS). The OPSIM model dynamically simulates the operation of the water management system and keeps complete account of all site water volumes and representative water quality on a daily time step.

The model has been designed to simulate the operation of all major components of the WMS at IPC, including:

- Climatic variability – rainfall and evaporation;
- Catchment runoff and capture;
- CHPP operations and site water demands, including dust suppression
- Pit dewatering;
- Pump and gravity transfers;
- Water storage inflows/outflows, discharge and seepage; and
- Controlled release capabilities.

The proposed model configuration and operating parameters are summarised in the following sections.

2.2 RAINFALL AND EVAPORATION

Long term daily rainfall and evaporation data for the area from January 1889 to December 2020 (132 years) obtained from the SILO database (https://longpaddock.qld.gov.au/silo/) has formed the basis of the simulation.

Morton's Lake evaporation has been used to estimate evaporation losses from storages. Table 2.1 shows the long-term monthly averages for Morton's evaporation and monthly SILO rainfall data.

Figure 2.1 shows the annual distribution of monthly rainfall and evaporation. Rainfall across IPC is greatest during the summer months, with the lowest rainfalls occurring mid-winter, as inferred in Figure 2.1.

Table 2.1 - Long-term average rainfall and evaporation (SILO 1889 - 2020)

Month	Rainfall (mm)	Morton's lake evaporation (mm)
Jan	106.2	198.3
Feb	97.8	166.8
Mar	66.2	166.8
Apr	30.6	132.9
May	25.6	102.4
Jun	28.5	81.8
Jul	19.9	92.3
Aug	18.7	120.2
Sep	14.3	153.5
Oct	29.8	190.0
Nov	48.8	200.9
Dec	83.1	210.0
TOTAL	569	1,814

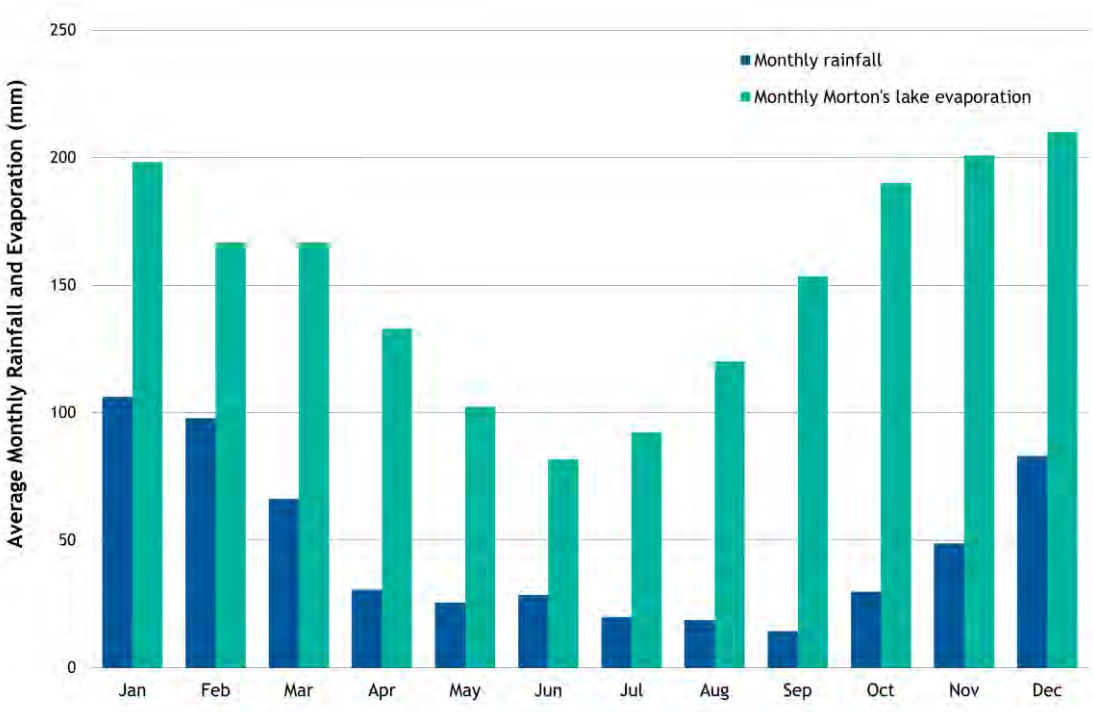

Figure 2.1 - Distributions of monthly rainfall and evaporation (SILO 1889 - 2020)

2.3 SIMULATION METHODOLOGY

The IPC WB model has been run for 4 stages, as shown in Table 2.2.

Stage 1 was used to validate the WB model against data recorded during this period. Stage 2 to Stage 4 provided a forecast of the storage behaviour, external water demand and spill risks for the 4.5 year period between July 2021 and December 2025.

The Stage 1 (validation) model was run using historical site rainfall and SILO Climate Morton's Lake evaporation data. The forecast model (Stage 2 to 4) was run for 128 climate sequences, each referred to as a "realisation". Each realisation is based on a 4.5-year sequence extracted from the historical rainfall data. The first realisation was based on rainfall data from 1889 to 1894. The second used data from 1890 to 1895 and so on. This approach provides the widest possible range of climate scenarios covering the full range of climatic conditions represented in the historical rainfall record. Statistical analysis of the results from all realisations provides a probability distribution of key hydrologic parameters, such as storage inventories and pit inundation.

Table 2.2 – IPC project staging

Stage	Representative mine year	Modelled period	No. of model years
1 (validation)	-	July 2019 – June 2021	2
2 (forecast)	2021	July 2021 – December 2022	1.5
3 (forecast)	2023	January 2023 – December 2024	2.0
4 (forecast)	2025	January 2025 – December 2025	1.0

3 Water management system configuration and assumptions

3.1 WMS COMPONENTS AND LAYOUT

A summary of the existing and proposed storages within the IPC WMS are summarised in Table 3.1. A schematic of the IPC water management system configuration is shown in Figure 3.5.

A summary of the modelled (base case) WMS operating rules is outlined in Table 3.9. These have been based on the information provided by Stanmore personnel and previous studies.

Table 3.1 - Existing and proposed IPC storage details

Storage name	Storage Type	Storage Capacity (ML)	Overflows to
Existing Storages			
RD1	Mine affected water dam / Release point	205	Smoky Creek
RD2	Sediment dam / Release point	148	Billy's Gully
CHPP PP	Mine affected water dam	17	RD1
S2 SD	Sediment dam / fill point supply	172	Smoky Creek
N1 SD	Sediment dam / sump	14	Smoky Creek
S2 Pit	Inactive void / mine affected water storage	-	Smoky Creek
S3 Pit	Inactive void (partially backfilled)	-	Billy's Gully
N1 Pit	Tailings storage facility / Possible future water storage	-	Smoky Creek
Raw Water Dam	Raw water dam	1.2	Smoky Creek
E2 SD	Sediment dam	18.0	Billy's Gully
E4a SD	Sediment dam	2.6	Smoky Creek
E4b SD	Sediment dam	5.3	Smoky Creek

3.2 CATCHMENT RUNOFF

3.2.1 Overview

The Australian Water Balance Model (AWBM) model was used to represent the runoff characteristics of mine site catchments. AWBM uses a group of connected conceptual storages (3

surface storages and 1 groundwater storage) to represent catchment runoff. Water in the conceptual storages is replenished by rainfall and reduced by evapotranspiration. Simulated surface runoff occurs when any of these storages fill and overflow. The model parameters define the depth and relative area of each of the storages, as well as the rate of water flux from/between storages.

3.2.2 AWBM calibration for natural catchment type

As part of previous investigations, the AWBM model was calibrated to the recorded daily Phillips Creek flows at Tayglen, using the Rainfall Runoff Library (RRL) developed by the CRC for Catchment Hydrology (Podger, 2004). The model was run for a warm-up period (19/5/1968 to 27/8/1968) to initialise the various model storages and calibrated over the period 28/8/1968 to 29/9/1988. The model was calibrated to achieve a similar total volumetric runoff coefficient to the recorded data. Table 3.2 shows the calibration data statistics and Table 3.3 shows the adopted AWBM parameters and calculated volumetric runoff coefficient for the natural catchment.

Table 3.2 - Calibration data statistics, Phillips Creek

Parameter	Total runoff (mm)	Mean (mm)	Std. deviation (mm)	Skew (mm)
Observed runoff	740.07	0.101	0.858	15.867
Modelled runoff	740.44	0.101	0.756	14.807

3.2.3 AWBM parameters

To adequately simulate the site water balance, it is necessary to define the runoff characteristics of the various catchment surface types. Catchments across the site were characterised into the following land use types:

- Natural, representing areas undisturbed by mining;
- Compacted, representing hauls roads, hardstand areas, stockpile and the pit floor;
- Cleared or pre-strip areas ahead of mining;
- Rehabilitated areas; and
- Spoil dump, representing uncompacted dumped overburden material.

To represent undisturbed areas on the mine site ("natural" catchments), the same calibrated parameters developed for Phillips Creek were used. When this parameter set is applied to the synthetic long-term rainfall data at IPC, the runoff coefficient is around 4.0%.

Compacted catchments (mining pit, roads/hardstand and stockpile/industrial areas) are characterised by hard surfaces which inhibit water infiltration, resulting in much higher rates of surface runoff. To represent compacted catchments, the depth of the model surface stores was substantially reduced and baseflow eliminated. The simulated volumetric runoff coefficient for disturbed catchments was 25.8%, about 6.5 times higher than natural catchments. This value is similar to typical values for urban catchments, which have similar characteristics.

The adopted model parameters for "rehabilitated spoil" assume lower opportunities for evapotranspiration than natural catchments and also that a significant component of runoff will seep through the spoil, discharging over several weeks rather than running off within a few hours of rainfall. The modelled runoff coefficient of 8.1% is around double than that for natural catchments.

The model parameters for "spoil" were revised to achieve better agreement with the observed site inventory over the 2016/17 calibration period (WRM, 2017). The runoff coefficient of 10.7% is around 2.7% higher than rehab catchments.

The adopted AWBM parameters for IPC used for modelling are summarised in Table 3.3.

Table 3.3 - Adopted AWBM parameters

Parameter	Natural/ Undisturbed	Cleared/ Pre-strip	Compacted	Rehabilitated spoil	Spoil dump
A1	0.013	0.1	0.134	0.1	0.1
A2	0.444	0.9	0.433	0.4	0.4
A3	0.543	-	0.433	0.5	0.5
C1	15	12	1.9	15	15
C2	100	54	19.1	100	100
C3	651	-	80.0	200	100
C_{av}	398.1	49.8	43.2	141.5	91.5
K_{base}	0.914	-	-	0.8	0.8
K_{surf}	0.502	-	-	-	-
BFI	0.21	-	-	0.9	0.9
C_v	4.0%	17.5%	25.8%	8.1%	10.7%

3.3 SALINITY PARAMETERS

The water balance model has been configured to use electrical conductivity (EC) as an indicator for water quality. Each runoff type has been assigned an EC concentration that has been based on the available historical water quality monitoring data. The adopted EC concentrations are given in Table 3.4. Note that natural catchments include Smoky Creek, and Billy's Gully as well as the undisturbed areas on the mine site.

Table 3.4 - Adopted salinity runoff parameters

Catchment land use	EC (µS/cm)
Natural	250
Spoil dump	1,000
Mining pit	6,000
Roads/hardstand	1,700
Cleared/pre-strip	600
Rehabilitated spoil	850
Stockpile/industrial area	6,000

3.4 CATCHMENT AREAS AND LANDUSE CLASSIFICATIONS

Catchment areas for the various pits and site water management infrastructure have been based on the latest topographic information provided by Stanmore (current as of May 2021) and discussions with IPC personnel. A breakdown of each catchment by land use classification has been undertaken using the latest aerial photography provided by Stanmore for the existing IPC (current as of May 2021) and discussions with IPC personnel. A summary of adopted catchment areas and land use types for each modelled stage at IPC are provided in Appendix A. Figures showing the representative disturbance footprints and adopted land use breakdown for each

modelled stage at IPC are shown in Figure 3.1 to Figure 3.4. Note that E2 and E3 pits were modelled as a single combined pit.

3.5 STORAGE CURVES

The storage curves for each of the modelled storages were based on the latest topographic information, discussions with IPC personnel and stage plans. The adopted storage curves for IPC are provided in Appendix B.

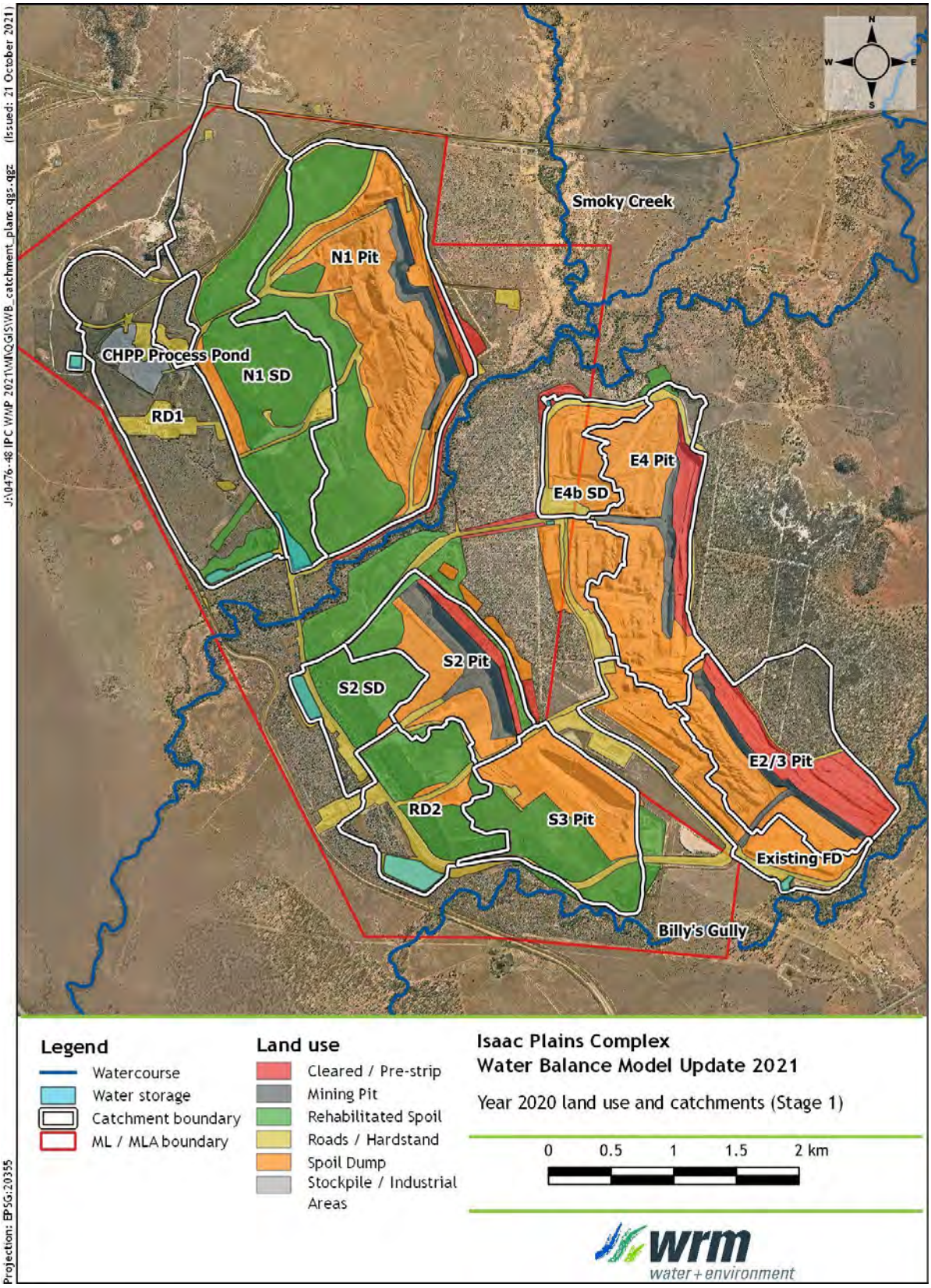

Figure 3.1 - Proposed catchment and land use boundaries - Stage 1

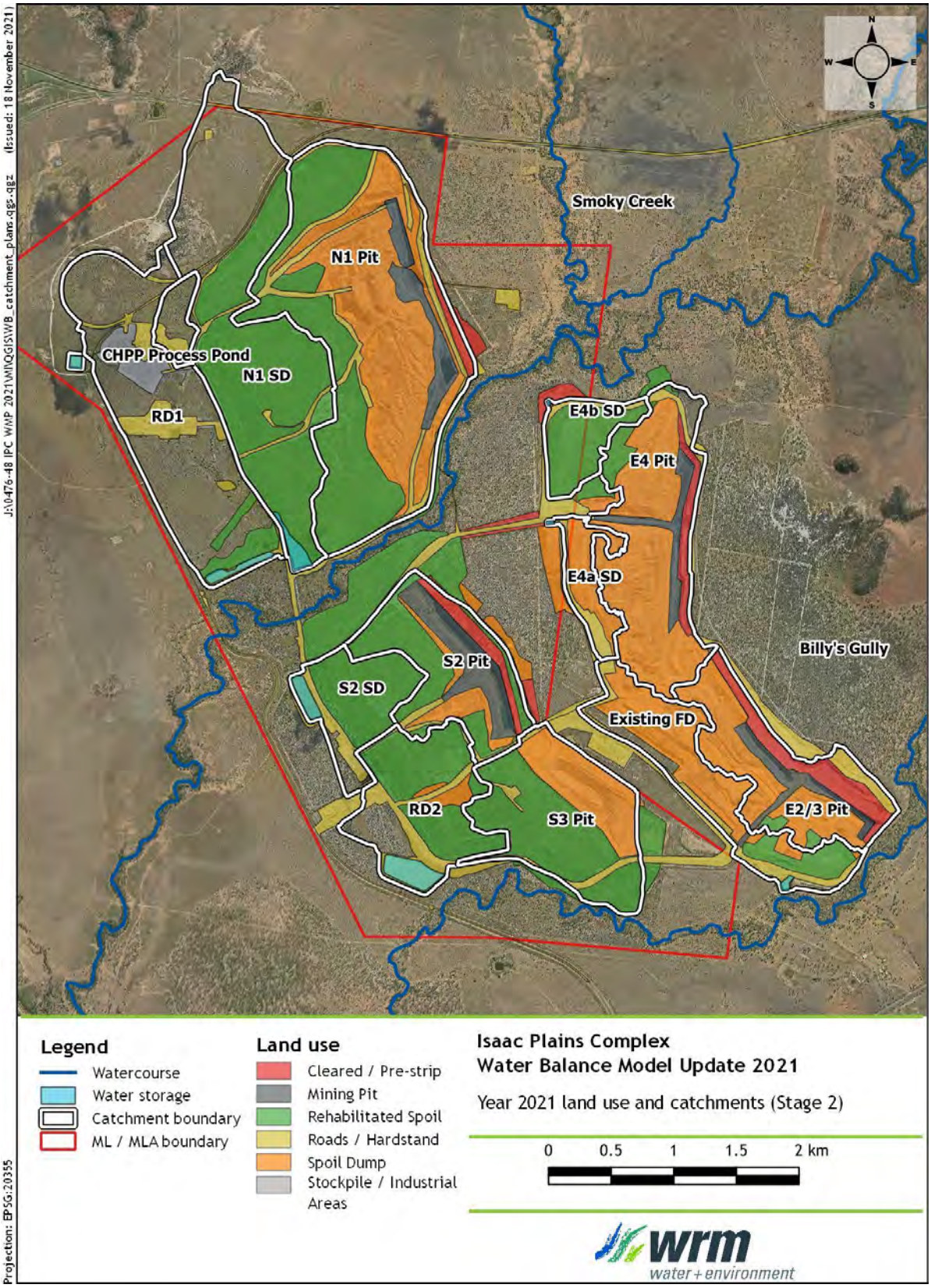

Figure 3.2 - Proposed catchment and land use boundaries - Stage 2

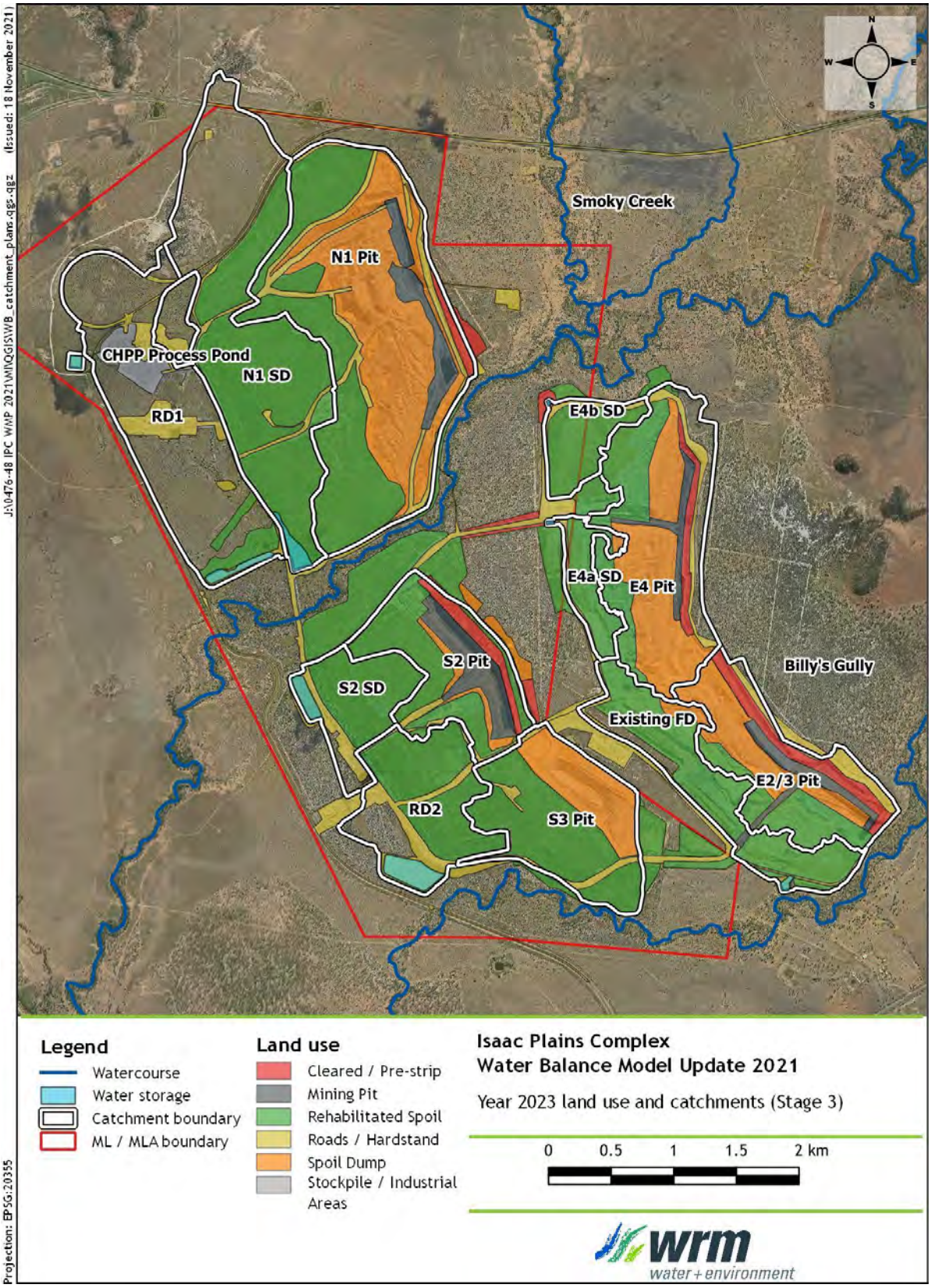

Figure 3.3 - Proposed catchment and land use boundaries - Stage 3

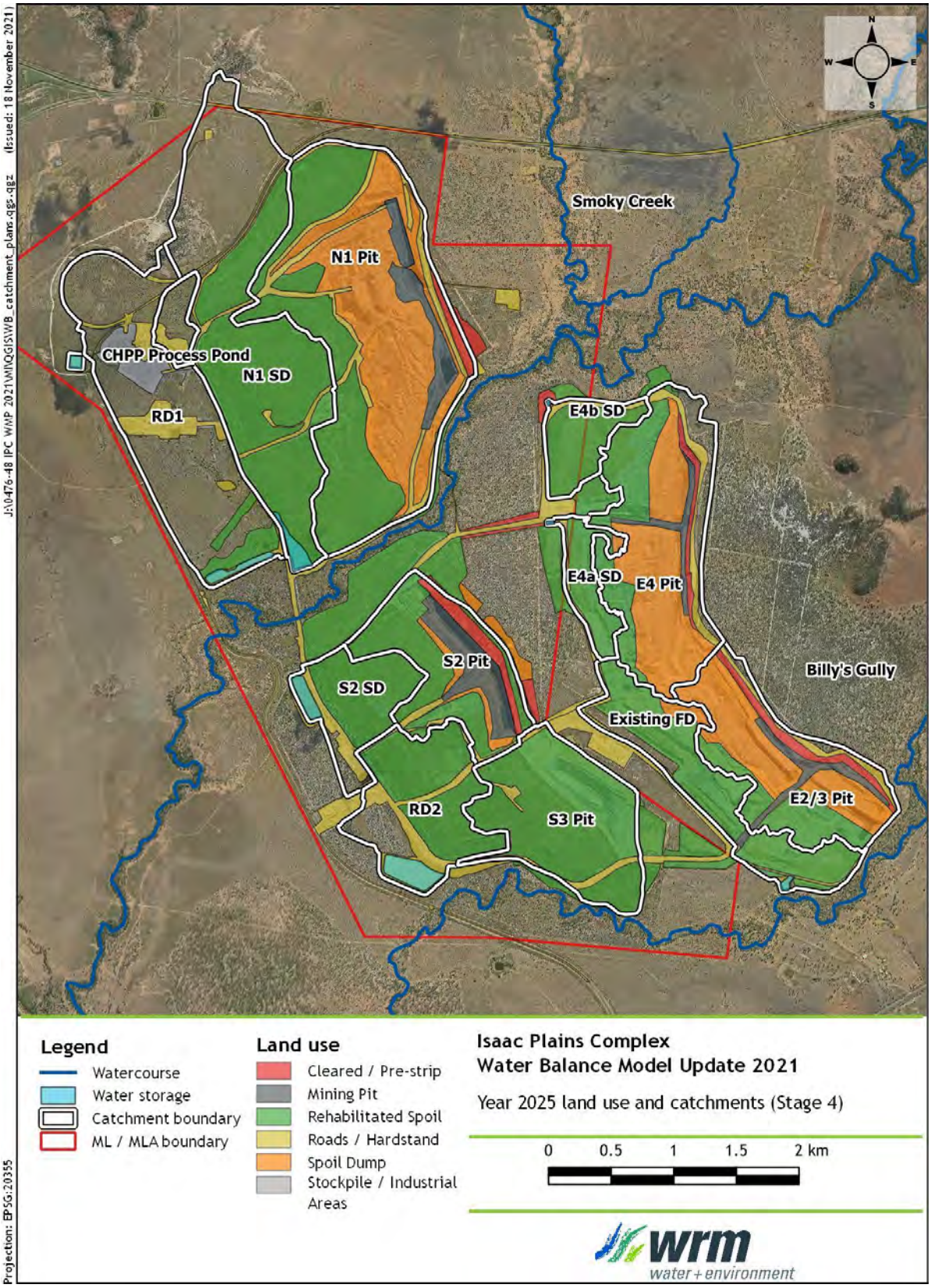

Figure 3.4 - Proposed catchment and land use boundaries - Stage 4

3.6 EXTERNAL WATER SUPPLY

The industrial/miscellaneous usage (includes usages such as washdown, fire circuit, pump gland seals and sprays) for IPC is solely supplied via the Eungella/Burdekin pipeline, via the Raw Water Dam. The maximum yearly allocation of external water is 938 ML/a. Within this yearly allocation, IPC is required to source 150 ML/a to Isaac Regional Council (IRC). Hence, the maximum yearly allocation including the IRC allowance is 788 ML/a.

The CHPP water usage for IPC will be mine affected water supplied from S2 Pit water storage, via the CHPP Process Pond, where possible. If mine affected water is not available, the CHPP would be supplied via the Eungella/Burdekin pipeline and the Raw Water Dam.

3.7 FORECAST CHPP PRODUCTION

Annual forecast tonnages for Stage 2 is 3.3 Mt feed. The annual forecast tonnages for Stage 3 and Stage 4 is 3.0 Mt feed.

3.8 WATER DEMANDS

3.8.1 Coal handling and preparation plant (CHPP)

Stanmore provided the following information regarding the average material moisture contents for the CHPP operations for the wet tailings disposal method for Stage 2:

- ROM coal feed: 7.0% w/w
- Primary product coal: 11.0% w/w
- Secondary product coal: 9.5% w/w
- Coarse rejects: 20.0% w/w
- Fine tailings: 80.0% w/w

The adopted CHPP throughputs for product coal and the various waste streams are as follows (shown as dry yields):

- Primary product yield (dry): 60.9% of ROM coal feed
- Secondary product yield (dry): 15.5% of ROM coal feed
- Coarse rejects (dry): 70% of total rejects
- Fine tailings (dry): 30% of total rejects

Based on these parameters, the gross water requirement for material process at the CHPP is approximately 312 L/ROM tonne. The fine tailings will decant to an average material moisture content of 20%, with the excess water reporting to the N1 Pit water storage. This would result in a CHPP and tailings circuit net loss of 69.5 L/ROM tonne.

3.8.2 Industrial/miscellaneous usage

Based on the CHPP operating specifications listed in Section 3.8.1, a CHPP water mass balance indicates that the average daily net processing requirement is 627 kL/d, or 229 ML/a over the Stage 2 period for a 3.3 Mt of feed tonnage.

Forecast industrial/miscellaneous usage (includes usages such as washdown, fire circuit, pump gland seals and sprays) has been based on advice from site personnel. The adopted industrial/miscellaneous usage for the simulation period is 1,315 kL/d (480 ML/a) (assuming 100% loss) based on the advice from site personnel.

3.8.3 Haul road dust suppression usage

Water from haul road dust suppression is sourced solely from S2 SD, which is supplied with mine affected water from S2 Pit. Forecast dust suppression usage rates have been based on the weighted average of the observed usage at IPC between:

- July 2017 and December 2018 period (around 83 ML/a per Mt of ROM tonnage);
- January 2020 and June 2021 period (around 302 ML/a per Mt of ROM tonnage); and
- Weighted average across the two periods (around 171 ML/a per Mt of ROM tonnage).

The average dust suppression usage is scaled up based on expected future annual ROM coal tonnage. The proposed dust suppression usage is 1,542 kL/d (563 ML/a) for 3.3 Mt feed.

3.9 GROUNDWATER INFLOWS TO MINING PITS

The net groundwater inflow rate to the existing IPM pits has been modelled as zero as per previous studies for the site.

For the IPE pits, the modelled groundwater inflows rates from Appendix B of the IPE Environmental Assessment Report (EAR) (Hansen Bailey, 2016) have been adopted. Groundwater inflow rates have been reduced to allow for face evaporation, as well as moisture entrainment within ROM coal hauled from the pit. The calculations for the proposed groundwater losses are provided in Table 3.5.

The gross and net groundwater inflows rates proposed for this assessment are provided in Table 3.6. Note that the groundwater inflow rates at IPE are not consistent with the groundwater inflow rates experienced at the existing IPM.

Table 3.5 - Estimated groundwater losses for IPE pits

Year	Estimated pit face length (m)[1]	Estimated pit face evaporation (ML/d)[2]	In-site ROM coal moisture (ML/d)[3]	Estimated average daily GW loss (ML/d)
2021	4,000	0.20	0.10	0.35
2022	4,200	0.21	0.10	0.37
2023	4,300	0.22	0.09	0.38
2024	4,200	0.21	0.09	0.37
2025	4,000	0.20	0.09	0.38

Notes: 1/Estimated from mine progression plans provided by Stanmore
2/Estimated by assuming a 20 m face height, average annual MLake evapotranspiration rate of 1,835 mm, and a coefficient of evaporation of 0.5
3/ Estimated using the coal tonnage and moisture content data provided by Stanmore

Table 3.6 - Adopted groundwater inflows rates for IPE pits (from EAR)

Year	Gross average daily GW inflow (ML/d)	Estimated average daily GW loss (ML/d)	Net average daily GW inflow (ML/d)	Net average annual GW inflow (ML)
2021	1.62	0.35	1.27	463
2022	1.45	0.37	1.08	396
2023	1.40	0.38	1.02	372
2024	1.38	0.37	1.01	368
2025	1.35	0.38	0.97	354

Based on a review of the Groundwater Report prepared as part of the EAR, we have assumed an average salinity for groundwater inflow of 7,500 µS/cm.

3.10 EA RELEASES CONDITIONS

IPC currently has an Environmental Authority (EPML00932713; DES 2021) which includes water release conditions. The integrated water balance model has been configured to simulate these release conditions, using electrical conductivity (EC) as the target contaminant.

A description of the current water release conditions is provided below.

3.10.1 Release conditions

Table 3.8 and Table 3.9 shows the contaminant release conditions given in the EA. Under these conditions, the release of mine affected water from authorised release points to receiving waters must not exceed those values (dependant on receiving water flow for some contaminants).

Table 3.7 - Mine affected water release limits

Quality Characteristics	Units	Minimum	Maximum
Electrical Conductivity (EC)	µS/cm	n/a	Variable[1]
pH	pH units	6.5	9.0
Total Suspended Solids (TSS)	mg/L	n/a	Variable[1]
Sulphate (SO_4^{2-})	mg/L	n/a	Variable[1]

Note: 1/ Release limits for EC, TSS and SO_4 are dependent on receiving water flow.

Table 3.8 - IPC EA - controlled release rules

Receiving Waters/Streams	Release Point (RP)	Gauging Station	GS Latitude (dec. degree, GDA 94)	GS Longitude (dec. degree, GDA 94)	Receiving Water Flow Criteria for Discharge (m^3/s)	Maximum release rate (for all combined RP flows)	Electrical Conductivity, Sulphate and TSS Release Limits
Isaac River (via Smoky Creek & Billy's Gully)	RP1, RP2, RP3, RP4 & RP5	130414A Isaac River @ Goonyella	-24.8555ºS	-147.9726ºE	Low Flow <4 m^3/s For a period of 28 days after natural flow events	<2 m^3/s	Electrical conductivity: 720 µs/cm Sulphate (SO_4^{2-}): 250 mg/L TSS: 55 mg/L
					Medium Flow 4 m^3/s	0.142 m^3/s	Electrical conductivity: 3,000 µs/cm Sulphate (SO_4^{2-}): 300 mg/L TSS: 55mg/L
					10 m^3/s	0.257 m^3/s	Electrical conductivity: 4,000 µs/cm Sulphate (SO_4^{2-}): 300 mg/L TSS: 200 mg/L
					High Flow 50 m^3/s	1.09 m^3/s	Electrical conductivity: 5,000 µs/cm Sulphate (SO_4^{2-}): 4000 mg/L TSS: 200 mg/L
					Very High Flow 100 m^3/s	2.02 m^3/s	Electrical conductivity: 5,000 µs/cm Sulphate (SO_4^{2-}): 400 mg/L TSS: 300 mg/L
					Flood Flow 250 m^3/s	3.07 m^3/s	Electrical conductivity: 8,000 µs/cm Sulphate (SO_4^{2-}): 400 mg/L TSS: 400 mg/L

3.11 OPERATING RULES & MODEL SCHEMATIC

Based on review of IPC documentation and discussions with site personnel, representative water management system operating rules have been developed, and are provided in Table 3.9. A schematised plan of the IPC water management system configuration is shown in Figure 3.5.

Table 3.9 - IPC water management system operating rules

Item	Node Name	Operating Rules
1.0	*External Water Supply*	
1.1	Eungella/Burdekin Pipeline	• Supplies the CHPP (via Raw Water Dam) • Maximum yearly allocation of 938 ML/a • Can provide emergency supply to fill point and S2 SD
2.0	*Supply to Demands*	
2.1	CHPP	• Demands from the Raw Water Dam and CHPP PP, plus an additional usage from Raw Water Dam associated with washdown/fire circuit/pump glands • Pumps tailings slurry to N1 Pit tailings facility • 100% loss assumed for washdown/fire circuit/pump glands water usage
2.2	Haul road dust suppression	• Demands from the following sources: o S2 SD o Eungella/Burdekin Pipeline (emergency supply) • 100% loss assumed
3.0	*Transfer of pit water*	
3.1	E2 Pit	• Active mining area • Continuous pumping from pit dewatering pumps at a nominal maximum rate of 100 L/s (8,640 kL/d) • Pit dewatering directed to S2 Pit
3.2	E3 Pit	• Active mining area • Continuous pumping from pit dewatering pumps at a nominal maximum rate of 100 L/s (8,640 kL/d)) • Pit dewatering directed to S2 Pit
3.5	E4 Pit	• Existing inactive void • Can provide emergency supply in the event where S2 Pit starts to run out of water
4.0	*Operation of site dams*	
4.1	RD1 (Release Dam 1)	• Existing mine affected water dam • Licensed discharge point (RP1), which discharges to Smoky Creek • Receives uncontrolled overflows from CHPP PP • Dam overflows to Smoky Creek • Operated at 2 to 5 ML • Acts as a bog pit when empty
4.2	RD2 (Release Dam 2)	• Existing sediment dam • Former mine affected water dam • Licensed discharge point (RP2), which discharges to Billy's Gully • Dam overflows to Billy's Gully
4.3	S3 Pit	• Partially backfilled void • Licensed discharge point (RP5), which discharges to Billy's Gully (not modelled) • Storage overflows to Billy's Gully

Item	Node Name	Operating Rules
4.4	S2 Pit	• Existing inactive void, which acts as the primary mine affected water storage for site • Receives dewatering inflows from N1 Pit, and the active IPE pits • Receives make-up inflows from inactive E4 pit at a maximum rate of 100 L/s (8,640 kL/d), if required. • Pumps water to S2 SD at a maximum rate of 100 L/s (8,640 kL/d), as required • Pumps water to CHPP PP at a maximum rate of 100 L/s (8,640 kL/d), as required • Pumps water to S2 Pit at a maximum rate of 100 L/s • Storage overflows to Smoky Creek
4.5	N1 Pit	• Existing inactive void, which acts as the tailings decant water storage • Maintains a 50 ML sump within the N1 Pit water storage which is controlled by S2 Pit • Pumps water to S2 Pit at a maximum rate of 100 L/s • Storage overflows to Smoky Creek
4.6	S2 SD	• Existing mine affected water storage • Supplies to dust suppression demands via a fill point • Demands from N1 Pit water storage up to a maximum level of 221.85 mAHD • Licensed discharge point (RP4), which discharges to Smoky Creek (not modelled) • Overflows to Smoky Creek
4.7	CHPP PP (CHPP Process Pond)	• Existing mine affected water dam • Receives pumped transfers from S2 Pit water storage, up to a maximum level of 234.0 mAHD (17.0 ML) Supplies the CHPP • Storage overflows to RD1
4.8	N1 SD	• Existing sediment dam/sump • Overflows to Smoky Creek
4.9	N1 Pit tailings facility	• Primary tailing storage facility • Former inactive mining pit • Receives pumped tailing slurry from CHPP • Deposited slurry consolidates to 20% solids content and releases excess water to N1 Pit water storage • Storage overflows to N1 Pit water storage
4.10	E2 SD	• Sediment dam • Storage overflows to Billy's Gully • Previously an existing farm dam
4.11	E4a SD	• Sediment dam • Storage overflows to Smoky Creek
4.12	E4b SD	• Sediment dam • Storage overflows to Smoky Creek
5.0	*Receiving water*	
5.1	Smoky Creek	• Receives controlled discharges from RD1 • May receive uncontrolled overflows from the following storages: o RD1 o S2 SD o N1 SD o E4a SD o E4b SD

Item	Node Name	Operating Rules
5.2	Billy's Gully	• Receives controlled discharges from RD2 • May receive uncontrolled overflows from the following storages: o RD2 o E2 SD
6.0	*General*	• All storages and pits receive local catchment runoff and lose water through evaporation

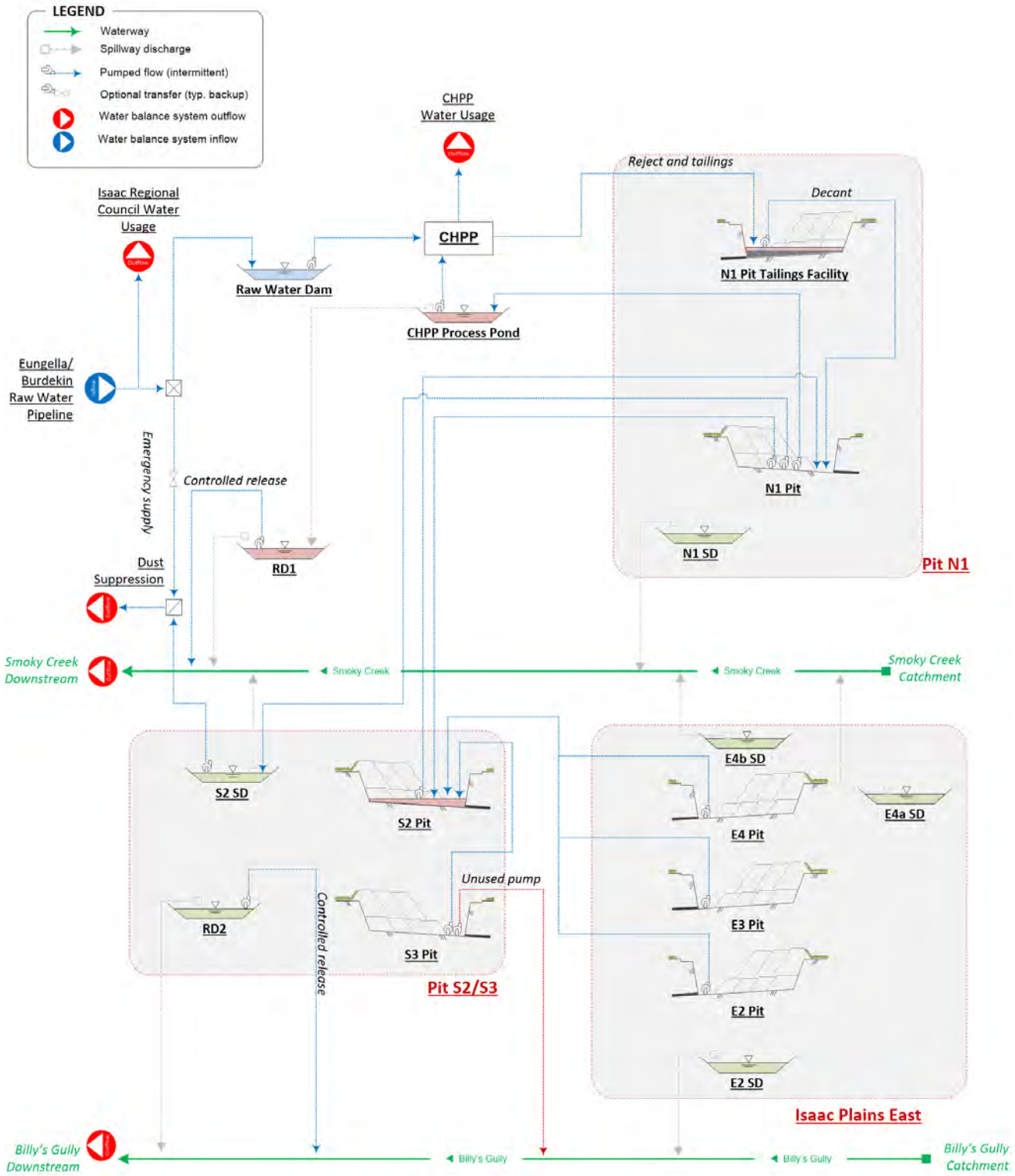

Figure 3.5 - IPC WMS schematic

3.12 ISAAC RIVER STREAMFLOWS

The Queensland Government maintains a calibrated IQQM model of the Fitzroy River basin, which includes the Isaac River. This model is based on that prepared for the Fitzroy Basin Water Resource Plan (WRP).

The Queensland Government made the results of the IQQM modelling available to WRM for this assessment. These results included modelled daily flows at the gauging station at Goonyella on the Isaac River over the period 1889 to 2007.

The modelled Isaac River flows have been supplemented with flows recorded at the gauging station between 2008 and 2021, to create a composite stream flow covering the period 1889 to 2021.

This composite streamflow file has been used in the water balance model as the receiving water flow criteria for controlled discharges in accordance with the IPC EA.

3.13 POTENTIAL INTERACTION WITH THE PROPOSED ISAAC DOWNS PROJECT

Stanmore is currently in the early stages of mining at the Isaac Downs Project (ID), an open cut metallurgical coal mine located adjacent to the IPC operation. ID is projected to deliver approximately 35 million tonnes of run-of-mine (ROM) coal over 16 years.

The proposed ID footprint is approximately 1,100 ha. The equipment being used for mining activities at IPC, and a similar workforce, is planned to be transitioned to ID.

The ID water management system will have the capability to transfer mine affected water to and from IPC to meet operational needs.

There are two proposed external water supplies to ID:

- Raw water supply (via an existing Sunwater allocation at IPC); and
- Mine affected water supply (from IPC operations).

Raw water will be supplied via a pipeline that goes to RWD (via Millennium Mine), which is supplied under a contract with Sunwater for offtake from the existing Eungella Burdekin water supply pipeline. Raw water is only required to supply vehicle washdown and fire fighting requirements, however it could potentially provide an emergency supply of water should mine affected water reserves at ID and IPC be depleted.

The dedicated pipeline connecting IPC and ID has not been commissioned yet, therefore it is unknown how the pipeline will interact between the two sites. The pipeline connection between IPC and ID has not been modelled in this assessment.

3.14 MODEL VALIDATION

3.14.1 Model validation overview

A validation of the water balance model was undertaken over the period January 2020 to July 2021, for which stored water volumes onsite and water usage were available.

The previously modelled AWBM parameters (as per Section 3.2.3) were used for this assessment, as well as recorded daily site rainfall data. Note that this assessment only considered the total water storage for the following storages:

- Release Dam 1 (RD1);
- Release Dam 2 (RD2);
- S2 Sediment Dam 2 (S2 SD2);
- S3 Pit;

- CHPP Process Pond;
- N1 Pit; and
- S2 Pit.

3.14.2 Model validation outcomes

The modelled combined inventory for the storages noted in Section 3.14.1 were compared with the recorded combined inventory, as shown in Figure 3.6.

Review of Figure 3.6 indicates the following:

- The validation model matches well to the first and last 6 months of the recorded inventory.
- There are discrepancies during the July 2020 to December 2020 period. The recorded inventory data shows that the S2 Pit water level would remain constant from July 2020 to December 2020. Site personnel have advised that the S2 Pit water levels were not accessible for survey during this period, hence the last recorded point in July was adopted for the 5-month period. Hence it has been assumed that the S2 Pit data recorded during this period is erroneous.
- Given the gaps in the available monitoring information, the adopted model parameters were considered suitable for this assessment.

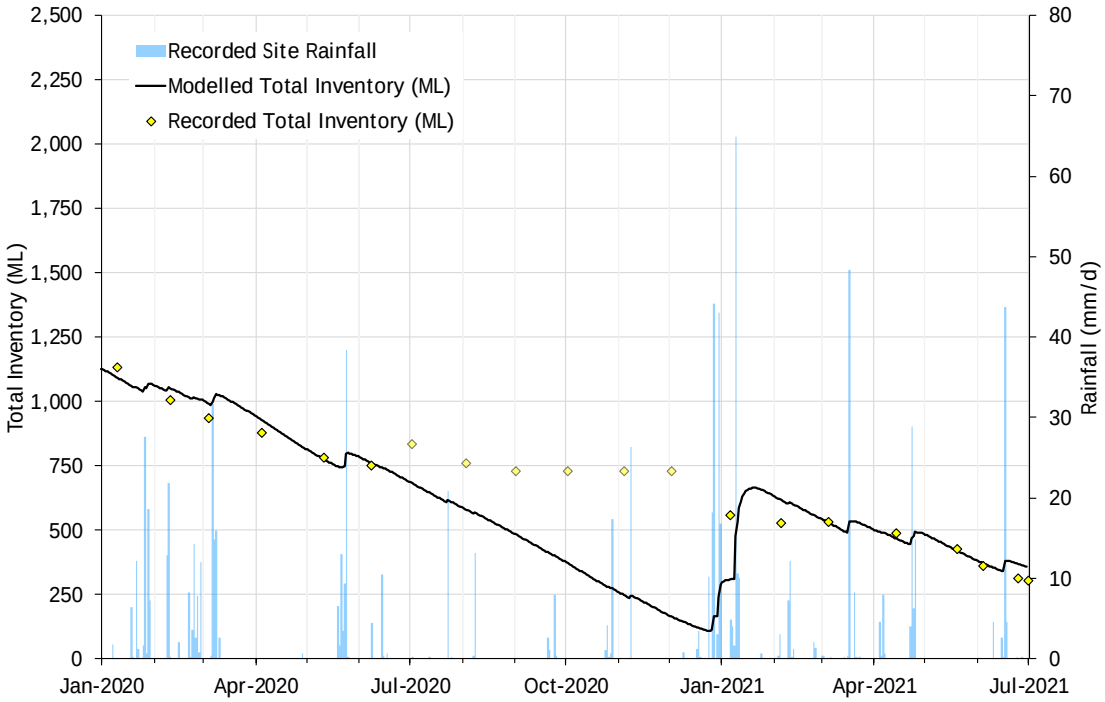

Figure 3.6 - Model validation - WMS inventory (January 2020 to June 2021)

4 Model results

4.1 OVERVIEW

Assessment of the proposed IPC water management system has been undertaken using the water balance model with the adopted rainfall runoff parameters, against the following key performance indicators:

- Site raw water requirements;
- Pit inundation characteristics;
- Active mining pit inventory;
- Mine affected water inventory;
- Controlled releases; and
- Uncontrolled spillway discharges

A schematic layout of the IPC model is presented in Figure 3.5. Operational rules applied to the model are described in Table 3.9.

It is important to note that investigation outcomes are dependent on the accuracy of input assumptions. There is inherent uncertainty with respect to some key site characteristics (e.g. catchment yield/rainfall runoff, mining area groundwater inflows). The use of a large number of climate sequences reflecting the full range of historical climatic conditions provides an indication of the system performance may vary under very wet, very dry and average climatic conditions.

4.2 INTERPRETATION OF RESULTS

The modelling methodology of a forecast simulation is described in Section 2.3. In interpreting the results of the water balance assessment, it should be noted that the results provide a statistical analysis of the water management system's performance over the next 4.5 years of mine life, based on 128 different climatic sequences (realisations).

The 50th percentile probability envelope represents the median results, the 10th percentile represents 10% exceedance (i.e. wet conditions) and the 90th percentile results represent 90% exceedance (i.e. dry conditions). There is an 80% chance that the result will fall within the 10th and 90th percentiles and a 98% chance the result will fall between the 1st and 99th percentiles. Importantly, note that a percentile envelope shows the percentage chance of exceeding particular value on any particular day, and does not represent continuous results from a single model realisation (e.g. the 90th percentile trace does not represent a single continuous 90th percentile climate scenario, rather it shows the volume/rate exceeded by 90% of the 128 realisations on each day of the simulation).

4.3 ANNUAL WATER BALANCE

Table 4.1 provides an indication of the long-term average annual inflows and outflows for Stage 2 across 128 realisations. The following is of note regarding the annual water balance:

- A starting inventory of 301 ML was adopted on 1 July 2021, based on estimates from site personnel.
- For an average climatic year, the IPC total site inventory will experience a surplus.
- The majority of the mine water stored on site will be used on site for operational water uses such as haul road dust suppression and CHPP water demands.

- External water is required to make-up site demand. An average annual volume of up to 610 ML may be required. This is approximately 65% of the annual allocated amount.
- Sediment dam spills are predicted to occur in most years in the absence of controlled (pumped) releases. The predicted annual average spill volume from the sediment dams is 148 ML.

Table 4.1 - Average annual water balance for Stage 2

Component	Process	Volume (ML/yr) Stage 2
Inflows	Rainfall Runoff	1,005
	Eungella Pipeline	610
	Net Groundwater	418
	Total	2,033
Outflows	Evaporation	311
	Dust Suppression	563
	CHPP Net Loss	229
	Misc. Usage	480
	Mine Dam Spills	0
	Sediment Dam Spills	148
	Controlled Release	44
	Total	1,775
Change in Site Water Inventory		258

4.4 WATER MANAGEMENT SYSTEM INVENTORY

Figure 4.1 shows the forecast total WMS inventory. The following is of note:

- During extreme wet (1%ile) climatic conditions, the IPC WMS may accumulate up to 3,400 ML by the end of 2025;
- During median (50%ile) climatic conditions, the IPC WMS would not accumulate significant volumes of water; and
- During conditions drier that the median, the IPC WMS would generally be maintained at around 300 ML, topped up by the Eungella pipeline.

Figure 4.1 - Forecast WMS inventory

4.5 MINE AFFECTED WATER INVENTORY

Figure 4.2 and Figure 4.3 shows the forecast inventory for S2 Pit and N1 Pit over the 4.5-year forecast period.

The forecast modelling results for S2 Pit are summarised as follows:

- There is 1% chance that the S2 Pit storage inventory will exceed 3,000 ML over the 4.5 year forecast period.
- There is 10% chance that the S2 Pit storage inventory will exceed 1,800 ML over the 4.5 year forecast period.
- There is a 50% chance that the S2 Pit storage inventory would empty at some point over the 4.5 year forecast period. The S2 Pit stored inventory may empty as early as late 2021 during median climatic conditions.

The forecast modelling results for N1 Pit are summarised as follows:

- There is 1% chance that the N1 Pit storage inventory will exceed 960 ML over the 4.5 year forecast period.
- There is 10% chance that the N1 Pit storage will exceed 240 ML over the 4.5 year period.
- N1 Pit does not spill under any climatic conditions.

These results indicate that, based on the adopted configuration and assumptions, the S2 pit has sufficient capacity to store all mine affected water over the 4.5 year forecast period.

The results predict accumulation of water in the mine affected water management system over the 4.5-year forecast during median and wetter climatic conditions. During dry climatic conditions, the site has a risk that the mine water reserves will deplete, leading to an increased reliance on the external water supply.

Figure 4.2 - Forecast S2 Pit inventory

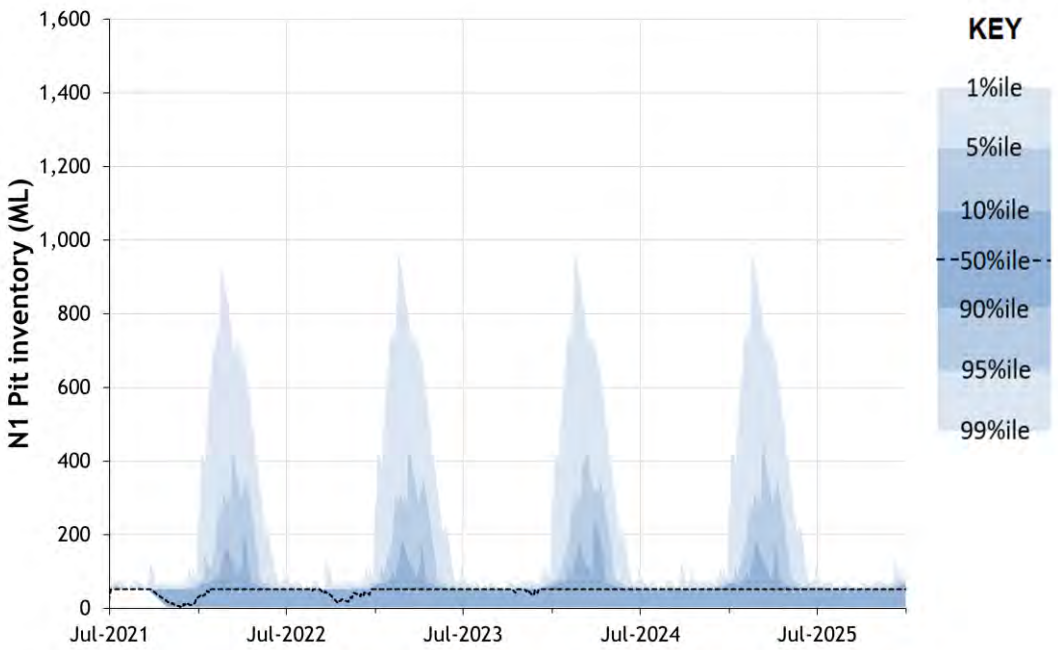

Figure 4.3 - Forecast N1 Pit inventory

4.6 SITE RAW WATER REQUIREMENTS

For the purposes of current investigations, the term "site raw water requirements" represents the amount of imported water from external water sources (Eungella/Burdekin raw water pipeline) that is required to sustain the nominated design production rate and associated operational demands at IPC.

For IPC, the CHPP demand is supplied from the CHPP Process Pond and the Raw Water Dam, if required. The miscellaneous/industrial demand is supplied from the Raw Water Dam. In addition, the modelling has assumed that any shortfall in dust suppression demand from the mine effected water system is made up from the raw water supply. That is, during dry periods, imported water is used to ensure that all operational demands are met.

The annual allocation for IPC is 938 ML/a, however, Stanmore have advised that an allowance of up to 150 ML may be provided to the IRC in the 2021/22 financial year. The model results have been compared against the allocation to assess the requirement (if any) for external water in addition to the approved allocation.

The modelled imported water requirements during the life of mine are provided in Table 4.1 and Figure 4.4. Review of the annual rate water requirements indicates:

- The minimum annual external water volume would be around 480 ML/a, which is equal to the miscellaneous/industrial usage;
- In the 2021/22 financial year, there is a 1% chance of requiring up to 798 ML of external water, which is slightly higher than available allocation considering the IRC allowance. In this case, site would likely use the 300 ML buffer stored in the WMS, rather than importing additional water. For all other climatic conditions, the external water requirement would be lower than the available allocation;
- There is a 1% chance that the external water requirements in the 2022/23 financial year would be within annual allocation (not considering any future IRC allowance);
- There is a 1% chance that the external water requirements for 2023/24 to 2024/25 would exceed the annual allocation (not considering any future IRC allowance);
- During the wet climatic conditions, the makeup required to meet water demands are about the same, indicating that minimal additional water is required on top of the miscellaneous raw water requirement.

Table 4.2 - Summary of annual external raw water requirements

Forecast year	1% chance of requiring (at least) (ML/a)	10% chance of requiring (at least) (ML/a)	50% chance of requiring (at least) (ML/a)	90% chance of requiring (at least) (ML/a)
2021/22	798	724	566	502
2022/23	927	822	600	488
2023/24	958	855	579	490
2024/25	961	857	496	488
2025/26[A]	505	482	247	245

[A]Note: Period 2025/26 runs from July 2025 to Jan 2026, an incomplete financial year.

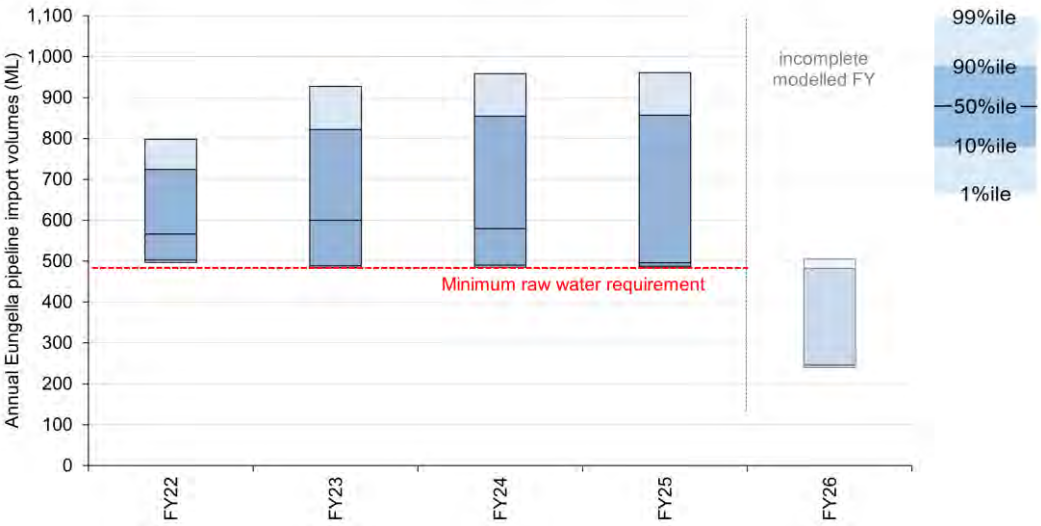

Figure 4.4 - Forecast annual external raw water requirements

4.7 ACTIVE MINING PIT INVENTORY

An assessment of pit inventory characteristics at IPC has been undertaken to determine the likelihood of water inundating the active pits, which could potentially impact production.

Figure 4.5 shows the forecast inventory for the combined E2 and E3 pits over the 4.5 year forecast.

The forecast modelling results for E2 Pit and E3 Pit are summarised as follows:

- There is 1% chance that the combined E2 Pit and E3 Pit storage inventory will exceed 180 ML over the 4.5 year forecast period.
- There is 5% chance that the combined E2 Pit and E3 Pit storage inventory will exceed 60 ML over the 4.5 year forecast period.
- Using a combined pump capacity of 100 L/s, the maximum number of days to completely dewater the pit is 128 days.

The results show that there is only a relatively small chance that significant quantities of water will be stored in the pits, if very wet climatic conditions occur. The main cause of modelled pit inundation is the capacity of the pumping system to transfer water to S2 Pit. Increasing the pit dewatering capacity would reduce the risk of pit inundation.

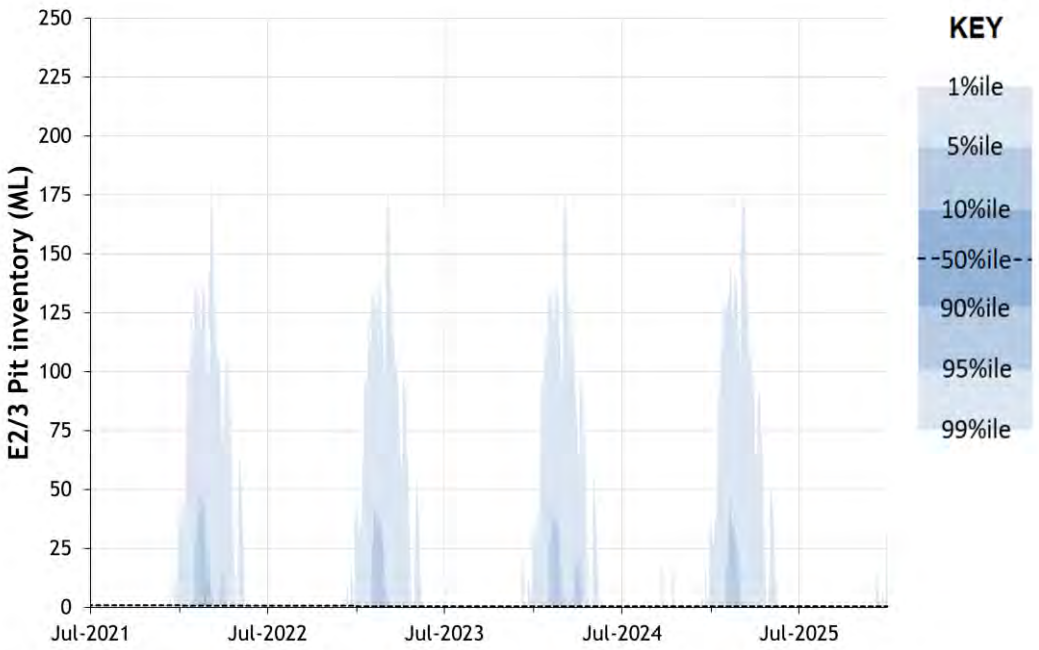

Figure 4.5 - Forecast E2 and E3 pits inventory

4.8 CONTROLLED RELEASES

The water balance model is configured to simulate releases of water from the water management system to the receiving environment via the RP1 and RP2 release points (located at RD1 and RD2, respectively), in accordance with the IPC EA.

The current release conditions provide significant opportunity to release mine affected water to receiving waters, assuming that the water quality in the release dams improves. However, it is unlikely that controlled discharges would actually occur during all release opportunities, due to timing of flows, time of day etc. As such, the modelling has been based on the assumption that suitable infrastructure is available to release mine affected water approximately 30% of the time.

Note that salinity (as EC) is the only water quality parameter that has been modelled in the water balance model. It has been assumed that sufficient dilution can be achieved at RD1 to achieve the pH release limit.

The predicted probabilities and annual controlled discharge volumes are provided in Table 3.2. The results show that:

- The discharge volumes associated with the 1% probability of exceedance, vary between 638 and 668 ML/a over the 4.5 year forecast period;
- The discharge volumes associated with the 10% probability of exceedance, vary between 194 and 216 ML/a over the 4.5 year forecast period; and
- There is a 50% chance of no controlled releases occurring during the 4.5 year forecast period.

Table 4.3 - Summary of annual controlled releases

Forecast year	1% chance of discharging (at least) (ML/a)	10% chance of discharging (at least) (ML/a)	50% chance of discharging (at least) (ML/a)
2021/22	668	216	0
2022/23	650	209	0
2023/24	638	194	0
2024/25	667	200	0
2025/26[A]	32	0	0

[A]Note: Period 2025/26 runs from July 2025 to Jan 2026, an incomplete financial year.

4.9 UNCONTROLLED STORAGE DISCHARGES

The IPC water balance model has been configured to minimise off-site spills from mine affected water storages to the receiving environment. However, the results of the water balance model indicate that dams RD1, RD2 and S2 SD have some likelihood of discharging to receiving waters in wet climatic conditions.

The model results for uncontrolled spills over the 4.5 year forecast are summarised below.

- RD1
  - There is a 1% chance of discharging up to 113 ML of water over the spillway to the receiving environment, in any one year.
- RD2
  - There is a 1% chance of discharging up to 177 ML of water over the spillway to the receiving environment, in any one year.
- S2 SD
  - There is a 1% chance of discharging up to 125 ML of water over the spillway to the receiving environment, in any one year.
  - There is a 10% chance of discharging up to 15 ML of water over the spillway to the receiving environment, in any one year.

Stanmore are currently investigating options to reduce the spill risk of RD1 and RD2.

5 Conclusion

The key outcomes of the IPC water balance model are as follows:

- The water management system does not run out of water for operations under any of the modelled climatic conditions over the 4.5 year forecast simulation. However, it does heavily rely on the external raw water supply makeup under drier climatic sequences.
- During very dry climatic conditions, the imported raw water requirements exceeds the IPC's annual allocation of 938 ML/a during FY2023/2024 to FY2024/2025. Note that this does not include any IRC provision.
- During the remaining years and climatic conditions, the imported raw water requirements do not exceed 930 ML/a.
- The mining pits within IPC have some likelihood of filling up during very wet climatic conditions due to insufficient pit dewatering rates:
    - E2/3 Pit takes a maximum of 128 days to dewater the pit using a pump capacity of 100 L/s.
- The S2 Pit has sufficient capacity to store all mine affected water over 2021. There is a 50% chance that S2 Pit would empty at some point over the simulation period.
- Mine affected water dams RD1 and S2 SD have some likelihood of discharging to receiving waters in wet climatic conditions.
- RD1 has a 1% chance of discharging at least 113 ML of water over the spillway to the receiving environment, in any one year.
- S2 SD has a 1% chance of discharging at least 125 ML and a 10% chance of discharging at least 15 ML of water over the spillway to the receiving environment, in any one year.

6 References

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Appendix A - Catchment areas and land use classifications

Table A.1: Catchment areas and land use breakdown summary - IPC Stage 2

Dam	Contributing catchment (ha)							
	Cleared/ pre-strip	Mining Pit	Roads/ hardstand	Rehabilitated spoil	Spoil dump	Stockpile/ industrial area	Natural	Total
CHPP PP	0.00	0.00	5.78	0.00	0.00	0.00	11.43	17.2
E2 SD	0.00	0.57	19.23	16.41	57.71	0.00	9.15	103.1
E2/3 Pit	26.83	14.50	8.19	3.90	61.98	0.00	0.24	115.6
E4 Pit	13.02	13.64	5.07	9.48	111.23	0.00	5.00	157.4
E4a SD	0.00	0.00	9.18	0.00	22.29	0.00	0.00	31.5
E4b SD	0.32	0.00	5.75	33.41	0.00	0.00	0.00	39.5
N1 Pit	6.71	22.65	37.01	127.12	145.18	0.00	1.19	339.9
N1 SD	0.00	0.00	15.13	160.92	0.00	0.00	85.12	261.2
RD1	0.00	0.00	34.94	13.16	0.00	14.89	137.62	200.6
RD2	0.00	0.00	26.98	59.49	6.68	0.00	15.01	108.2
RWD	0.00	0.00	1.41	0.00	0.00	0.00	0.10	1.5
S2 Pit	12.12	30.04	8.97	45.14	15.73	0.00	0.00	112.0
S2 SD	0.00	0.00	14.30	45.08	0.00	0.00	5.15	64.5
S3 Pit	0.04	0.00	9.99	78.23	42.75	0.00	0.23	131.2

Table A.2: Catchment areas and land use breakdown summary - IPC Stage 3

Dam	Contributing catchment (ha)							
	Cleared/ pre-strip	Mining Pit	Roads/ hardstand	Rehabilitated spoil	Spoil dump	Stockpile/ industrial area	Natural	Total
CHPP PP	0.00	0.00	5.78	0.00	0.00	0.00	11.43	17.2
E2/3 Pit	19.89	13.90	11.92	36.21	40.25	0.00	1.63	123.8
E4 Pit	10.57	10.05	9.97	50.69	76.59	0.00	19.93	177.8
E4a SD	0.00	0.00	4.64	25.28	1.55	0.00	0.00	31.5
E4b SD	0.32	0.00	5.75	33.29	0.00	0.00	0.00	39.4
E2 SD	0.00	0.78	9.60	80.59	5.45	0.00	6.64	103.1
N1 Pit	6.71	22.65	37.01	127.12	145.18	0.00	1.19	339.9
N1 SD	0.00	0.00	15.13	160.92	0.00	0.00	85.12	261.2
RWD	0.00	0.00	1.50	0.00	0.00	0.00	0.01	1.5
RD1	0.00	0.00	34.94	13.16	0.00	14.89	137.62	200.6
RD2	0.00	0.00	27.01	66.14	0.00	0.00	15.01	108.2
S2 Pit	12.02	26.19	8.96	56.68	8.16	0.00	0.00	112.0
S2 SD	0.00	0.00	14.30	45.08	0.00	0.00	5.15	64.5
S3 Pit	0.04	0.00	9.99	78.23	42.70	0.00	0.28	131.2

Table A.3: Catchment areas and land use breakdown summary - IPC Stage 4

Dam	Contributing catchment (ha)							
	Cleared/ pre-strip	Mining Pit	Roads/ hardstand	Rehabilitated spoil	Spoil dump	Stockpile/ industrial area	Natural	Total
CHPP PP	0.00	0.00	0.00	0.00	5.78	0.00	11.43	17.2
E2/3 Pit	36.22	0.00	11.46	11.25	8.17	61.82	4.21	133.1
E4 Pit	50.69	0.00	6.46	8.15	11.33	84.57	17.20	178.4
E4a SD	25.28	0.00	0.00	0.00	4.64	1.55	0.00	31.5
E4b SD	33.29	0.00	0.62	0.00	5.75	0.00	0.00	39.7
E2 SD	80.59	0.00	0.00	0.78	9.60	5.40	6.69	103.1
N1 Pit	127.12	0.00	6.71	22.65	37.01	145.18	1.19	339.9
N1 SD	160.92	0.00	0.00	0.00	15.13	0.00	85.12	261.2
RWD	0.00	0.00	0.00	0.00	1.41	0.00	0.10	1.5
RD1	13.16	14.89	0.00	0.00	34.94	0.00	137.62	200.6
RD2	66.14	0.00	0.00	0.00	26.98	0.03	15.01	108.2
S2 Pit	56.68	0.00	12.02	26.19	10.96	8.16	0.00	114.0
S2 SD	45.08	0.00	0.00	0.00	14.30	0.00	5.15	64.5
S3 Pit	121.10	0.00	0.04	0.00	9.99	0.05	0.06	131.2

Appendix B - Storage curves

Table B.1: RD1

Height (mRL)	Area (ha)	Volume (ML)
217.5	0.0	0.0
218	0.1	2.0
218.5	0.2	4.0
219	0.6	11.0
219.5	2.2	22.0
220	3.5	38.0
220.5	5.6	59.0
221	8.2	89.0
221.5	11.9	125.0
222	15.0	167.0
222.4	16.2	205.0
222.8	16.2	269.8

Table B.2: RD2

Height (mRL)	Area (ha)	Volume (ML)
220.9	0.8	0.0
221	1.0	0.1
221.1	1.1	1.4
221.2	5.0	5.6
221.3	5.9	11.6
221.4	7.0	18.2
221.5	7.1	25.0
221.6	7.2	31.9
221.7	7.3	38.9
221.8	7.4	46.0
221.9	7.5	53.2
222	7.5	60.5
222.1	7.6	68.0
222.2	7.7	75.5
222.3	7.8	83.1
222.4	7.9	90.8

Height (mRL)	Area (ha)	Volume (ML)
222.5	8.0	98.6
222.6	8.1	106.5
222.7	8.2	114.5
222.8	8.3	122.6
222.9	8.4	130.9
223	8.7	139.2
223.1	8.8	147.7
223.2	8.8	156.5

Table B.3: N1 Pit

Height (mRL)	Area (ha)	Volume (ML)
143	0.0	0.0
144	0.1	0.4
145	0.2	2.0
146	0.4	5.2
147	0.8	11.0
148	1.1	20.8
149	1.5	34.0
150	1.9	51.0
151	2.1	71.0
152	2.3	92.0
153	2.4	116.0
154	2.6	141.0
155	2.8	168.0
156	3.1	198.0
157	3.3	230.0
158	3.5	264.0
159	3.8	301.0
160	4.1	340.0
161	4.4	383.0
162	4.8	429.0
163	5.2	479.0
164	5.6	533.0
165	7.5	599.0
166	8.5	678.0

Height (mRL)	Area (ha)	Volume (ML)
167	9.1	766.0
168	9.7	861.0
169	10.3	961.0
170	10.9	1067.0
171	11.6	1180.0
172	12.2	1298.0
173	12.8	1423.0
174	13.5	1555.0
175	14.6	1695.0
176	15.8	1847.0
177	17.5	2013.5
178	18.9	2195.5
179	20.4	2392.0
180	21.7	2603.0
181	23.0	2826.0
182	24.4	3064.0
183	25.6	3314.0
184	26.7	3575.0
185	27.6	3847.0
186	28.6	4128.0
187	29.4	4418.0
188	30.3	4717.0
189	31.1	5023.0
190	31.9	5338.0
191	32.6	5660.0
192	33.4	5991.0
193	34.3	6329.0
194	35.2	6677.0
195	36.0	7032.0
196	36.9	7397.0
197	37.7	7770.0
198	38.5	8150.0
199	39.4	8540.0
200	40.4	8938.0
201	41.6	9348.0

Height (mRL)	Area (ha)	Volume (ML)
202	43.1	9771.0
203	44.7	10210.0
204	46.3	10665.0
205	47.8	11135.0
206	49.1	11620.0
207	50.3	12116.8
208	51.5	12625.7
209	52.7	13146.9
210	54.1	13680.9
211	55.4	14227.9
212	56.7	14788.3
213	58.0	15362.0
214	59.4	15948.9
215	60.8	16549.5
216	62.4	17165.3
217	64.7	17800.9
218	67.3	18461.0
219	70.1	19147.7
220	72.7	19861.4
221	74.9	20599.4
222	76.9	21358.3
223	79.2	22138.5
224	81.5	22942.0
225	83.9	23769.0
226	86.2	24619.6
227	88.6	25493.7
228	90.7	26390.2
229	92.8	27307.6
230	94.6	28244.1
231	96.2	29197.8
232	97.6	30166.5
233	98.7	31147.9
234	99.6	32139.6
235	100.5	33140.1
236	101.3	34148.8

Height (mRL)	Area (ha)	Volume (ML)
237	101.9	35164.9
238	102.5	36187.3
239	103.0	37214.8
240	103.3	38246.3
241	103.5	39280.6
242	103.7	40316.9
243	103.8	41354.7
244	104.0	42393.9
245	104.1	43434.1
246	104.2	44475.2
247	104.2	45517.1
248	104.3	46559.6
249	104.3	47602.7
250	104.4	48646.2
251	104.4	49689.9
252	104.4	50733.8
253	104.4	51777.8

Table B.4: S2 pit

Height (mRL)	Area (ha)	Volume (ML)
156	0.0	0.0
157	3.9	12.9
158	5.6	58.4
159	6.3	118.0
160	6.8	183.0
161	7.4	254.5
162	7.9	331.0
163	8.3	412.0
164	8.7	497.0
165	9.1	586.0
166	9.5	679.0
167	9.8	776.0
168	10.2	876.0
169	10.5	980.0
170	11.0	1,087.0

Height (mRL)	Area (ha)	Volume (ML)
171	11.4	1,199.0
172	11.7	1,314.0
173	12.1	1,433.0
174	12.4	1,555.0
175	12.7	1,681.0
176	13.0	1,809.0
177	13.3	1,940.0
178	13.6	2,075.0
179	13.9	2,212.0
180	14.1	2,352.0
181	14.4	2,495.0
182	14.7	2,640.0
183	15.0	2,788.0
184	15.3	2,940.0
185	15.6	3,094.0
186	15.9	3,251.0
187	16.3	3,413.0
188	16.7	3,578.0
189	17.1	3,747.0
190	17.6	3,920.8
191	18.1	4,099.4
192	18.6	4,283.0
193	19.2	4,472.0
194	19.7	4,667.0
195	20.3	4,867.0
196	20.8	5,072.0
197	21.3	5,283.0
198	21.8	5,498.0
199	22.2	5,718.0
200	22.6	5,942.0
201	23.1	6,171.0
202	23.6	6,404.0
203	24.1	6,642.0
204	24.6	6,886.0
205	25.2	7,135.0

Height (mRL)	Area (ha)	Volume (ML)
206	25.7	7,390.0
207	26.2	7,649.0
208	26.7	7,914.0
209	27.2	8,183.0
210	27.6	8,457.0
211	28.2	8,736.0
212	29.1	9,023.0
213	30.0	9,318.0
214	31.2	9,624.0
215	31.9	9,939.0
216	32.4	10,261.0
217	33.0	10,588.0
218	33.7	10,921.0
219	34.4	11,261.0
220	35.1	11,608.4
221	35.7	11,962.0
222	36.2	12,321.3
223	36.8	12,686.2
224	37.4	13,056.8
225	38.0	13,433.3
226	38.5	13,815.8
227	39.1	14,204.0
228	39.7	14,597.8
229	40.2	14,997.1
230	40.8	15,402.1
231	41.2	15,812.2
232	41.5	16,226.1
233	41.8	16,642.6
234	42.0	17,061.5
235	42.1	17,482.2
236	42.2	17,904.1
237	42.3	18,326.9
238	42.3	18,750.1
239	42.4	19,173.8
240	42.4	19,597.8

Table B.5: S3 Pit

Height (mRL)	Area (ha)	Volume (ML)
175	0.0	0.0
176	0.0	0.1
177	0.1	0.9
178	0.3	3.2
179	0.6	8.0
180	0.8	14.7
181	1.0	24.0
182	1.1	34.0
183	1.2	45.0
184	1.4	58.0
185	1.5	72.0
186	1.6	88.0
187	1.8	105.0
188	1.9	123.0
189	2.0	143.0
190	2.2	164.0
191	2.3	186.0
192	2.4	209.0
193	2.6	234.0
194	2.7	261.0
195	2.8	289.0
196	3.0	318.0
197	3.1	348.0
198	3.3	380.0
199	3.4	413.0
200	3.5	448.0
201	3.7	484.0
202	3.8	521.0
203	4.0	560.0
204	4.1	601.0
205	4.3	642.0
206	4.4	686.0
207	4.6	730.0
208	4.7	777.0

Height (mRL)	Area (ha)	Volume (ML)
209	4.9	824.4
210	5.0	873.6
211	5.2	924.0
212	5.3	977.0
213	5.5	1,030.0
214	5.6	1,086.0
215	5.8	1,143.0
216	5.9	1,201.0
217	6.1	1,261.0
218	6.3	1,323.0
219	6.4	1,387.0
220	6.6	1,452.0
221	6.8	1,519.0
222	7.1	1,588.0
223	7.7	1,662.0
224	9.0	1,745.0
225	10.7	1,844.0
226	12.1	1,957.0
227	13.5	2,085.0
228	14.9	2,227.0
229	17.5	2,389.0
230	20.3	2,577.0
231	22.7	2,792.0
232	25.0	3,030.0
233	27.4	3,292.0
234	29.0	3,574.0
235	29.4	3,866.0
236	29.5	4,161.0
237	29.5	4,456.0

Table B.6: E2 SD

Height (mRL)	Area (ha)	Volume (ML)
232.00	0.28	0.0
232.25	0.30	0.7
232.50	0.32	1.5

Height (mRL)	Area (ha)	Volume (ML)
232.75	0.34	2.3
233.00	0.37	3.2
233.25	0.39	4.2
233.50	0.41	5.2
233.75	0.44	6.2
234.00	0.46	7.3
234.25	0.48	8.5
234.50	0.50	9.7
234.75	0.53	11.0
235.00	0.55	12.4
235.50	0.55	13.8

Table B.7: E4a SD

Height (mRL)	Area (ha)	Volume (ML)
235.75	0.48	0.0
236.00	0.52	1.2
236.25	0.56	2.6
236.50	0.60	4.0
236.75	0.64	5.6
237.00	0.67	7.2
237.25	0.71	8.9
237.50	0.75	10.8
237.75	0.79	12.7
238.00	0.83	14.7
238.25	0.87	16.9
238.50	0.91	19.1
238.75	0.95	21.4
239.25	0.95	26.0

Table B.8: E4b SD

Height (mRL)	Area (ha)	Volume (ML)
228.00	0.34	0.0
228.25	0.37	0.9
228.50	0.39	1.8
228.75	0.42	2.9

Height (mRL)	Area (ha)	Volume (ML)
229.00	0.45	3.9
229.25	0.48	5.1
229.50	0.51	6.3
229.75	0.54	7.6
230.00	0.56	9.0
230.25	0.59	10.5
230.50	0.62	12.0
230.75	0.65	13.6
231.00	0.68	15.2
231.50	0.68	18.4

APPENDIX N INFRASTRUCTURE RETENTION LETTER

Isaac Plains Coal Mine
Peak Downs Highway via Coppabella
Moranbah QLD 4744

Stanmore IP Coal Pty Ltd
PO Box 635
Moranbah QLD 4744

www.stanmorecoal.com.au

19 April 2018

Mr. Ross Flohr and Mrs. Margaret Flohr
"Wotonga Station"
Nebo, Qld, 4742

Dear Ross and Margaret

Stanmore IP Coal Pty Ltd – Retention of infrastructure post mine life

As you are aware, Stanmore IP Coal Pty Ltd (Stanmore) is the holder of MLs 70342, 700016, 700017, 700018 and 700019 and environmental authority EPML00932713 in relation to the Isaac Plains Coal Mine.

You are the registered owners of certain parcels of land covered by the mining leases (Land).

The Department of Environment and Science has requested that Stanmore provide a statement from relevant landholders for the retention of dams post mine closure.

The current and proposed dams on the Land are shown on the attached map at Annexure 1. As discussed with Ross, these dams as well as any other future dams are proposed to be retained on the Land post mine closure in a condition suitable for pastoral purposes and for the long-term benefit of you as landholder.

Could you please sign two copies of this letter where indicated below to confirm that you and Margaret agree to the dams being retained on the Land post mine closure and return one copy to us at your earliest convenience.

Yours faithfully,

Bernie O'Neill
General Manager
Stanmore IP Coal Pty Ltd

We, Ross and Margaret Flohr, agree to the above listed infrastructure being retained on our Land post mine closure.

Signature

ROSS FLOHR.
Name

30.4.18
Date

ANNEXURE 1

Minserve
stanmore
Source Minserve
Drawn Minserve
Scale See Scale Bar A4P
Cad File 20220625 IPC ERC Forecast Disturbance.APRX
ISAAC PLAINS COMPLEX
ERC 2022
Dams Retained for Landowner Post Mining
0 200 400 600 800 1,000
Meters
Legend
Mining_leases
Dams Retained for Landowner
Pit 5
Pit N1
Pit 4N
Pit 4S
Pit S2
Pit 3
Pit S3
Pit 2
614000
616000
618000
620000
7574000
7572000
7570000
7568000
7566000

APPENDIX O HYDROGEOLOGICAL ASSESSMENT

Klohn Crippen Berger

Stanmore Resources Limited

Isaac Plains Complex PRCP

Hydrogeological Assessment

Final

ISO 9001 14001 45001

DX70068A06

September 2024

Klohn Crippen Berger

12 September 2024

Stanmore Resources Limited
Email Delivery: ciara.kruger@stanmore.net.au

Ciara Kruger
Senior Environmental Approvals

Dear Ciara:

Isaac Plains Complex PRCP
Hydrogeological Assessment
Final

KCB Australia Pty Ltd (KCB) is pleased to provide this final hydrogeological assessment update for the Isaac Plains Complex PRCP to Stanmore Resources Limited (Stanmore). Should you have any queries regarding this report, please do not hesitate to contact Chris Strachotta (cstrachotta@klohn.com) at +61 7 3004 0244.

Yours truly,

KCB AUSTRALIA PTY LTD.

Carly Waterhouse, RPGeo
Senior Hydrogeologist

CS/MN/CW

240912R IPC PRCP Hydrogeological Assessment.docx
DX70068A06

KCB Australia Pty Ltd.
Level 3, 150 Mary St ▪ Brisbane QLD 4000 ▪ Australia
t +617.3004.0244 ▪ www.klohn.com

EXECUTIVE SUMMARY

KCB Australia Pty Ltd (KCB) was commissioned by Stanmore Resources Limited (Stanmore) to undertake a hydrogeological assessment to support the Isaac Plains Complex (IPC) Progressive Rehabilitation and Closure Plan (PRCP). The IPC consists of the Isaac Plains Mine (IPM), Isaac Plains East (IPE), Isaac Plains East Extension (IPEE) and the proposed approved Isaac Plains Underground (IPU).

Stanmore operates IPC under the conditions of their Environmental Authority (EA) EPML00932713 authorised under the Queensland *Environmental Protection Act 1994* (EP Act). Stanmore is required to prepare a PRCP for submission to the Queensland Government. A PRCP is an element of the Queensland Government's Mined Land Rehabilitation Policy (State of Queensland 2021a) and the Environmental Protection Act (1994). The EP Act requires that all areas disturbed within the relevant mining tenure are rehabilitated to a post-mining land use (PMLU) or managed as a non-use management area (NUMA).

The PRCP for IPC was submitted to the Queensland Department of Environment, Science and Innovation (DESI) in September 2022. It was compiled by SGM Environmental Pty Limited (SGM) and based on numerical modelling and impact assessment completed for the IPEE approvals prepared in 2018 (SGM Environmental, 2022). A Request for Information (RFI) was received from DESI in November 2022. The hydrogeological assessment has been updated in response to the RFI. This hydrogeological assessment included an update to the 2020 numerical groundwater model, re-simulating the post-closure landform. The hydrogeological conceptual model for IPC was updated incorporating any additional data collected since submission of the IPEE approvals.

The key hydrostratigraphic units at IPC comprise localised thin deposits of alluvium associated with minor water courses, a shallow highly weathered veneer of Tertiary sediments, Tertiary basalt, Rewan Group sediments and Permian sediments comprising the coal seams. The main groundwater-bearing formations are the fresh Tertiary basalt and the coal seams of the Permian sediments. These formations have been significantly depressurised and impacted by mining and gas production activities at nearby operations. The Rewan Group is a low permeability formation that is a regionally recognised aquitard. The Tertiary sediments do not form a permanent, saturated aquifer, and persistent groundwater occurs only where these sediments extend below the regional water table. The alluvium associated with Billy's Gully is an ephemeral perched aquifer located above the regional groundwater system that develops following rainfall and associated runoff events.

Maximum groundwater drawdown occurs at the end of the approved operations, with groundwater levels recovering throughout the closure period. Groundwater levels are predicted to have reached an equilibrium state between 500 and 1,000 years. The underground recovers first followed by the recovery of the final voids.

The IPC mine has seven approved residual voids, or NUMAs, under the Environmental Authority (N1, S2, E1, E2/E3/E4, and E5). The groundwater model was used to predict the final void water elevations in the long-term post-closure modelling. These residual voids are predicted to experience groundwater inflow and act as groundwater sinks through the closure period and beyond. Based on the model predictions, impacts to environmental values of groundwater are not anticipated.

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Appendix I Monitoring Network

Appendix II Groundwater Elevation

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Appendix IV Numerical Groundwater Model Report

CLARIFICATIONS REGARDING THIS REPORT

This is a report only and we solicit your review and comments within four weeks of submission. This draft report must not be relied upon for design, implementation and/or construction.

1 INTRODUCTION

KCB Australia Pty Ltd (KCB) was commissioned by Stanmore Resources Limited (Stanmore) to undertake a hydrogeological assessment to support the Isaac Plains Complex (IPC) Progressive Rehabilitation and Closure Plan (PRCP). This assessment is in response to a Request for Information (RFI) from the Department of Environment, Science and Innovation (DESI) after the submission of a PRCP by SGM Environmental Pty Ltd (SGM) in September 2022.

1.1 Background

The IPC is located approximately 4.5 km northeast of Moranbah in Central Queensland (Figure 1.1). The IPC consists of the Isaac Plains Mine (IPM), Isaac Plains East (IPE), Isaac Plains East Extension (IPEE) and the proposed Isaac Plains Underground (IPU). IPC produces export coking and thermal coal. The IPC Environmental Authority (EPML00932713) prescribes a maximum coal extraction rate of 4 million tonnes per annum (Mtpa) of Run of Mine (ROM) coal. The IPC comprises mining lease (ML) 70342, ML 700016, ML 700017, ML 700018 and ML 700019.

Open cut mining operations, which commenced in 2006, involve the removal of overburden by dragline, with truck and shovel pre-stripping. Coal is excavated from the active pits and hauled by truck to an onsite coal handling and preparation plant (CHPP) for washing and processing. Product coal is transported from the IPC, via an onsite rail loop and train load out facility. Product coal is railed to the Dalrymple Bay Coal Terminal, for export. An underground bord and pillar mine (IPU) is also approved at IPC, however, has not yet commenced.

Stanmore are required to prepare a PRCP for submission to the DESI. A PRCP is an element of the Queensland Government's Mined Land Rehabilitation Policy (State of Queensland 2021a) and the EP Act. The EP Act (State of Queensland 2022) requires that all areas disturbed within the relevant mining tenure are rehabilitated to a post-mining land use (PMLU), or managed as a non-use management area (NUMA).

An initial PRCP for IPC was submitted to the DESI in September 2022. The initial IPC PRCP was compiled by SGM and was based on numerical modelling and impact assessment completed for the IPU approvals prepared in 2020. Based on the feedback received from DESI (Table 1.1), an updated hydrogeological assessment has been prepared. This updated hydrogeological assessment includes an update to the 2020 numerical groundwater model, simulating the proposed post-closure landform, as presented in the initial PRCP.

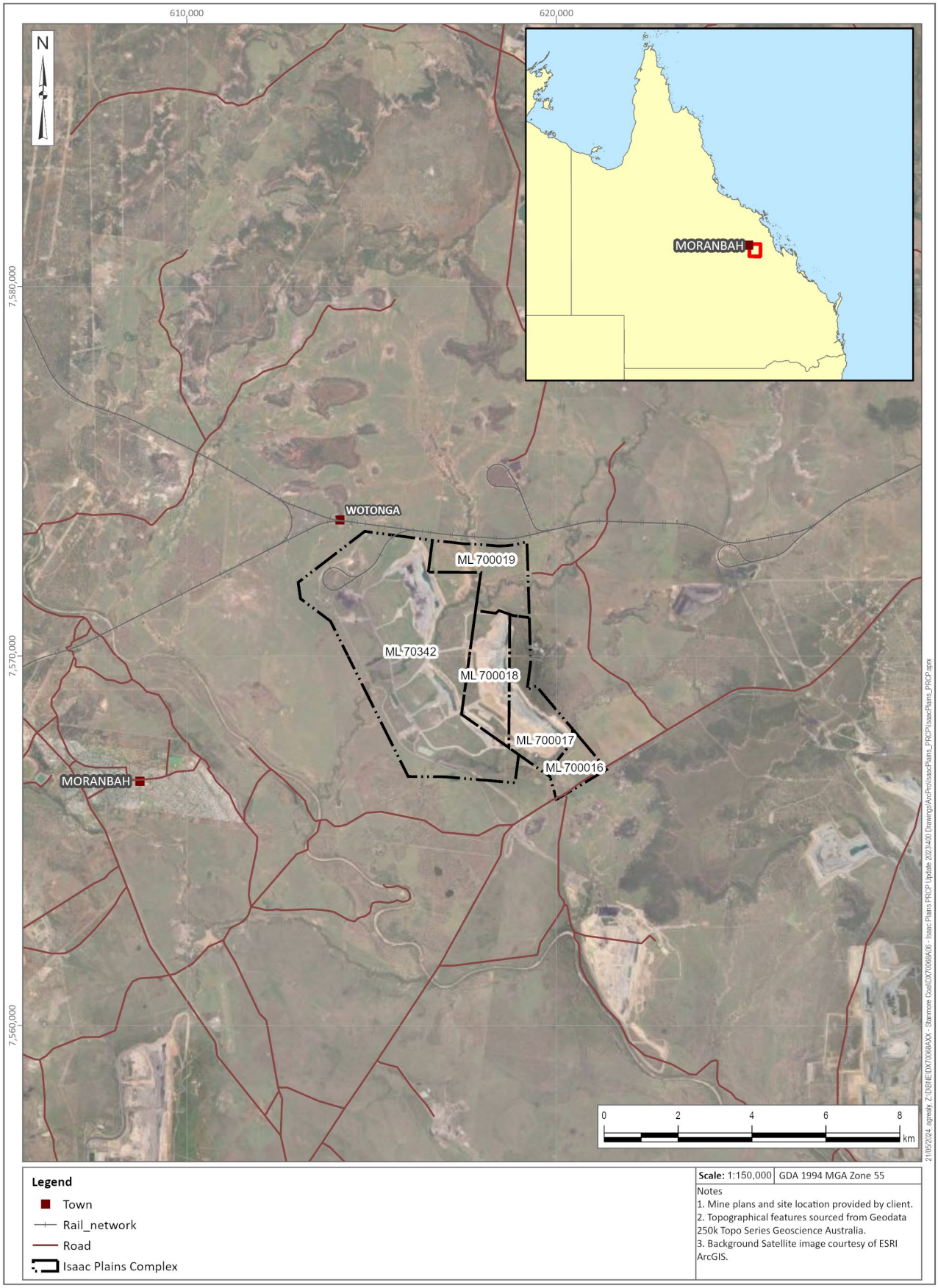

Figure 1.1 Location of Isaac Plains Complex Project Area

1.2 Scope of Work

A hydrogeological assessment is a requirement of the overarching PRCP. The PRCP guideline (DES 2023) includes the following requirements for hydrogeology:

- Assessment of the hydrogeology of the site and all connected strata and develop a conceptual model of the mine site's groundwater systems. This information must be integrated into the design of rehabilitation strategies and choice of PMLU or NUMA. The hydrogeological assessment should include the following steps:
  - Determining the groundwater occurrence including the existence of, and depth to, aquifers and aquitards.
  - Locating groundwater recharge and discharge locations locally and regionally.
  - Groundwater quality within each of the aquifers and from surface expressions (i.e., seeps and springs).
  - Current and potential future uses of groundwater including existing groundwater extraction bores.
  - Groundwater flow direction and velocity, including field tests to determine hydraulic conductivity.
  - The development of potentiometric mapping and hydrostratigraphic cross-sections.

This hydrogeological assessment was undertaken to address several of the above items, as well as provide the following information to support the surface water study, being completed by others:

- Groundwater flow in the final voids.
- The extent and area of influence of groundwater level drawdown associated with the final voids.
- Areas of potential risk where groundwater impact mitigation / control measures may be required.

In addition, the specific Request for Information (RFI) from DESI, based on the submitted PRCP in 2022, is addressed in Table 1.1 with specific reference to relevant sections in this report.

1.3 Report Structure

This report is structured as follows:

- Section 1: Introduction
- Section 2: Regulatory Framework
- Section 3: Overview of Operations
- Section 4: Hydrogeological Conceptual Model
- Section5: Numerical Groundwater Modelling Overview
- Section 6: Impact Assessment
- Section 7: Conclusion

The report is supported by the following appendices:

- Appendix I Monitoring Network

  A summary of the current monitoring network.

- Appendix II Groundwater Elevation

  Provision of groundwater hydrographs at groundwater monitoring bores.

- Appendix III Groundwater Chemistry

  Timeseries plots for key groundwater chemistry analytes at groundwater monitoring bores.

- Appendix IV Numerical Groundwater Model Report

  Information on the numerical groundwater model used to simulate post-closure groundwater levels.

1.4 DESI Request for Information Response

The RFI provided by DESI, in response to the submitted PRCP document (SGM Environmental, 2022), is presented in Table 1.1. The table provides a response to each request, and a reference to the location in the report where further information to support the response can be found.

Table 1.1 Request for Information from DESI (from 2022 PRCP)

Item	Relevant Section of Plan or Schedule	Matter	Request for Information	Response	Relevant Report Section
3	3.5.1.1 Hydrogeology	Section 3.5.1.1d refers to Appendix F for a source/sink trigger assessment based on long-term water balance modelling. This assessment informs the conclusion that all residual voids are modelled as groundwater sinks and that no further groundwater considerations are necessary. Appendix F section 3.2.2 states: This assessment was completed by simulating pre-mining conditions across the model domain (i.e. all mining activity, not just mining associated with IPC); which included the following model conditions / modifications prior to undertaking the simulation: Drain cells simulating all mining activities in the model domain were deactivated; Material properties for hydrostratigraphic units (i.e. model layers) intersected by the pit voids reinstated in the model domain to represent pre-mining conditions; and, Recharge rates for the pit voids updated to represent pre-mining pit void surface geology conditions. The last two points appear to indicate that, in the modelling of post-closure conditions, the backfilled pits are treated as if mining had not occurred (pre-mining conditions applied). This interpretation is also indicated by Appendix IV, Table 2-3 (Summary Calibrated Hydraulic Properties) where there is no identification of calibrated properties for spoil and backfill. Backfill material is likely to result in a higher recharge rate, higher hydraulic conductivity (horizontal and vertical) and higher storage parameters than had existed before mining occurred. It is assumed that excluding these characteristics of the spoil from the model will impact the long-term prediction of void water levels and quality. The impact of this modelling variable on the prediction of the void sink/source threshold is not known and requires clarification to ensure the residual voids do not cause pollution of the surrounding aquifers.	Provide a Rehabilitation Planning Part with updated modelling that incorporates the changed recharge rate, hydraulic conductivity, and aquifer storage capacity in the areas backfilled with spoil.	A new groundwater model simulation representing the proposed post-closure landform has been undertaken. Prior to undertaking the new simulation a re-calibration of the numerical model was conducted to current conditions based on available groundwater monitoring records. The new model considers and represents the properties of the backfilled spoil. The spoil is represented with a hydraulic conductivity of 5 m/d.	Section 7
4	3.5.1.1 Hydrogeology	Inconsistencies in the water elevation prediction and associated threshold values of the relevant models have been identified between Appendix F, Appendix D and the Rehabilitation Planning part. The inconsistent predictions of void water level may have implications for the accuracy of the void sink/source threshold stated in the Rehabilitation Planning Part and requires clarification to ensure the residual voids do not cause pollution of the surrounding aquifers. The inconsistencies are outlined below. Appendix F section 6.2.3 and Appendix IV of Appendix F, provide discussion of how the groundwater model (with inputs from the surface water model in relation to catchment run off) is used to predict post-closure void water levels and the time to steady-state water level conditions. Appendix F Table 6.1 provides predicted post-closure steady-state void water elevation and pit void source/sink trigger threshold for each void. Appendix F states in section 6.2.3 "Steady-state water level conditions is predicted to be established after approximately 500 (N1 pit and S2 pit) to 700 years (E5 pit, E4/4N pit and E2/3 pit) following the cessation of mining." This prediction is inconsistent with that provided in Appendix D. Appendix D, section 9 predicts the water level to reach equilibrium in all voids after 100 years in contrast to the 500 to 700 years predicted in Appendix F. Section 9 also provides groundwater source/ sink threshold levels attributed simply to "KCB". These threshold levels are notably different to those referenced in Appendix F. The range of long-term water levels predicted in each void in Appendix D are similar to those predicted in Appendix F but there are notable differences.	Provide an updated Rehabilitation Planning Part that includes analysis and discussion about how groundwater and surface water modelling have been used to determine the cumulative impacts on long-term void water levels.	The groundwater modelling has been revised using the proposed final landform which is consistent with the surface water modelling. The predicted long-term void water levels (in terms of recovery) have been determined through the groundwater modelling, allowing recovery of the voids during the closure period and applying evaporation to the void water level. It is assumed that there is no surface water runoff into the voids. The lack of runoff into the pit in the model results in a conversative prediction, with recovery occurring slower than that of reality. The predicted cumulative impact on groundwater levels from all the IPC voids suggests some flow between the voids until an equilibrium is reached, but no flow is expected away from the site. Predicted post-closure equilibrium conditions have similar timeframes as predicted in the 2020 KCB report (Appendix F to PRCP report).	Section 6 Section 7

Item	Relevant Section of Plan or Schedule	Matter	Request for Information	Response	Relevant Report Section
		Section 3.4.2, Figure 11, of the Rehabilitation Planning Part provides maximum water levels in each void. Some of these are different to the water levels referenced in both Appendix F and Appendix D. Section 3.5.1.1, Table 32, of the Rehabilitation Planning Part shows post-closure water levels and trigger levels in the voids aligning with Table 6.1 in Appendix F. Section 3.5.3.4 of the Rehabilitation Planning Part provides information on time to water level equilibrium in the voids, ranges of water level at that time and salinity and references Appendix M but this appears to be an error, **and the reference should be to Appendix D.** There is no overarching discussion of the different methodologies used to determine long-term water levels and time to equilibrium in the final voids and the comparison and discussion of the outputs.			
5	3.5.1.1 Hydrogeology	Appendix IV of Appendix F (Figures A7 to A11) provide post-closure groundwater influxes for each void, including predicted groundwater inflow rates (L/s) at various water level elevations in the voids. In Figure A7 (N1 void), the predicted inflow rate appears to increase as the water level elevation in the void rises. This is not an expected phenomenon and requires further analysis and discussion to ensure the residual void does not cause pollution of the surrounding aquifers.	Provide an updated Rehabilitation Planning Part that includes an analysis and discussion of the predicted groundwater inflow to void N1.	Recovery of groundwater levels in each of the pit voids at the Project site is dynamic because in addition to the variable stage-storage characteristics of the pit voids, and the associated varying surface water contributions (i.e. incident rainfall,) and evaporative losses, groundwater inflows to the voids are influenced by the hydraulic gradient of the groundwater system in the vicinity of the pit voids created by the recovering water level in each void. These varying characteristics of the pit voids result in varying rates of recovery of groundwater within each of the voids, therefore, creating varying hydraulic gradients between the voids. Figure 7.1 identifies that the N1 void has one of the lowest pit lake elevations of all the pit voids following post-closure quasi steady-state equilibrium of groundwater levels, therefore, there will be a hydraulic gradient would be towards the N1 void. N1 is one of the first to recover as it is receiving water from the other voids. An increasing groundwater inflow into the N1 void over time indicates that the hydraulic gradient between the pit lakes of the surrounding voids and the N1 void is increasing over the duration of the post-closure groundwater level recovery.	Groundwater inflow to voids is discussed in Section 7
6	3.5.1.1 Hydrogeology	Appendix G, Appendix III, Section 3.1 states that hydraulic parameters of underground workings have been considered in predictive scenarios of mine development. It is not clear in the Rehabilitation Planning Part or in Appendix F whether these scenarios have been incorporated into modelling of long-term void water levels.	Provide an updated Rehabilitation Planning Part that includes clarification and/or updated modelling regarding the incorporation of underground works into long-term void water level and quality modelling. Modelling should predict the void water level, water quality (EC and heavy metals), and groundwater source/sink threshold for a variety of possible mine development scenarios.	The groundwater modelling has considered the underground workings, and the associated material parameters have been considered in the predictive scenario of mine development as well as post-closure groundwater recovery.	Section 5, Section 6 Appendix IV
10	3.5.4 Underground Mining	Several requirements of the PRCP guideline are not adequately addressed in section 3.5.4 of the Rehabilitation Planning part. These requirements must be included in the Rehabilitation Planning Part to ensure that impacts on land are clearly understood and that appropriate rehabilitation activities can be included in the PRCP schedule. The requirements of the PRCP guideline (section 3.6.4) that should be elaborated on are: ▪ an assessment of groundwater interactions and potential lowering of groundwater levels that includes: ♦ consideration of the potential exposure of previously saturated geological formations to air - leading to AMD generation	Provide an updated Rehabilitation Planning Part that includes details of the surface impacts caused by underground mining and any proposed rehabilitation measures and sealing of underground workings.	Specific to the groundwater-related aspects identified in the "Matters" column, KCB considers that these aspects have been addressed as part of the PRCP submission and the additional information provided as part of this table. <u>Discharge to surface</u> - post-closure groundwater levels are not predicted to recover to above surface levels, except within the pit voids, therefore, impacts associated with discharge to the surface are not predicted.	Section 6

Item	Relevant Section of Plan or Schedule	Matter	Request for Information	Response	Relevant Report Section
		♦ consideration of measures to avoid or minimise groundwater discharges to the surface through appropriate mine access planning, including post-mining sealing off of tunnels, shafts, adits, boreholes, and other openings ♦ subsidence analysis and modelling and a subsidence vegetation/habitat impact assessment that includes: ♦ damage to vegetation in the vicinity of surface cracks ♦ impacts associated with changed hydrogeological characteristics ♦ changes in surface drainage, leading to changes in the composition of vegetation communities and distribution of flora and fauna species ♦ consideration of how potential entries to underground workings will be sealed (i.e. through some form of capping or back filling) ♦ how surface ponding and cracking will be mitigated		Subsidence - the proposed underground development associated with the Isaac Plains Underground is to be undertaken using "bord and pillar" methods, which is not predicted to result in any significant subsidence above the underground workings. No changes in hydrogeological characteristics are predicted for the Project as a result of mine development and/or post-closure landform establishment.	

2 REGULATORY FRAMEWORK

This section describes the relevant regulations and requirements relevant to this hydrogeological assessment, prepared to support IPC's PRCP.

2.1 Mineral Resources Act 1989

Underground and open cut mining activities are authorised under the *Mineral Resources Act 1989,* (State of Queensland 2021b). The *Mineral Resources Act 1989* is an Act to provide for the assessment, development and utilisation of mineral resources to the maximum extent practicable consistent with sound economic and land use management (State of Queensland 2021b).

2.2 Environmental Protection Act 1994

The *Environmental Protection Act 1994* (State of Queensland 2024) is an Act with the objective to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development).

This Act states that 'to carry out an environmentally relevant activity (ERA) an EA is required'. Stanmore IP Coal Pty Ltd operate under the conditions of their EA EPML00932713, authorised under the *Queensland Environmental Protection Act 1994* (EP Act) (State of Queensland 2021d).

Section 754 of the *Environmental Protection Act 1994* provides details related to requirements for mining EA holders to prepare a proposed PRCP.

2.3 Mineral and Energy Resources (Financial Provisioning) Act 2018

The *Mineral and Energy Resources (Financial Provisioning) Act 2018* (State of Queensland 2021c) was passed by Queensland Government in November 2018 as part of a broad package of reforms to improve rehabilitation and financial assurance outcomes in the resources sector. The Act was passed to replace the financial assurance arrangements for resource activities under the *Environmental Protection Act 1994*. Changes included a new financial provisioning scheme, changes to how the estimated rehabilitation cost for an EA is calculated and amendments to the *Environmental Protection Act 1994* to introduce new requirements for the progressive rehabilitation and closure of mined land.

2.4 Mined Land Rehabilitation Policy

The Queensland Government have established the Mined Land Rehabilitation Policy as they are committed to ensuring land disturbed by mining activities is rehabilitated to a safe and stable landform that does not cause environmental harm and is able to sustain an approved PMLU (State of Queensland 2021b).

A critical element of the Mined Land Rehabilitation Policy is the PRCP. The aim of the plan is to provide certainty about timing of rehabilitation. The plan will include binding, time-based milestones for actions that achieve progressive rehabilitation and will ultimately support the transition of the mine site's future use.

2.5 PRCP Guideline

DES published a PRCP guideline (ESR/2019/4964), the purpose of which is to assist applicants in developing a PRCP. The guideline identifies a number of statutory information requirements applicable to most mining activities in Queensland. The guideline was developed using contemporary best practice and industry standards, in line with the Environmental Protection Act 1994 and the Mined Land Rehabilitation Policy (State of Queensland 2021a).

The PRCP guideline has been used to assist with this hydrogeological assessment to support IPC's PRCP.

2.6 Environmental Values

The EP Act defines an Environmental Value (EV) as:

- A quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or
- Another quality of the environment identified and declared to be an EV under an Environmental Protection policy or regulation.

Under the EP Act, the Environmental Protection (Water and Wetland Biodiversity) Policy (EPP) 2019 (State of Queensland 2020) is established as subordinate legislation to achieve the object of the Act in relation to Queensland Waters.

The IPC is located in the upper reaches of the Isaac River sub-basin, which forms part of the larger Fitzroy River Basin.

The *Environmental Protection (Water) Policy 2009* provides defined EVs and water quality objectives (WQOs) for the Isaac River sub-basin under Schedule 1 of the policy and are detailed in Department of Environment and Heritage Protection (DEHP) (2011). EVs for the Isaac River groundwaters are presented in Table 2.1.

The EPP provides WQOs to support and protect the various EVs identified for waters within the Fitzroy River catchment. The WQOs for the Fitzroy River Sub-Basin groundwaters are provided in the Fitzroy River Sub-basin Environmental Values and Water Quality Objectives according to their chemistry zone and depth category. Groundwater within the vicinity of the IPC is classified as 'shallow' (<30 m) and deep (>30 m) under chemistry zone 34, a saline (Na Cl) type water.

Table 2.1 Environmental Values for the Isaac River Sub-Basin Groundwaters at the IPC

Groundwaters	Environmental Values											
	Aquatic Ecosystem	Irrigation	Farm Supply / Use	Stock Water	Aquaculture	Human Consumer	Primary Recreation	Secondary Recreation	Visual Recreation	Drinking Water	Industrial Use	Cultural and Spiritual Values
Isaac groundwaters	✓	✓	✓	✓			✓			✓		✓

3 OVERVIEW OF OPERATIONS

3.1 Historical and Current Operations

The IPC consists of the Isaac Plains Mine (IPM), Isaac Plains East (IPE), Isaac Plains East Extension (IPEE) and the proposed Isaac Plains Underground (IPU). Details on each of these areas include:

- Mining has occurred since 2006 as an open cut truck and shovel operation producing coking coal. Overburden is removed by a combination of drilling, blasting, dragline, dozing, excavation and haul methods. Overburden material from open cut areas has been placed in out-of-pit dumps and previously exhausted pits. Open cut mining was suspended in 2021 with the start of the neighbouring Isaac Downs Project (IDP).
- Mining is planned for new open cut pits E5 and E1 as well as an extension to pit E4 (IPEE). The E4 extension is referred to as E4N or E5S in some documentation. E5 is also referred to as E5N in some studies. All pits are approved as per Table 17 of the EA. The E4 extension is located south of Smoky Creek while E5 is a new pit north of Smoky Creek. E1 is south of E2 pit on the southern side of Billy's Gully (Figure 3.1). Mining will be undertaken as a conventional dragline/truck and shovel operation. This is consistent with the existing IPC operation and will provide similar conditions for rehabilitation at the end of mining.
- The IPU area is located between IPM and IPE with access to the underground being from the S2 pit highwall. IPU is a bord and pillar operation planned to commence in 2026 for a duration of 10 years, and consequently, this mining methodology is not predicted to result in surface subsidence above the underground workings.

Open cut mining restarted in 2023 with completion planned for 2032. Underground mining is scheduled to start in 2026 and is scheduled to be completed in 2036.

Several neighbouring operations are located in the vicinity of the IPC. These are shown on Figure 3.2 and include:

- The Isaac Downs Mine located south of IPC;
- The Grosvenor Mine adjoining the Isaac Plains Complex to the west;
- The Moranbah North Mine located to the northwest;
- The Burton, Broadlea and Ironbark No. 1 Mines located to the north;
- Carborough Downs Mine located to the east;
- Millennium and Poitrel Mines located to the southeast; and
- The Moranbah South Project and Caval Ridge Mine located southwest.

The Moranbah Gas Project, which is one of Australia's largest operating coal seam gas (CSG) projects, also extends over the Grosvenor Mine, Moranbah North Mine and surrounding areas. The Moranbah Gas Project is a joint venture between Arrow Energy and AGL.

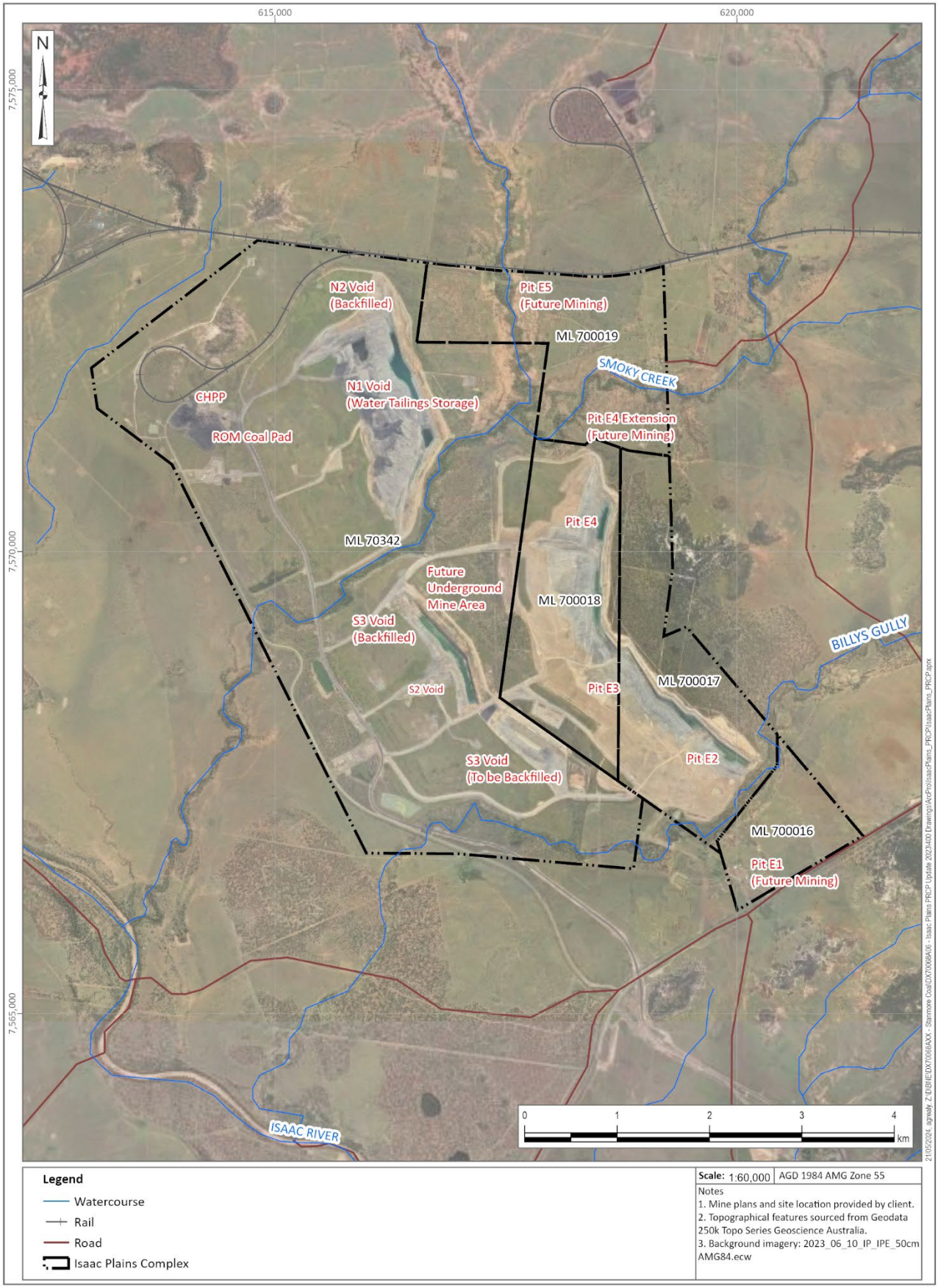

Figure 3.1 Layout of the IPC Operations

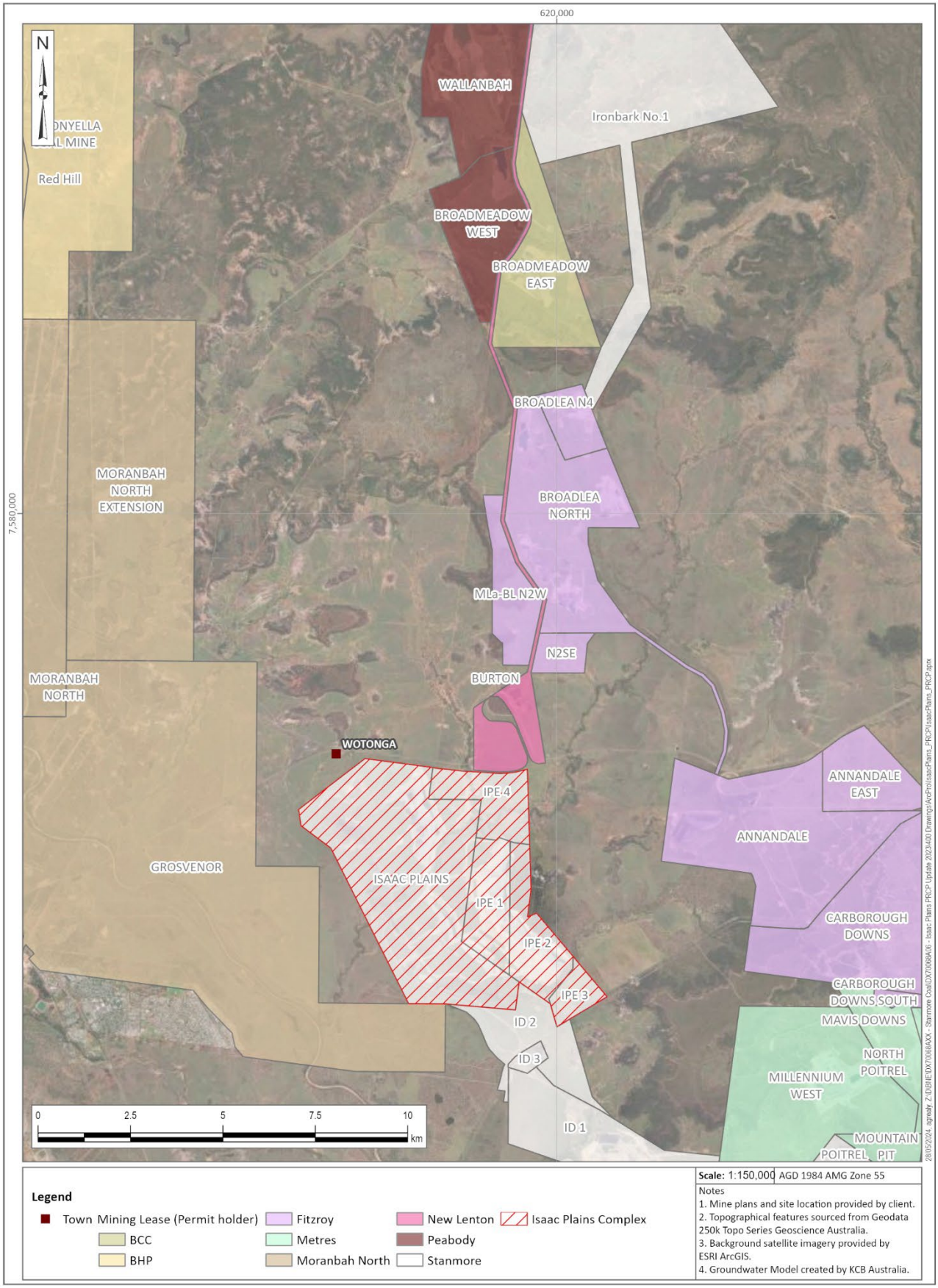

Figure 3.2 Neighbouring Mining Leases to IPC

3.2 Closure Strategy

The proposed final landform for the IPC is presented in Figure 3.3. IPC has a total of ~601 ha of previously disturbed land that has already been rehabilitated. The current and provided mining process will be conducted in similar to what has been undertaken previously, with the exception of the underground development. Overburden is removed by a combination of drilling, blasting, dragline, dozing, excavation and haul methods, with the overburden material placed in out-of-pit dumps and previously exhausted pits.

During operations, a mine water management system was established and operated to protect the receiving environment from mine affected water (WRM, 2020).

For water management system purposes, the water generated at IPC is classified into four types:

1) Raw water (i.e. water sourced external to the mine operations);
2) Clean water (i.e. surface runoff form undisturbed areas);
3) Mine affected water (i.e. pit water, processing plant water); and,
4) Sediment water (i.e. rainfall runoff from catchments which can discharge through release points associated with erosion and sediment control structures).

Specific objectives are set in the IPC water management system for each water type to comply with operational, social and environmental objectives stipulated in the EA.

Progressive rehabilitation will be implemented by starting and completing rehabilitation as soon as practicable after the mined land becomes available.

Land is considered available for rehabilitation when:

- the land is no longer being mined;
- the land is no longer being used for operating infrastructure or machinery for mining including dams or water storages;
- the land is not needed for mining of a probable or proved ore reserve; or
- the land contains permanent infrastructure remaining for a post-mining land use (PMLU).

Once each pit has been mined, residual voids will be retained as part of the approved final landform.

There are seven proposed final pit voids which have been approved as NUMAs. The location of these voids is shown in Figure 3.3. The following strategies will be applied to each of the pit voids:

- N1 Void

  Rehabilitation of the out-of-pit spoil was completed in 2020 with in-pit spoil rehabilitation progressing as mining advanced. The remaining areas of in-pit spoil are being utilised for disposal of rejects and tailings. The rejects cells will be capped with inert spoil as they become available, reshaped and rehabilitated to a PMLU of grazing. The in-pit tailings storage facility will be capped with inert spoil from the adjacent dragline spoil.

- S2 Void

  The central S2 ramp will be used as access for IPU with new facilities proposed to support the Mine on the backfill spoil to the south. Once the underground mine is completed it will be possible to reshape the batters of the access ramp and reshape the northern low wall spoil. There will be a residual void.

- E1 Pit

  Once mining is completed there will be a residual void. Out-of-pit spoil will be reshaped to 15%, topsoiled and seeded to support the grazing PMLU.

- E2 Pit

  Out-of-pit batters on the low wall side will be reshaped, topsoiled and seeded to support the grazing PMLU. There will be a residual void.

- E3 Pit

  Out-of-pit batters on the low wall side will be reshaped, topsoiled and seeded to support the grazing PMLU. There will be a residual void.

- E4 Pit

  Out-of-pit batters on the low wall side will be reshaped, topsoiled and seeded to support the grazing PMLU. There will be a residual void.

- E5 Pit

  Once mining is completed there will be a residual void. Out-of-pit spoil will be reshaped, topsoiled and seeded to support the grazing PMLU.

Once the overburden dumps have been shaped into the final landform design, topsoil will be placed on the landform surface and the disturbed areas will be replanted with suitable predefined vegetation. The success of this revegetation will be monitored along with the stability of the rehabilitated landscape and will be documented in an annual rehabilitation inspection report.

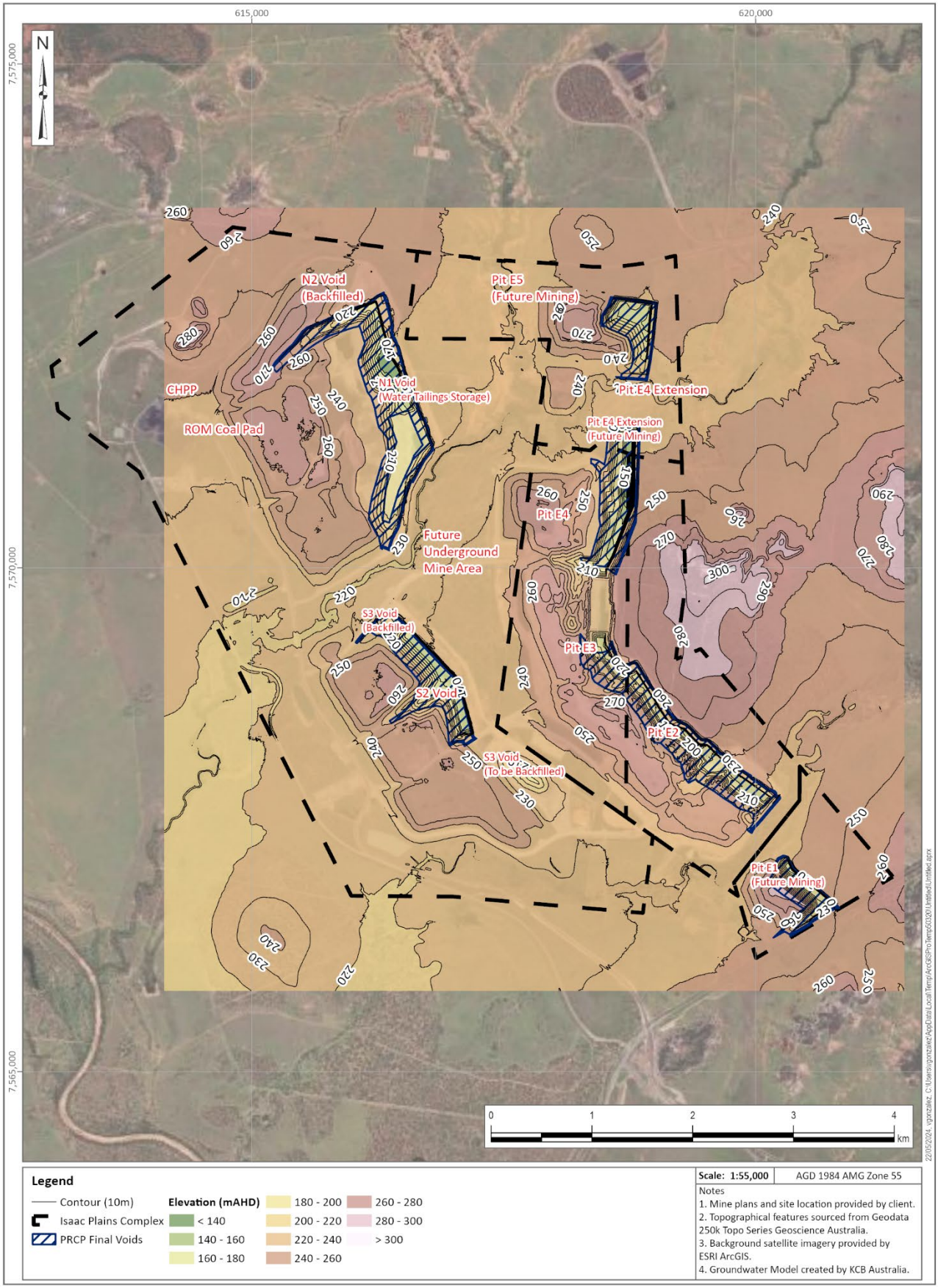

Figure 3.3 Proposed Final Landform

4 HYDROGEOLOGICAL CONCEPTUAL MODEL

4.1 Physical Setting

4.1.1 Climate

The climate at the Project area is sub-tropical continental, characterised by high variability in rainfall, temperature and evaporation, typical of the regional Central Queensland area.

The nearest available climate data has been collected from two Bureau of Meteorology (BOM) weather stations within the vicinity of the Project area. These weather stations include:

- Moranbah Water Treatment Plant (Station 034038) – now decommissioned, operating from 1972 to March 2012. This monitoring station is located approximately 12 km southwest of the Project area.
- Moranbah Airport (Station 034035) – operational, operating from March 2012 to present. This monitoring station is located approximately 12.5 km south of the Project area.

Mean maximum temperatures range between 34.5°C in summer and 24.3°C in winter. Mean minimum temperatures range between 21.5°C in summer and 8.8°C in winter. Daily evaporation rates are generally high and exceed rainfall throughout the year. The average climate statistics are presented in Table 4.1. The highest rainfall occurs during December to February, with the lowest rainfall occurring during April to September. Daily rainfall with a cumulative rainfall departure (CRD) trend from January 2006 to December 2023 is presented Figure 4.1. CRD trends are a running deviation of actual rainfall from the long-term daily average. These trends provide season-scale identification of trends (wet / dry) as well as prolonged periods (decades or longer) of predominantly dry or wet conditions.

Table 4.1 Climate Statistics for Moranbah Airport (Station no 034035) (BOM 2024)

Period:	2012-2024			
	Mean minimum temperature	Mean maximum temperature	Mean rainfall (mm)	Mean evaporation (mm)
January	21.5	34.5	103.1	223.2
February	21.4	34.0	82.6	182.1
March	20.3	32.8	76.8	187.5
April	16.9	30.3	27.3	151.0
May	12.7	26.9	32.8	120.4
June	10.0	24.4	16.8	97.8
July	8.8	24.3	38.7	107.6
August	8.9	26.8	12.2	137.3
September	12.7	30.1	14.5	179.1
October	16.3	33.2	22.8	222.0
November	18.9	34.5	66.3	231.4
December	20.6	34.9	64.3	243.0
Annual	**15.8**	**30.6**	**558.2**	**173.5**

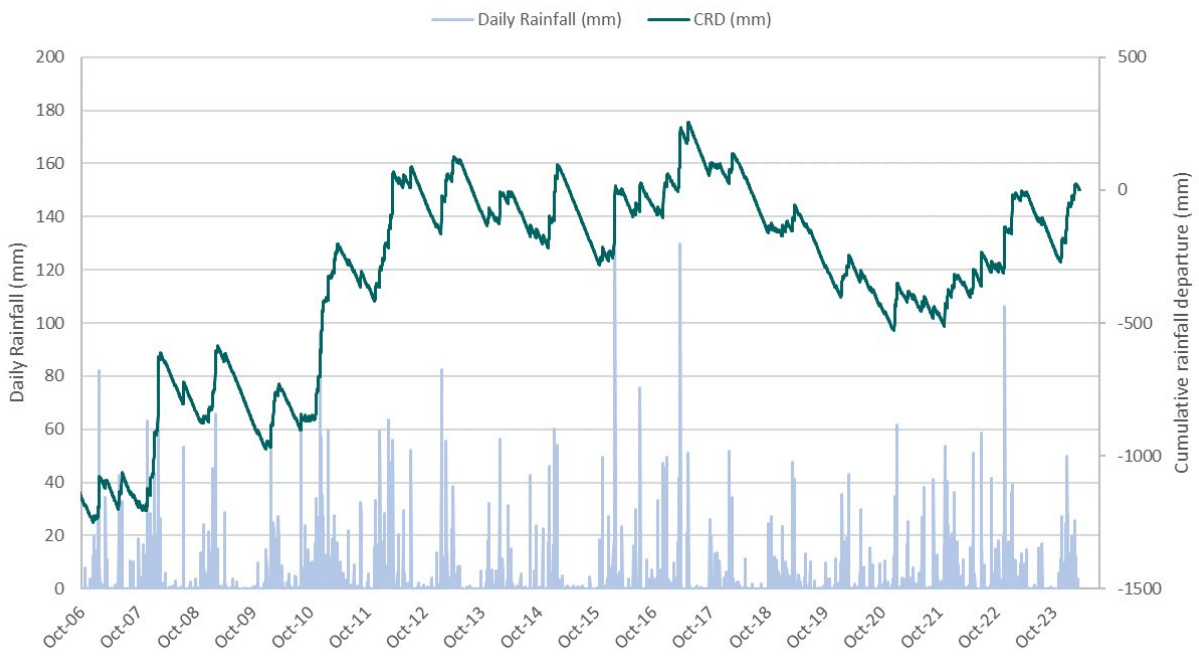

Figure 4.1 Daily Rainfall and Rainfall Excess / Deficit Trend Moranbah Airport (BOM 2024)

Available climate data highlights distinct cycles of above average and below average rainfall as illustrated in Figure 4.1. The Moranbah area experienced mostly below average rainfall between 2012 and 2023. However, some above average rainfall was experienced during February 2016, 2021, and January 2023.

4.1.2 Topography and Drainage

The Project mining area is traversed by Smoky Creek, its northern tributary; and Billy's Gully (Figure 4.2). Smoky Creek and its northern tributary converge to the west of the northern extent of the Project mining area. Surface water flow within Smoky Creek is towards the southwest and joins the Isaac River approximately 7 km downstream of the Project mining area boundary. Smoky Creek separates the approved Pit 4 (south of Smoky Creek) and Pit 5 (north of Smoky Creek) of IPE. Billy's Gully flows towards the west-southwest and is located adjacent to the southern extent of the Project mining area (Figure 4.2). The Billy's Gully drainage line separates the approved Pit 1 (south of Billy's Gully) and Pit 2 (north of Billy's Gully) of IPE.

The Project mining area comprises undulating terrain (Figure 4.2). In the northern part of the Project mining area, the land slopes towards creek channels. The remainder of the Project mining area slopes to the west.

The Isaac River, Smoky Creek, Billy's Gully and their tributaries are ephemeral and characterised by short-duration surface water flows that are typically restricted to periods during and immediately after rainfall events. Creek flows exhibit naturally elevated suspended sediment loads and the channels show extensive sediment deposition.

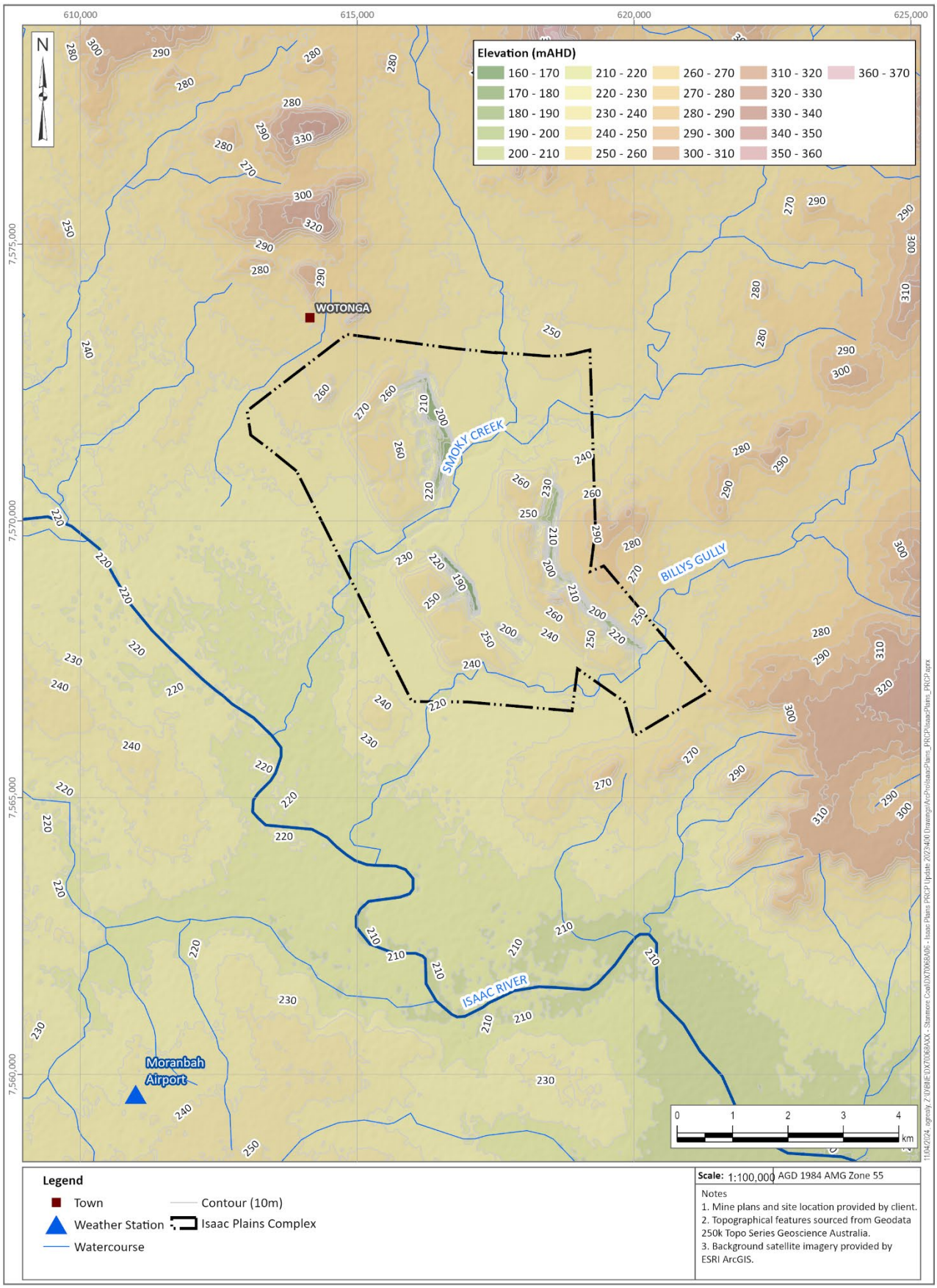

Figure 4.2 Topography and Drainage Surrounding IPC

4.1.3 Geology

The Project mining area is located on the northwestern flank of the Bowen Basin, a sedimentary basin comprising Permian to Triassic age geology. A veneer of more recent basalt and weathered sediments typically overlies the Bowen Basin strata (Figure 4.3).

The ground-truthed surface geology relevant to the Project mining area is shown in Figure 4.3, and includes:

- Thin deposits of alluvium within, and immediately adjacent to, the drainage channel of Billy's Gully;
- A veneer of recent weathered sediments comprising the Suttor Formation and associated colluvium and regolith;
- Localised Tertiary basalt deposits;
- Triassic sediments of the Rewan Group; and
- Permian sediments of the Rangal Coal Measures (including the target Leichardt Seam) and the deeper Fort Cooper Coal Measures (FCCM) and Moranbah Coal Measures (MCM).

KCB field investigations completed in 2018 identified limited Quaternary alluvium within the vicinity of Smoky Creek, in comparison to surrounding larger water courses (e.g. Isaac River), with the alluvium constrained to within the Smoky Creek water course by the adjacent banks. A summary of this field investigation in provided in Appendix VI. Field investigations completed by 3D Environmental in 2020, as part of a Groundwater dependent ecosystems (GDE) study at IPC (3D Environmental 2020), identified thin (~2 m) localised deposits of alluvium within and adjacent to the drainage channel of Billy's Gully.

Broader and thicker deposits of Quaternary alluvium, are mapped adjacent to the Isaac River, located approximately 6.5 km southwest of the Project area.

The Tertiary sediments comprise a heterogeneous profile of semi-consolidated sandstone, mudstone and other minor sediments associated with the Tertiary Suttor Formation, duricrusted palaeosols at the top of deep weathering profiles, colluvium and regolith (Figure 4.3). Published geological mapping confirms that the colluvium deposits transition to Suttor Formation sediments, indicating that these materials are frequently indistinguishable due to lithological similarities. These materials are therefore considered to form a single unit, hereafter referred to as the Tertiary sediments, which are widely distributed over the Project area and its surrounds. These sediments are up to approximately 15 m thick in the west and south of the IPC and are thin or absent elsewhere.

The Tertiary basalt comprises a heterogeneous profile of vesicular and massive basaltic lavas, with minor tuff and ash (Figure 4.4). The upper basalt profile is highly weathered forming a basaltic clay. The distribution of Tertiary basalt is confined to a paleo-channel that is incised into the Permian sediments. The Project area is located to the west of the main basalt paleo-channel; however, the northern extent of the mining area does intersect a western extension of basalt away from the main basalt paleo-channel. The basalt reaches a maximum thickness of approximately 15 m within the IPC area.

The Triassic Rewan Group overlies the Permian sediments within and to the east of the Project area and consists of fine/medium grained sandstones, siltstones and shale. The upper profile of the Permian sediments has been extensively weathered forming a clay. The Rewan Group subcrops beneath the Tertiary sediments and basalt within the IPC area and thickens as it dips to the east.

The Permian sediments include the Rangal Coal Measures and the underlying Fort Cooper Coal Measures and Moranbah Coal Measures. These units comprise a sedimentary sequence with interbedded coal seams, including the target Leichardt Seam, which is approximately 3.2 to 4.4 m thick. The upper profile of the Permian sediments has been extensively weathered forming a clay. The weathered Permian sediments outcrop at the ground surface across much of the IPC mining area and much of the surrounding area to the west. In the remainder of the Project area, the weathered Permian sediments subcrop under the Tertiary sediments and basalt and dip towards the east (Figure 4.5).

The Permian sediments (including the Leichardt Seam) and the Rewan Group are faulted to the west of the IPC (Figure 4.5). The fault dips gently to the east in the northern part of the IPC. In this area, the downthrust and upthrust Leichardt Seam (located west and east of the fault, respectively) overlap. Open cut mining in the Project area will target the upthrust coal seam (Figure 4.5). The fault is sub-vertical in the southern part of the IPC and there is negligible overlap in the Leichardt Seam in this area.

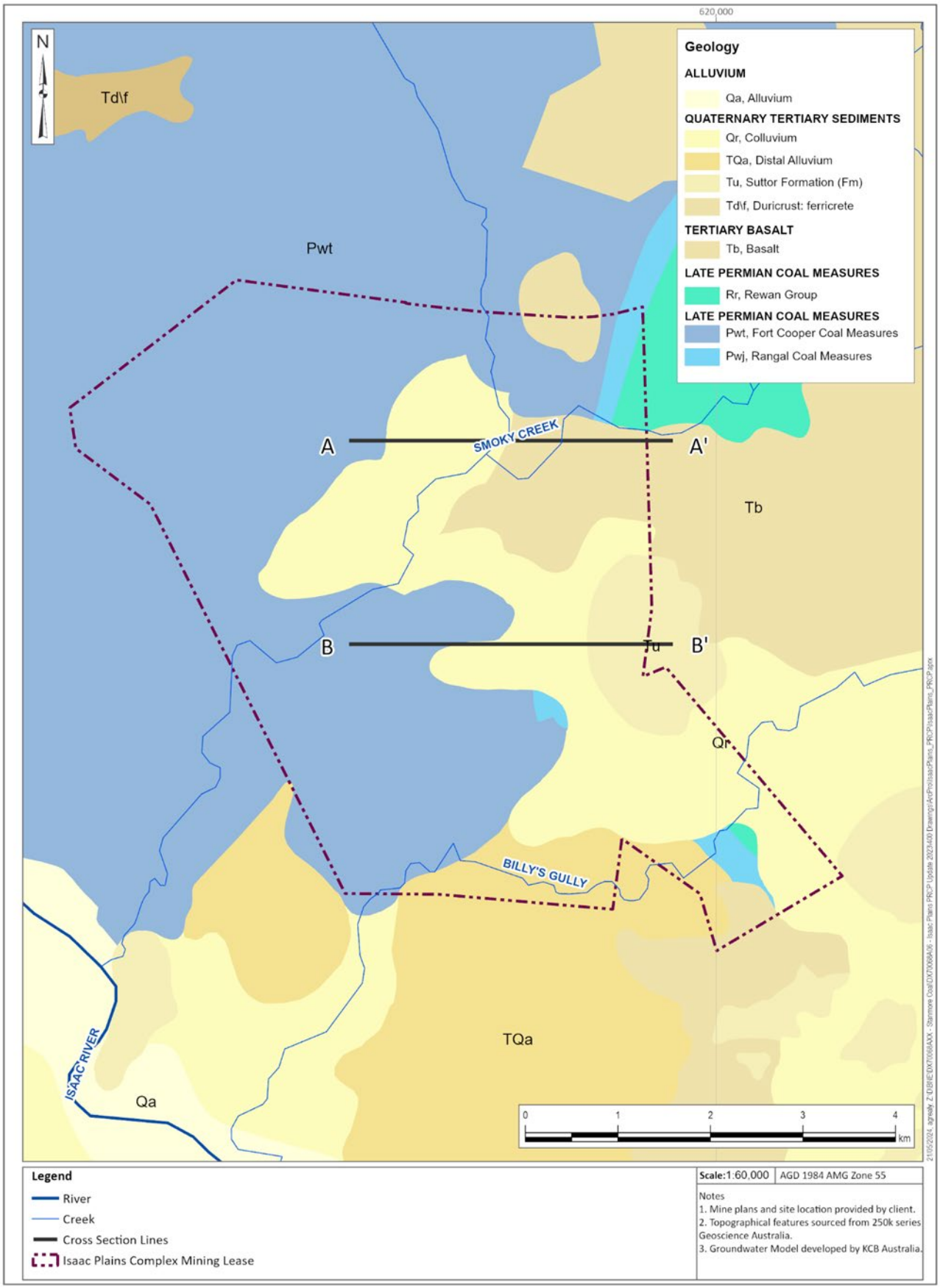

Figure 4.3 Surface Geology

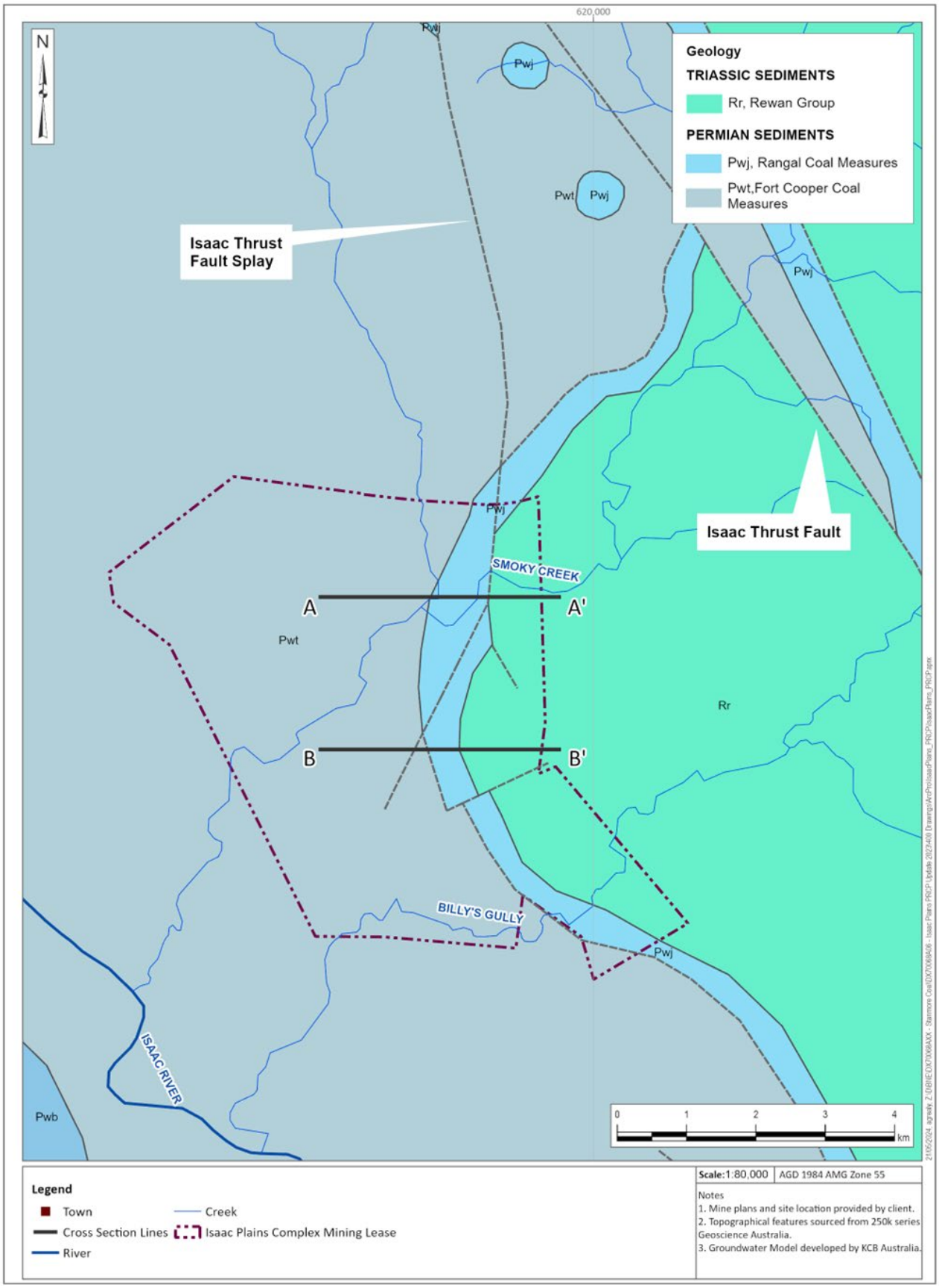

Figure 4.4 Solid Geology

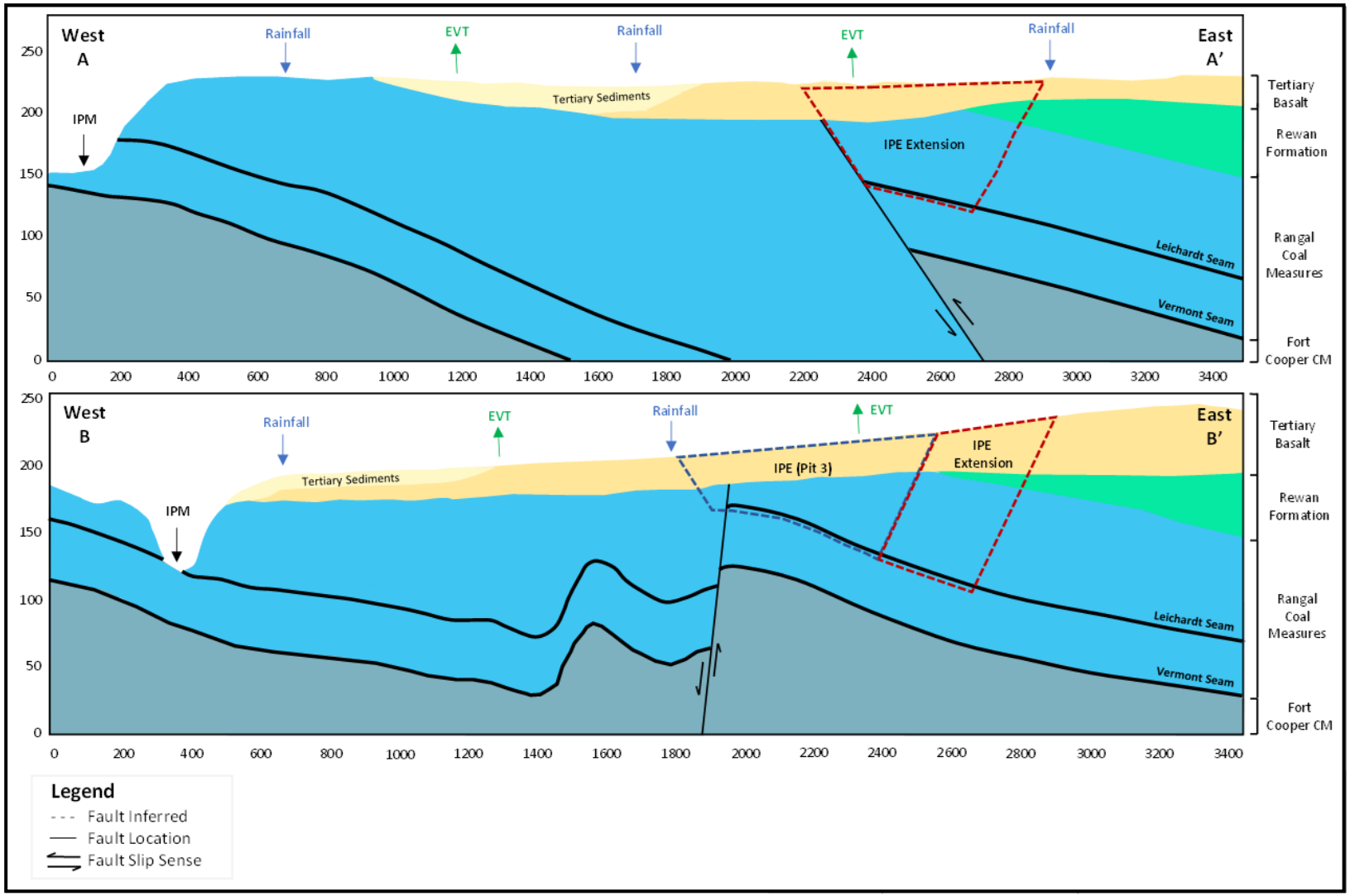

Figure 4.5 Conceptual Geological Cross-Section (KCB 2020)

5 HYDROGEOLOGICAL SETTING

The relevant hydrogeological units of the Project mining area and its surrounds broadly comprise:

1. Localised thin deposits of alluvium within and immediately adjacent to the watercourse of Billy's Gully;
2. A shallow, highly weathered veneer of low permeability Tertiary sediments;
3. Tertiary basalt comprising highly weathered, low permeability basaltic clay and a relatively permeably basalt aquifer;
4. Low permeability Rewan Group sediments; and
5. Permian sediments comprising low permeability sediments and relatively permeable coal seams.

The main groundwater-bearing formations are the fresh Tertiary basalt and the coal seams of the Permian sediments. These formations have been significantly depressurised and impacted by mining and gas production activities at nearby operations. The Rewan Group is a low permeability formation that is a regionally recognised aquitard. The Tertiary sediments do not form a permanent, saturated aquifer, and persistent groundwater occurs only where these sediments extend below the regional water table. The alluvium associated with Billy's Gully is an ephemeral perched aquifer located above the regional groundwater system that develops following rainfall and associated runoff events.

Recharge predominantly occurs via direct and diffuse rainfall to the weathered surface sediments (i.e. Tertiary sediments and basalt) and outcropping weathered Permian and Rewan Group sediments. A portion of the rainfall moves downwards to the groundwater table then moves through the system following the hydraulic gradient. Recharge to the Permian sediments and Rewan Group will occur where these units subcrop below the Tertiary sediments and basalt.

The regional groundwater flow is generally from elevated areas in the northeast to lower lying areas in the southwest (i.e. the Isaac River). However, groundwater flow has been significantly altered by mining operations in the vicinity of the Project mining area. A zone of depressurisation exists above and around the surrounding mines and gas production wells. This zone locally influences groundwater flow directions and results in groundwater flowing towards these mines and gas production activities.

Groundwater flow in the Billy's Gully alluvium occurs during and immediately following rainfall/runoff events, with the flow direction parallel with the water course. The duration of flow within this alluvium is anticipated to be minimal as the relatively high hydraulic conductivity of this unit results in the quick drain-down of the saturated profile following a recharge event.

The Tertiary sediments and upper weathered profile of the Tertiary basalt, Rewan Group and Permian sediments are predominantly unsaturated in the vicinity of the Project mining area, therefore, interpolated groundwater surfaces for these units are unable to be produced.

The ephemeral nature of groundwater in the alluvium associated with Billy's Gully also highlights the predominantly unsaturated characteristics of this unit.

Figure 4.5 shows a conceptual cross-section of the geology and groundwater regime within the Project mining area and its surrounds.

Regional groundwater quality within the Project mining area and its surrounds ranges from moderately saline to brine. Local groundwater is therefore generally unsuitable for potable, irrigation or stock watering uses. There are no current groundwater users in the Project mining area or its surrounds.

5.1 Quaternary Alluvium

Quaternary alluvium occurs within, and adjacent to, the water course of Billy's Gully. Field investigations completed in 2020 (3D Environmental 2020) identified the alluvium to be up to ~150 m wide across the water course with a maximum thickness of ~2 m. The alluvium comprises coarse sands with minor clays and intermittent lenses of gravel. The lithology underlying the alluvium comprises highly plastic clay with mottled clay features and weather sandstone. Both of these lithologies are representative of weathered residual bedrock of the Tertiary sediments and/or the Rewan Group. A conceptual model of the Billy's Gully alluvium system is provided in the GDE Assessment report (3D Environmental 2020).

Field investigation completed in March 2020 (3D Environmental) identified a shallow saturated zone at the base of the alluvium, above the residual bedrock, of approximately 0.2 m (i.e. water level at ~1.8 mbGL). This zone of saturation is interpreted to be perched on the low permeability residual bedrock and has resulted from recent rainfall and runoff recharge to the alluvium. Considering the field investigation along Billy's Gully was completed late in the wet season, the relatively shallow height of the saturated zone in the alluvium indicates that groundwater in the alluvium has a short residence time and drains away down-gradient (towards the Isaac River) relatively quickly following recharge events.

In comparison to the water levels recorded from other hydrostratigraphic units within the vicinity of the Billy's Gully alluvium, the water level in the alluvium (230.3 mAHD) is ~8 m higher than the water level in the underlying Tertiary sediments (MB4b) (see Appendix III); indicating that the alluvium is not in hydraulic connection with the Tertiary sediments. As a result of the difference in water levels between the alluvium and the Tertiary sediments, the alluvium in Billy's Gully is identified as a perched ephemeral aquifer that is not in connection with the regional groundwater system.

The relatively thin deposits of alluvium in Billy's Gully and the ephemeral nature of groundwater within the alluvium indicates that this unit is relatively insignificant. Furthermore, considering the groundwater in the alluvium is not in hydraulic connection with the regional groundwater system, this unit has not been simulated in the numerical groundwater model.

A site investigation at Smoky Creek, conducted in July 2018 by KCB, identified no alluvium beyond the extents of the creek channel. Weathered bedrock (sandstone) outcrops occur along the creek banks with minor soil cover. Alluvium (coarse sand/ gravel and silt) is limited to the creek channel beds with varying thickness between 0.1 and 3 m (KCB 2020).

5.2 Tertiary Sediments

5.2.1 Groundwater Distribution

The Tertiary sediments comprise a heterogeneous profile of semi-consolidated sandstone, mudstone and other minor sediments. The Tertiary sediments are widely distributed over the Project mining area and its surrounds (Figure 4.3) where they form undulating sandy plains. The Tertiary sediments have been extensively weathered resulting in the formation of a heterogeneous layer of residual soils and weathered clays.

The Tertiary sediments are up to 10 m thick within the Project mining area and its surrounds. The limited thickness and low primary porosity of these sediments results in limited capacity for groundwater storage and movement.

The Tertiary sediments are typically located above the regional groundwater table and are therefore generally dry and unsaturated in the vicinity of the Project mining area. Where saturated, the groundwater within the Tertiary sediments is in direct hydraulic connection with the underlying Triassic Rewan Group or Permian sediments. The Tertiary sediments are not a significant aquifer.

5.2.2 Hydraulic Parameters

Hydraulic testing data indicates the Tertiary sediments have a low to moderately low hydraulic conductivity, ranging from approximately 7.0×10^{-4} to 0.04 m/d. The hydraulic conductivity of this unit is within the range exhibited by the Triassic Rewan Group and Permian sediments. This supports the assessment that these sediments are not a significant aquifer.

5.2.3 Potentiometric Surface, Recharge, Flow and Discharge

The Tertiary sediments are recharged by direct infiltration from rainfall where these sediments are present at the surface. The Tertiary sediments are also recharged by the underlying groundwater regime where they are hydraulically connected.

Discharge predominantly occurs as seepage to the underlying Permo-Triassic groundwater regime.

Due to the depth of groundwater in the Tertiary sediments, there is no significant interaction with surface waters within the vicinity of the Project area.

5.2.4 Groundwater Quality

Groundwater quality in the Tertiary sediments at the IPC (MB4a and MB4b) has the total dissolved solids (TDS) concentration representative of highly saline water (e.g. mean TDS of 40,774 mg/L in MB4a and 19,477 mg/L in MB4b). The elevated salinity reflects the degree of connectivity with the underlying low permeability Permian sediments and the long groundwater residency times of groundwater in this formation.

5.2.5 Yield and Use

Groundwater yields are expected to be low (less than 1 L/s). No groundwater supply bores are located in the Tertiary sediments within 5 km of the Project area due to the general lack of saturation or reliable water supply in these sediments.

5.3 Tertiary Basalt

5.3.1 Distribution

The Tertiary basalt underlies the Tertiary sediments and overlies weathered Permo-Triassic strata at the Project mining area and typically occurs as a single composite unit comprising massive and vesicular lava, tuff and ash flows.

Regionally, the Tertiary basalt occurs within paleo-channels incised into the underlying Permo-Triassic bedrock. Paleo-channels with associated basalt flows are located to the north, east and south of the Project mining area. The basalt extends into the northern parts of the Project mining area from the main paleo-channel to the east. The local distribution of the Tertiary basalt is shown in Figure 4.3. Basalt within the Project mining area is typically dry or has a limited saturated profile of less than 5 m. The saturated profile thickens to the east of the Project mining area (i.e. towards the regional paleo-channel).

5.3.2 Hydraulic Parameters

The basalt exhibits highly variable hydraulic properties due to its complex lithology. Groundwater storage and flow is dominated by localised vesicular and fractured zones.

Fractured and vesicular basalt zones are compartmentalised by zones of massive basalt that is not significantly fractured or vesicular. In addition, the shallow highly weathered basalt also forms a very low hydraulic conductivity clay. Therefore, massive basalt and shallow highly weathered basalt do not generally contain significant groundwater and can act as barriers to flow.

The hydraulic conductivity of the Tertiary basalt in the Project mining area and its surrounds ranges from 4.0×10^{-3} to 6.5 m/d, reflecting the variability in the basalt characteristics. Higher hydraulic conductivity values are generally associated with the fractured / vesicular basalt within the centre of the basalt paleo-channel approximately 5 km east of the Project mining area. Lower hydraulic conductivity values are typically associated with massive basalt along the lateral extents of the paleo-channel, and as minor limbs of the paleo-channel. The limbs of the paleo-channel within the Project mining area are characterised by low permeability massive basalt.

5.3.3 Potentiometric Surface, Recharge, Flow and Discharge

Recharge to the Tertiary basalt occurs via direct rainfall infiltration in areas where the Tertiary basalt outcrops and via seepage from the overlying Tertiary sediments where present.

Regional groundwater flow in the Tertiary basalt is typically parallel with the orientation of the paleo-channels. Within the Project mining area and its local surrounds, the paleo-channel and groundwater flow are towards the southeast (i.e. towards the centre of the paleo-channel). Flows are locally influenced by mining and water abstraction from the Broadlea water supply borefield to the northeast of IPC.

Discharge occurs as seepage to underlying Permo-Triassic geology and licensed dewatering from the Broadlea water supply borefield.

5.3.4 Groundwater Quality

Groundwater in the Tertiary basalt at the Project mining area and its surrounds is of variable quality. Groundwater is typically moderately saline with an average TDS of 1,519 mg/L (MB10).

The salinity of groundwater in the Tertiary basalt is due to solute dissolution into the groundwater as a result of weathering of the rock structure and lengthy residence times. Weathering profiles in the Tertiary basalt may contribute to the salinity at various depths within the basalt. This is further confirmed by stratification of groundwater quality within the Tertiary basalt, supporting the concept that groundwater in the basalt occurs within discrete zone of fractured / vesicular basalt.

5.3.5 Yield and Use

Groundwater yield from the Tertiary basalt in the Project mining area and its surrounds is very low (9.0×10^{-3} L/s). This is due to the basalt within the Project mining area being dominated by low permeability, low yielding massive basalt (i.e. competent rock with negligible structure or defects that containing groundwater).

The Broadlea water supply borefield targets vesicular/fractured basalts approximately 4 km northeast of the Project mining area. The impact of the Project on the Broadlea water supply borefield is addressed in Section 7.3.

5.4 Rewan Group

5.4.1 Distribution

The Rewan Group is a thinly interbedded sequence of siltstone, claystone and minor fine-grained sandstone. This unit subcrops and outcrops across the Project mining area where it overlies the Rangal Coal Measures (Figure 4.3 and Figure 4.5). The Rewan Group is faulted in the north of the Project mining area.

The Rewan Group is uniformly saturated at depth and may become unsaturated where it outcrops or subcrops above the regional groundwater table east of the Project mining area.

5.4.2 Hydraulic Parameters

The measured hydraulic conductivity of the Rewan Group ranges from 1.0×10^{-3} to 1 m/d.

The Rewan Group is recognised as a regional aquitard and acts as a confining unit overlying the Permian sediments. This unit is characterised by low primary porosity and as a result, groundwater movement is controlled by local fracture sets. Where fractures are intersected, this unit shows slightly higher permeability, and conversely, where limited fractures are intersected this unit shows lower permeability associated with the primary porosity. Bulk permeability of this unit is therefore constrained by the degree of connection between localised fractures. This means that at the regional scale the representative average hydraulic conductivity is expected to be towards the lower end of the values measured by field testing.

5.4.3 Potentiometric Surface, Recharge, Flow and Discharge

The Rewan Group is recharged via direct rainfall infiltration in outcropping areas and via seepage from overlying units (including the Tertiary sediments and Tertiary basalt).

Groundwater flow is towards the southwest and is a subdued reflection of the topography and surface water catchments. Discharge into the underlying Permian sediments is the main discharge mechanism. However, discharge volumes are very low due to the very low rates of groundwater recharge.

5.4.4 Groundwater Quality

Groundwater quality within the Rewan Group at the Project mining area and its surrounds is moderately saline (bordering on saline) with an average TDS ranging from 2,450 to 7,070 mg/L (Burton Coal Bore 2 and Swamp Bore 2, respectively). The salinity of groundwater from the Rewan Group reflects the low hydraulic conductivity of this unit, which results in solute contribution from the rock mass to the groundwater due to the longer residence time of groundwater.

5.4.5 Yield and Use

Groundwater yields from the Rewan Group are typically very low. Slightly higher yields can occur where localised fractures are intersected by drilling. Water supply bores tend to have targeted these localised fractures.

A bore census conducted in 2018 confirmed the presence of a single active water supply bore (Swamp Bore 1) screened in the Rewan Group within 5 km of the Project mining area (KCB 2016). The highest recorded yield from this bore is approximately 1.13 L/s (i.e. low yield). The pump in this bore has been removed and the bore is no longer in use.

5.5 Permian Sediments

5.5.1 Distribution

The Permian sediments include the Rangal Coal Measures, the Fort Cooper Coal Measures (FCCM) and the Moranbah Coal Measures (Figure 4.4 and Figure 4.5). They comprise alternating layers of fine to medium grained sandstone, siltstone and coal, including the target Leichardt Seam. The upper profile of the sub-cropping coal measures has been extensively weathered forming a clay cap.

Individual coal seams form the principal water-bearing strata within the coal measures and are therefore typically saturated throughout their full thickness but may become unsaturated where they outcrop or subcrop above the regional groundwater table. Groundwater storage and movement occurs within the coal seam cleats and fissures and within open fractures that intersect the seams.

The overburden and interburden sediments of the coal measures (above and between the coal seams) comprise hydraulically “tight” and hence very low yielding sediments. These sediments form thick confining aquitards within the coal measures.

The Permian coal measures at the Project mining area are fault bound by the Isaac Thrust Fault and the associated fault splay. Faulted strata can exhibit a range of hydraulic characteristics, and

in extreme circumstances can act as either a barrier or a conduit to groundwater flow. In this setting, the faults are likely to restrict groundwater flow in the horizontal direction, compared to un-faulted areas for the following reasons:

- Fractures associated with the faults in the vicinity of the Project are typically sealed by mineralisation and precipitation.
- The high clay content of the Permian coal measures means that there is a significant likelihood of clay smearing across the fault plane that is likely to reduce the fault permeability by several orders of magnitude compared to the un-faulted areas.
- The coal seams are thin (up to 4.4 m) and represent an extremely small proportion of the overall thickness of the Permo-Triassic sediments (i.e. less than 1 %). There is therefore a greater than 99 % probability that fault displacement has resulted in a coal seam being juxtaposed with less permeable Permian interburden or Rewan Group sediments on the other side of the fault.
- Previous mining experience in the Bowen Basin indicates that coal seams are typically highly compartmentalised by faulting.

The low permeability of the fault zones is therefore likely to restrict groundwater flow, compared to un-faulted areas (OGIA 2016).

The Rangal Coal Measures is underlain by the FCCM. The FCCM is a sequence of sandstone, carbonaceous mudstone, coal and tuffaceous material and is recognised as a regional aquitard.

The FCCM separates the Rangal Coal Measures from the MCM. The FCCM therefore acts to limit the hydraulic interaction between the overlying Rangal Coal Measures and the underlying MCM (and associated coal seams).

5.5.2 Hydrogeological Parameters

Hydraulic conductivity within the Permian sediments is typically associated with secondary porosity through fractures and cleats within the coal seams. The spacing and nature of cleating are the primary controls on hydraulic conductivity within the coal seams. The thick sequences of siltstone and sandstone interburden form confining aquitards within the coal measures.

The hydraulic conductivity of the Leichardt Seam ranges from 0.07 to 2.3 m/d, while the other seams in the Permian sediments range from 1.0×10^{-5} to 2 m/d.

The hydraulic conductivity of the Permian sediments overburden/interburden range from 2.0×10^{-5} to 2 m/d. The hydraulic conductivity range in the interburden reflects the high degree of variability in the interburden strata, and includes measurements collected from very tight mudstones and extensively fractured horizons.

Hydraulic conductivity of the Permian sediments also reduces with increasing depth, as a result of increasing lithostatic pressure causing compression of the strata. Regionally, the measured ranges of hydraulic conductivity therefore reflect the depth at which measurements were collected. The regional and local dataset contains a high proportion of relatively shallow measurements due to the practical limitations of collecting deeper measurements.

5.5.3 Recharge, Flow and Discharge

Recharge occurs via rainfall infiltration on localised outcrops of Permian sediments within and to the west of the Project mining area, and slow downward seepage from overlying strata. As a result, the groundwater recharge to the Permian sediments is typically very low. Locally, seepage is enhanced by the storage of water within open cut pit voids west of the Project mining area. The rate of recharge may also be enhanced where the Permian sediments subcrop against the overlying strata, although the clayey nature of this weathered material will also limit recharge. Overall, the rate of recharge remains very low.

Conceptually, the undisturbed groundwater flow direction in the Permian sediments is towards the southwest.

However, coal mining at surrounding mining operations and CSG production at the Moranbah Gas Project have reduced groundwater pressures in the surrounding coal measures, creating a zone of depressurisation that gradually diminishes with distance from these operations. The Project mining area lies within the zone of depressurisation associated with the existing and approved Isaac Plains Complex mining activities. Depressurisation of the coal measures has reduced the potentiometric groundwater surface creating a hydraulic gradient towards the open cut pits. Groundwater movement in the vicinity of the Project mining area is therefore a reflection of the depressurisation within the coal measures (i.e. towards these pits).

Groundwater discharge within the vicinity of the Project mining area is therefore dominated by groundwater drainage associated with the IPC open cut mine pits. Groundwater discharge into overlying formations is negligible in the vicinity of the Project mining area.

5.5.4 Groundwater Quality

Groundwater within the Permian sediments at the Project area and its surrounds is moderately saline to (more typically) highly saline, with an average TDS ranging from 1,740 (MB1) to 18,300 mg/L (MB7), reflecting the long groundwater residency times and low permeability of this formation.

5.5.5 Groundwater Yields and Use

Groundwater yields from the Permian sediments are typically low, with a median yield of less than 0.5 L/s.

At the Project mining area, yields from the target Leichardt Seam and fractured overburden are very low (< 0.5 L/s).

There are no water supply bores targeting the Permian coal measures within 5 km of the Project mining area due to the typically low yields and therefore lack of reliable water supply in these sediments.

5.6 Groundwater Levels and Flow

5.6.1 Isaac Plains Complex Groundwater Monitoring Network

The groundwater monitoring network at IPC includes 23 monitoring bores, which are screened in the alluvium, Tertiary sediments, Tertiary Basalt, Rewan Group and Rangal Coal Measures hydrostratigraphic units at varying depths. The network is used to monitor groundwater levels and quality from a range of site activities, including historical and current mining operations, water storages and waste facilities. Figure 5.1 shows the location of the IPC groundwater monitoring network. As a result of progression of mining operations, some bores are being decommissioned while new replacements bores have been drilled/commissioned. Details of the monitoring bores are provided in Appendix I.

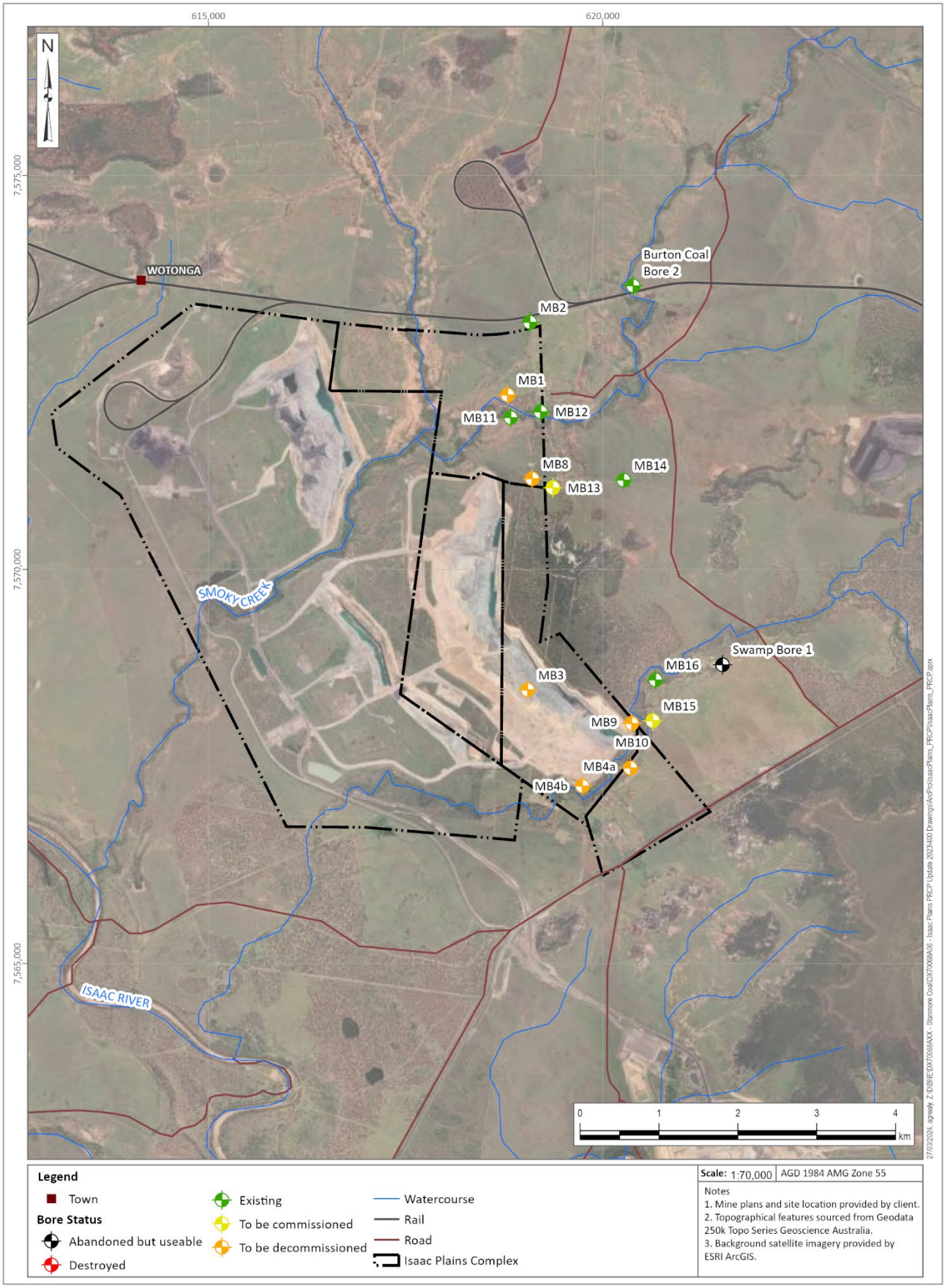

Figure 5.1 Current Groundwater Monitoring Network (as per EA (Table 11))

5.6.2 Groundwater Flow

Groundwater flow is towards the southwest and is a subdued reflection of the topography and surface water catchments.

Groundwater flows in the Tertiary sediments are towards the south-west and are locally influenced by groundwater abstraction from the Tertiary basalt at the Broadlea water supply borefield and by dewatering for the mining operations.

Due to the depth of groundwater in the Tertiary sediments, there is no significant interaction with surface waters within the vicinity of the Project area.

Regional groundwater flow in the Tertiary basalt is typically parallel with the orientation of the paleo-channels. Within the Project area and its local surrounds, the paleo-channel and groundwater flow are towards the south-east (i.e. towards the centre of the paleo-channel). Flows are locally influenced by mining and water abstraction from the Broadlea water supply borefield.

Conceptually, the undisturbed groundwater flow direction in the Permian sediments is towards the southwest. However, coal mining at surrounding mining operations and CSG production associated with the Moranbah Gas Project have reduced groundwater pressures in the surrounding coal measures, creating a zone of depressurisation that gradually diminishes with distance from this operation. Depressurisation of the coal measures associated with mining activities has reduced the potentiometric groundwater surface creating a hydraulic gradient towards the open cut pits.

5.6.3 Groundwater Levels

Groundwater elevation hydrographs for the various hydrostratigraphic units are presented in Figure 5.2 to Figure 5.6. Groundwater elevations in the alluvium bore (MB4b) decreased slightly from 2018 to 2021 (~2 m). In 2023 it increases by 12 m to 234 mAHD.

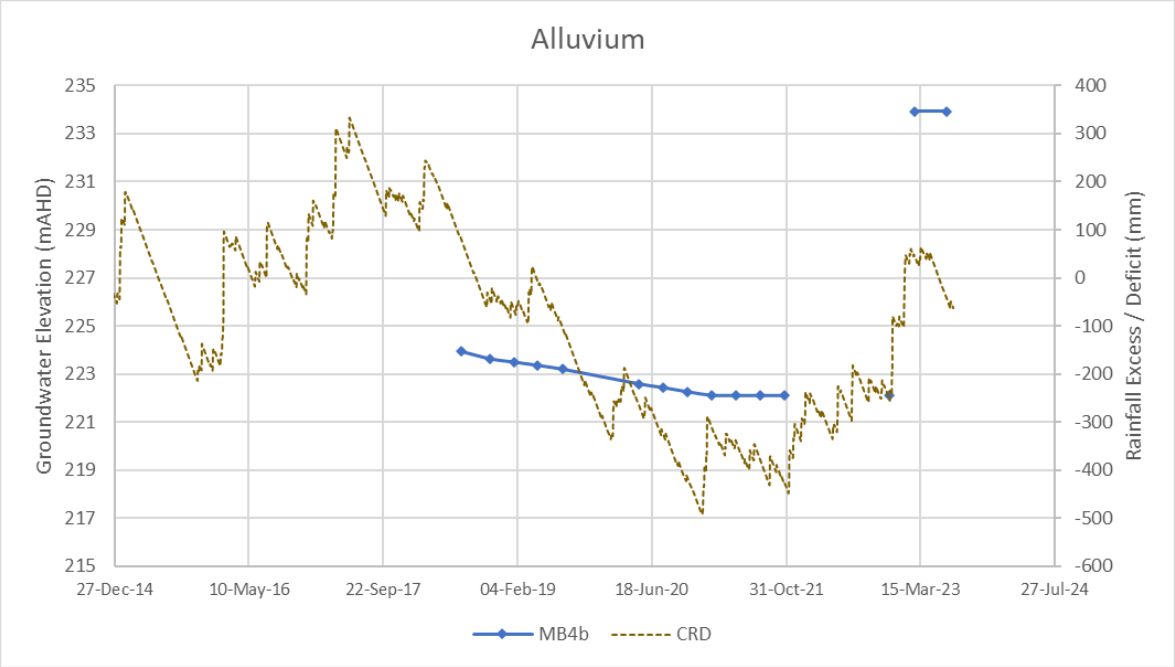

Figure 5.2 Groundwater Elevation Hydrograph, Alluvium

Bore MB4a – screened in the Tertiary sediments – remained relatively stable at approximately 226 mAHD from early 2016 to September 2017 (Figure 5.3), and then shows an increase of ~2 m in October 2017 whereafter the water level decreases gradually to 226.5 mAHD in April 2023.

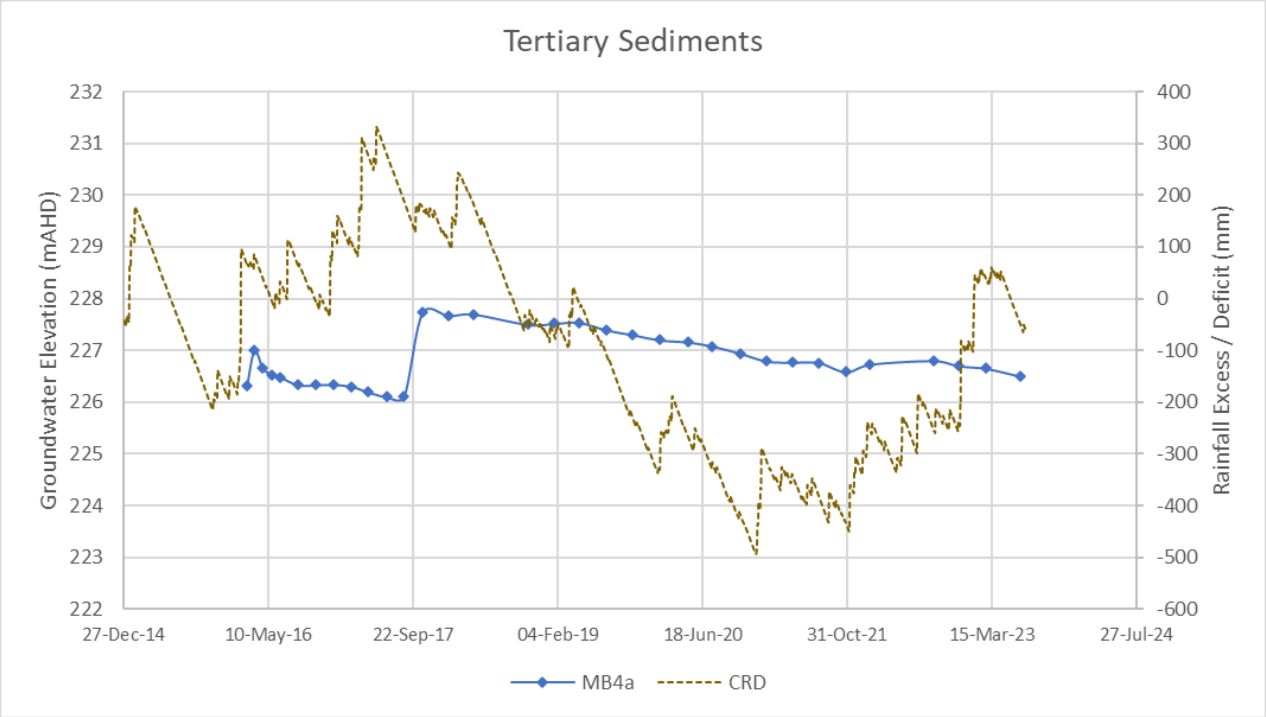

Figure 5.3 Groundwater Elevation Hydrograph, Tertiary Sediments

Bores in the Tertiary basalt show somewhat different trends (Figure 5.4). Groundwater levels recorded in MB16b remained relatively constant, while the levels in MB14 and MB10 has declined. MB10 experienced a decrease of ~3 m from the end 2017 to February 2022. This could be the result of the rainfall trend. Decreasing water levels correspond with the decrease in the rainfall excess/deficit trend and show some increase again once the rainfall trend changed.

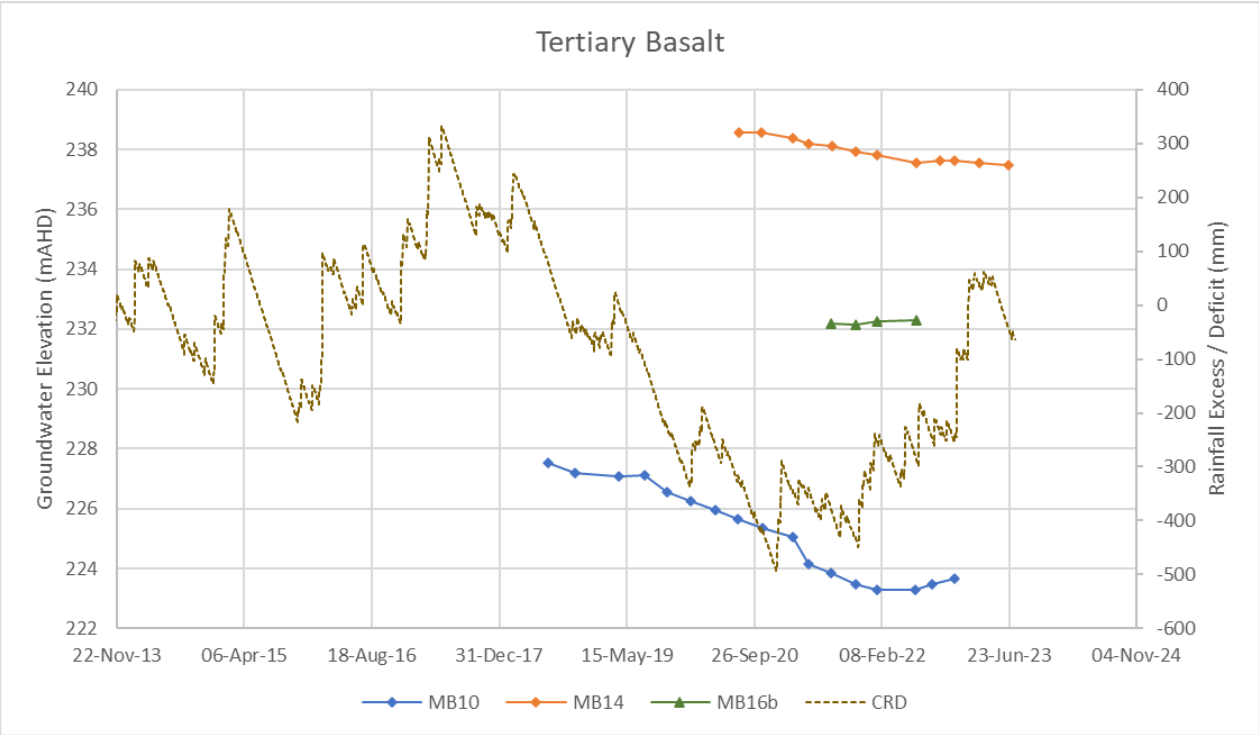

Figure 5.4 Groundwater Elevation Hydrograph, Tertiary Basalt

Groundwater elevations from bores screened in the Rewan Group does not show a correlation with the CRD trend (Figure 5.5). The decreasing trend of BC2 and SB1 is likely due to dewatering in the IPE pits. Groundwater elevations in the Rewan Group range between 229.5 mAHD and 235.5 mAHD.

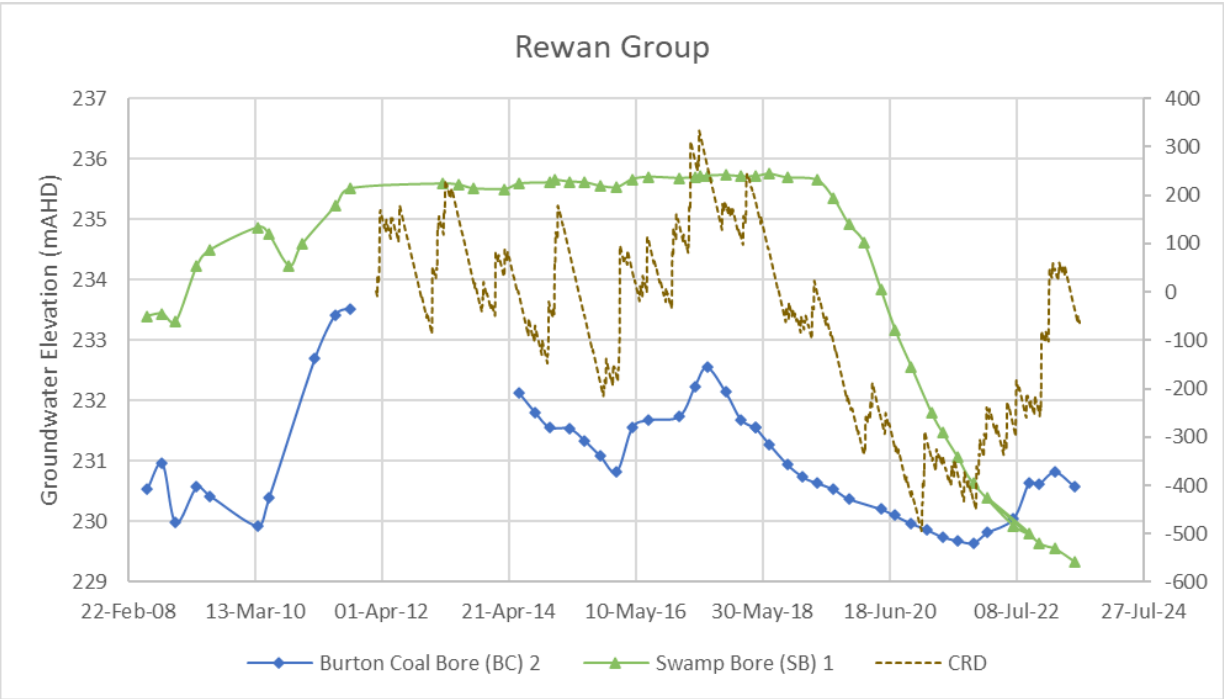

Figure 5.5 Groundwater Elevation Hydrograph, Rewan Group

Groundwater elevation in all bores screened in the Rangal Coal Measures (Figure 5.6), except for MB9A, remained constant with ranges between 157 mAHD and 224 mAHD. MB9(A) reported a decrease of ~40 m between mid-2019 to late 2023. This could be due to dewatering operations in the IPE pits.

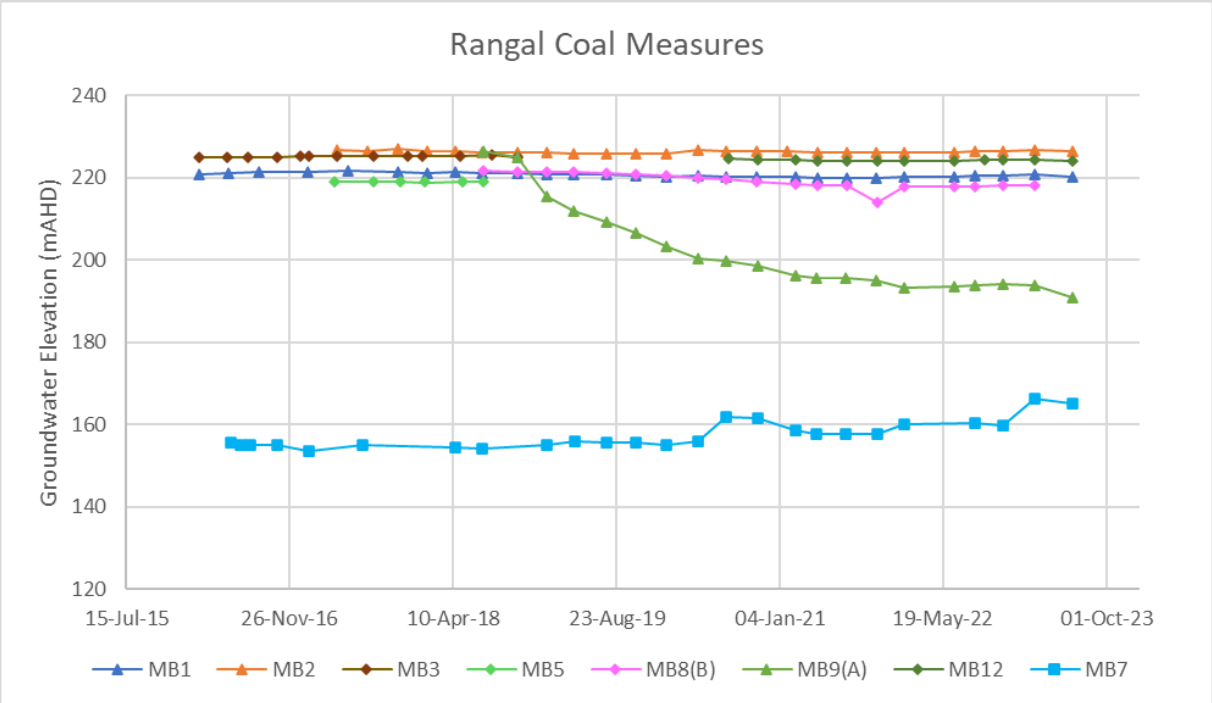

Figure 5.6 Groundwater Elevation Hydrograph, Rangal Coal Measures

5.7 Groundwater Quality

Timeseries graphs have been prepared for key indicator parameters, including pH, EC and sulfate, to support discussion/interpretation of the groundwater quality at the IPC (Appendix II).

Where suitable data exists, graphical depiction of the different water types and their influence is provided by using a suite of hydrochemical diagrams. Trilinear diagrams are commonly used for water classification and have been used to further understand the variation in groundwater quality. For this study, a Piper diagram has been adopted to present the water classifications and variability. For these types of diagrams, ionic speciation is converted from the analytical concentration to an equivalent molecular percentage (milli-equivalents, or meq/L).

Groundwater quality within the Project area, and its surrounds, ranges from saline to brine. Local groundwater is therefore generally unsuitable for potable, irrigation or stock watering uses.

Water Quality Characteristics

Piper plots provide an understanding of the hydrochemical composition of the groundwater as shown in Figure 5.7. The Piper plot for the IPC groundwater monitoring records indicates that the groundwater is generally dominated by sodium and potassium, with variable proportions of chloride and sulfate, indicating some variability.

As illustrated in Figure 5.7, groundwater for the coal seams have relatively more calcium or magnesium signature than the Quaternary alluvium. There is a sulfate dominated signature within the alluvium for the northwestern area.

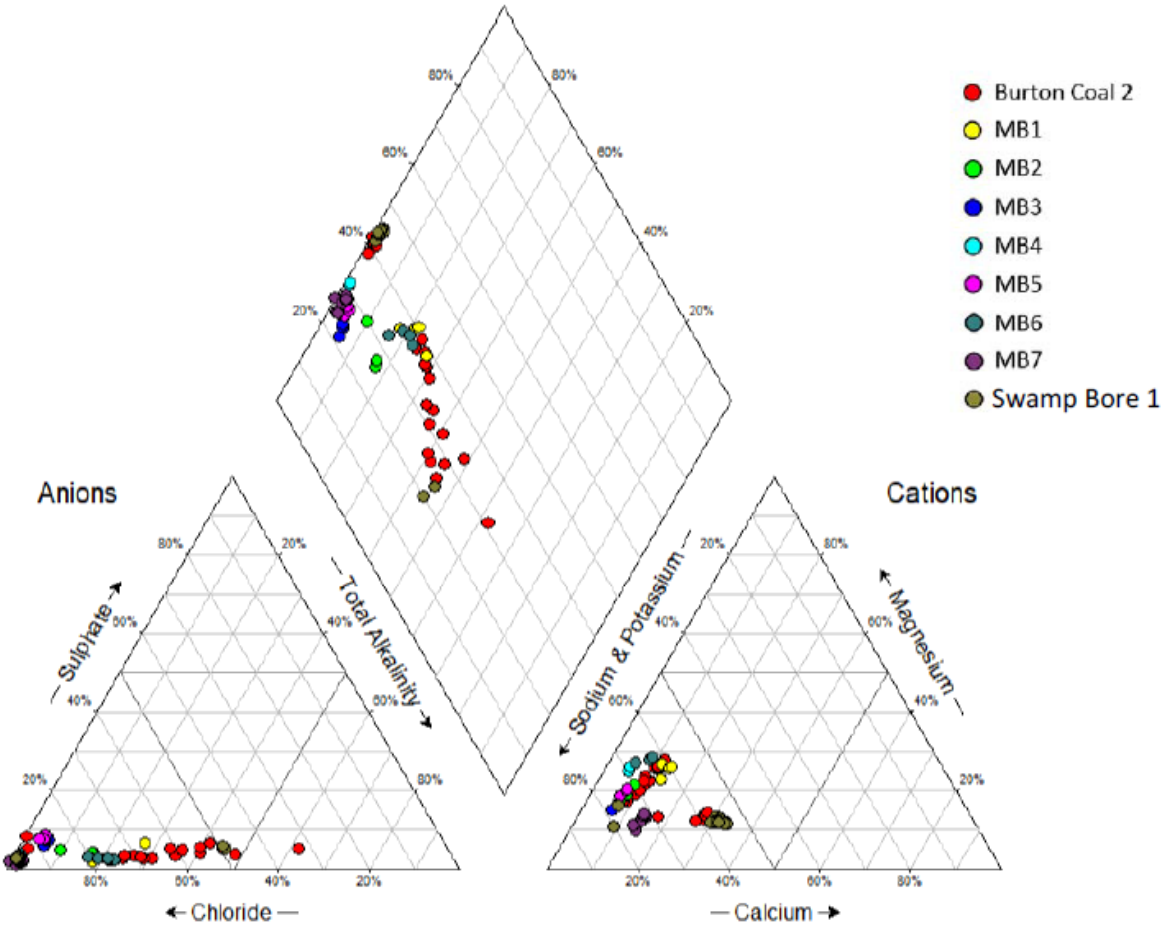

Figure 5.7 Piper Diagram of IPC Groundwater Quality

Key Water Quality Parameters

Figure 5.8 presents the timeseries of pH for groundwater sampled from monitoring bores across the IPC. Generally, neutral to alkaline groundwater conditions exist. Bores BC2 and BC095 recorded a once-off low pH level event at the end of 2016. This did not necessitate an investigation, and the pH levels have returned to neutral to alkaline conditions thereafter.

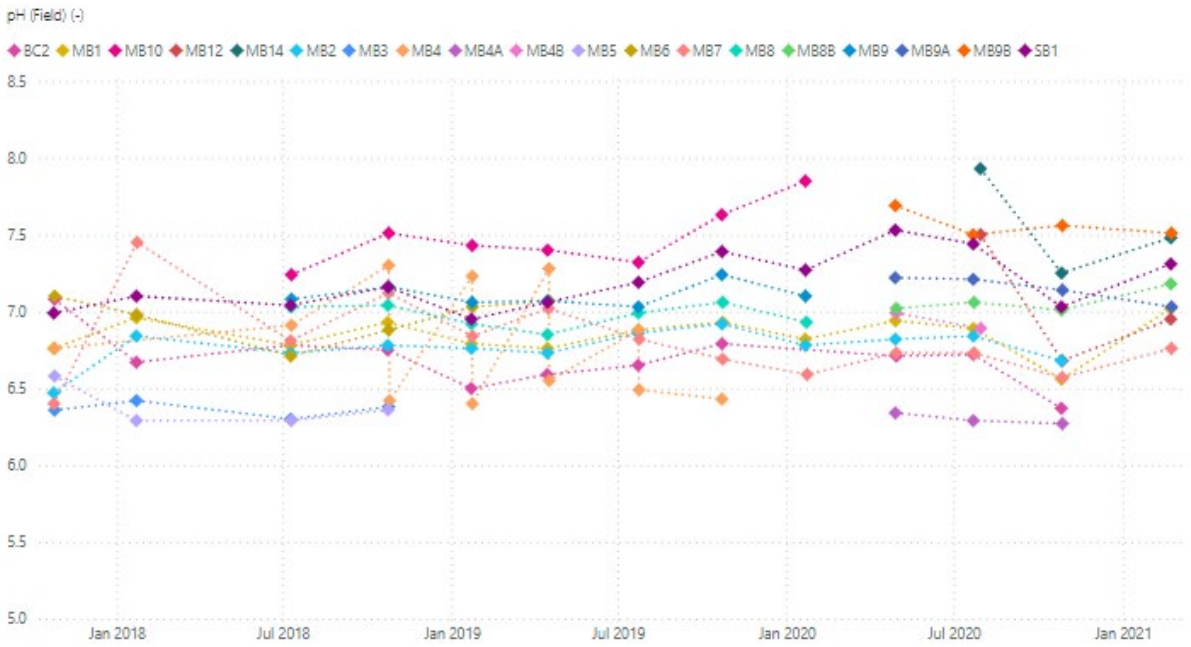

Figure 5.8 Field pH Levels

Figure 5.9 presents the EC measured at monitoring bores across the IPC between 2015 and 2023. Values range between ~1,700 to 52,000 µS/cm. Several bores have shown increasing trends historically, with stabilisation in recent years.

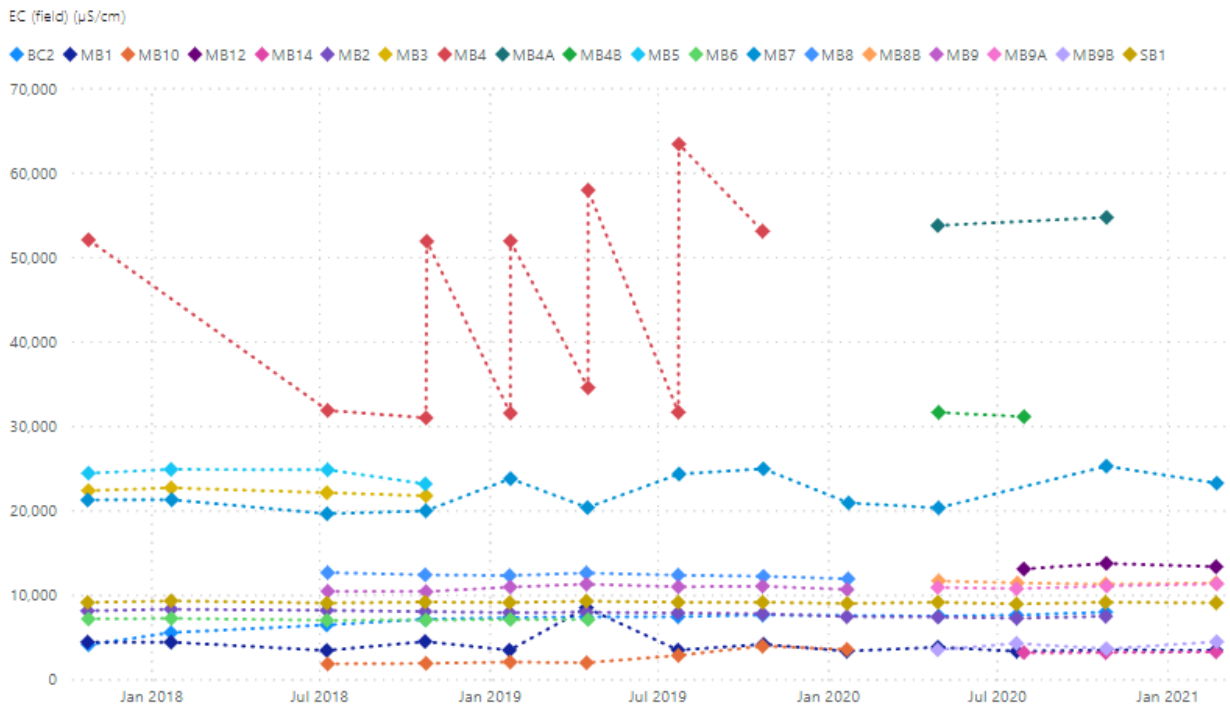

Figure 5.9 Field EC Concentrations

A timeseries graph of sulfate concentrations is presented Figure 5.10. Sulfate concentrations across the IPC are generally variable, from <10 mg/L to ~1,200 mg/L. The majority of bores show stable sulfate concentrations.

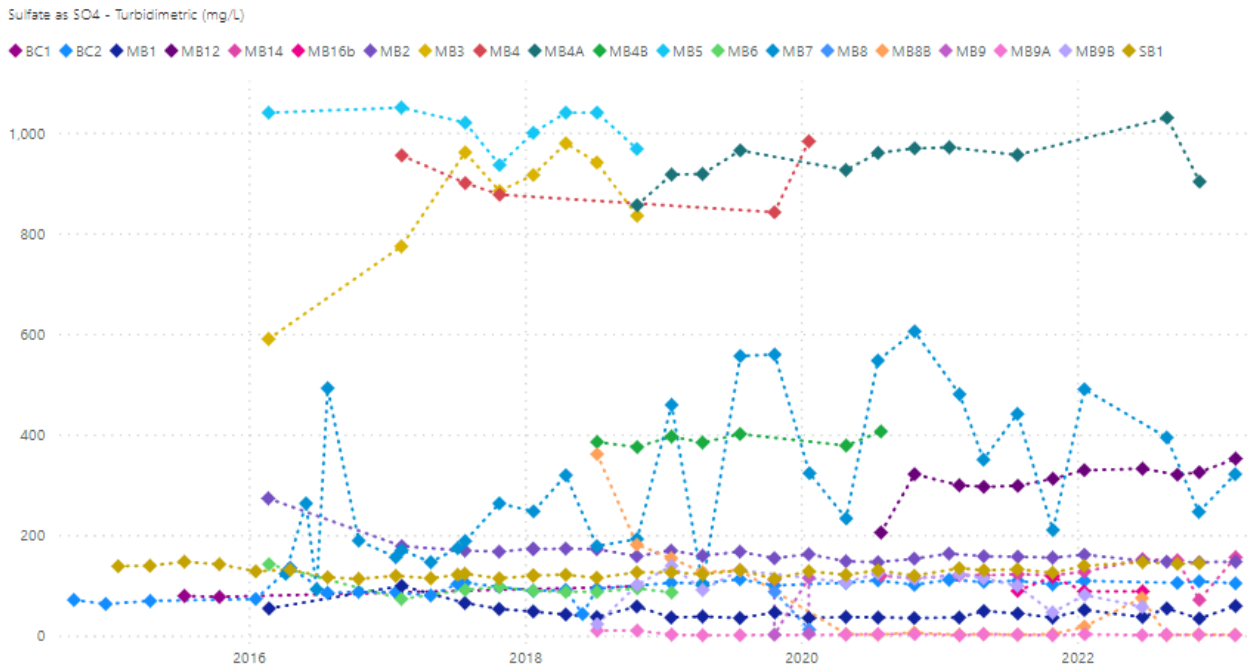

Figure 5.10 Sulfate Concentrations

5.8 Groundwater Receptors

5.8.1 Third-Party Groundwater Users

According to the Queensland groundwater database (GWDB), the closest water supply bore to the Project is bore RN81909 (also known as Smoky Creek bore), approximately 0.8 km to the northeast (Figure 5.11). However, this bore has been abandoned by the landholder (KCB 2016) and is not in use.

No groundwater supply bores are located in the Tertiary sediments with groundwater yields expected to be low (less than 1 L/s), likely due to the general lack of saturation or reliable water supply in these sediments.

The Broadlea water supply borefield is located to the northeast of the Project mining area and targets the Tertiary basalt aquifer.

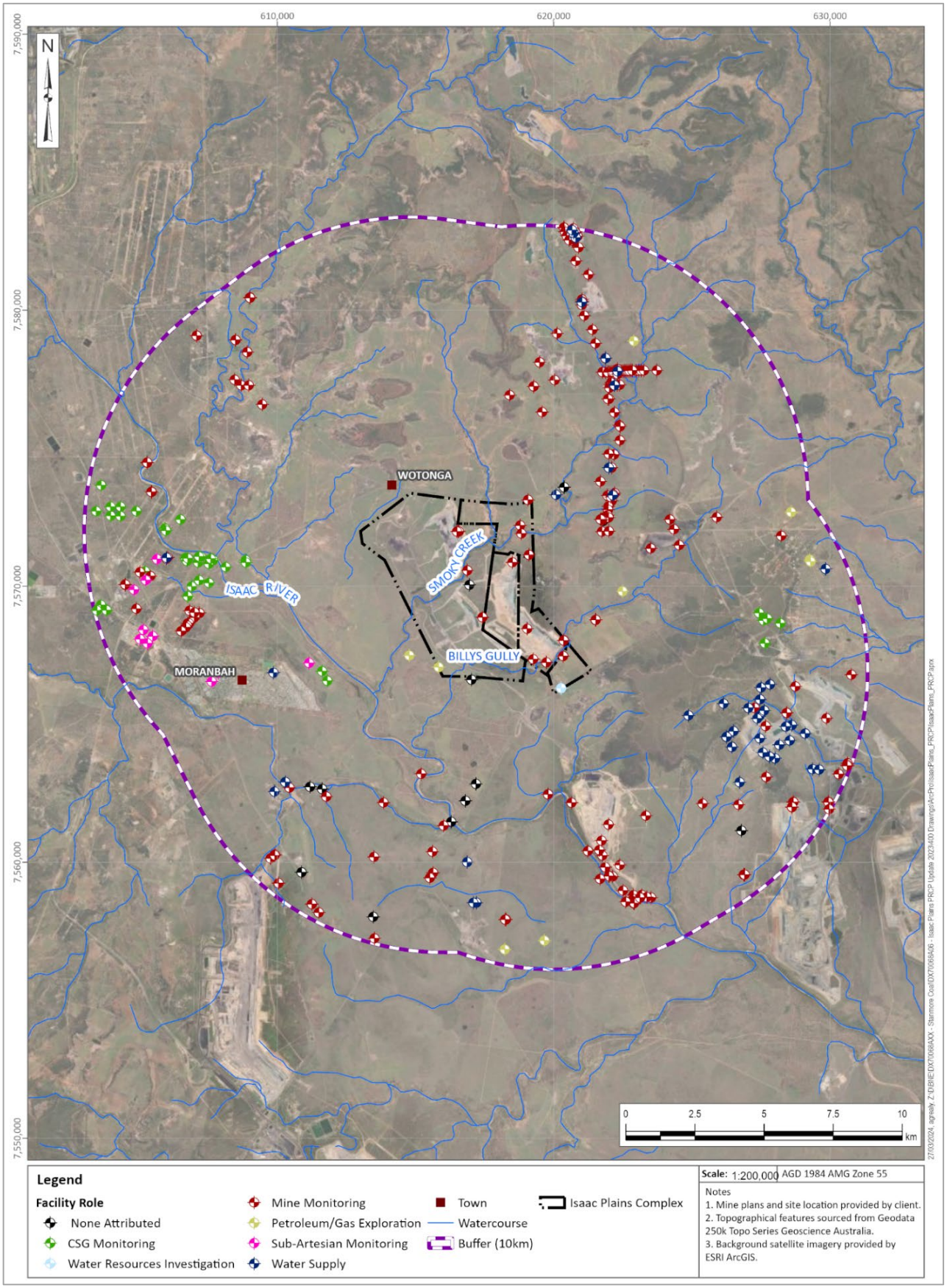

Figure 5.11 Location of GWDB Registered Bores by Facility Role

5.8.2 Groundwater and Surface Water Interaction

Smoky Creek and Billy's Gully traverses the Project area in the north and south respectively (Figure 4.2). These creeks are ephemeral and are characterised by short duration, surface water flows that are typically restricted to periods during and immediately after rainfall events. This is consistent with observations made during field investigations in 2018 (KCB, 2018). Additional drilling was conducted in 2021 (KCB) targeting the alluvium at a section of Billy's Gully, and no groundwater was encountered. This is also supported by the surface water assessment completed by WRM (2020), which indicates no perennial flows in the vicinity of the Project mining area.

The groundwater table is currently located approximately 10 m to 15 m below the bed of Smoky Creek to the north of the Project mining area, and approximately 10 m below the bed of Billy's Gully to the south. Further to the east along Smoky Creek, groundwater rises to approximately 5 m below the bed of Smoky Creek. Further to the west down Smoky Creek, and adjacent to the existing IPM open cut pits, groundwater deepens to approximately 50 m below the bed of Smoky Creek and approximately 25 m below the bed of Billy's Gully. Existing open cut pits have therefore reduced the elevation of the groundwater table by approximately 35 m and 15 m in these areas, respectively. In addition, stable isotope analysis completed as part of GDE study across the Project area (3D Environmental 2020) identified "there is no linkage between groundwater and surface water in the stream channel and baseflow is not supported".

The separating depth between the bed of these creeks and the groundwater table means that there is no direct interconnection between the groundwater table and surface water flows in this area. Groundwater does not provide baseflow to surface waters in the vicinity of the Project mining area. There is therefore no expected surface expression of the regional groundwater table, and no direct groundwater-surface water connectivity observed in the vicinity of IPC.

5.8.3 Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystems (GDEs) are defined by DES (2015) as "Natural ecosystems which require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services (Richardson et al 2011)."

Information gathered during a bore census (KCB 2016) confirmed that there are no water supply bores in the Quaternary alluvium due to limited yields and/or high salinity. This provides additional evidence of the lack of suitability of groundwater use tor vegetation.

The potential for the presence of GDEs has been determined through:

- A desktop study of the Queensland Springs Database and the Bureau of Meteorology's (GDE) Atlas (BOM 2019); and
- A Project specific GDE assessment and groundwater field investigation conducted by 3D Environmental (2020).

The characterisation by the field investigation applied multiple lines of evidence, including leaf water potential, soil moisture potential, groundwater monitoring data and physical observation to draw preliminary conclusions regarding the presence of GDEs in the assessment area, particularly in relation to Smoky Creek and Billy's Gully.

The mapped potential Terrestrial Groundwater Dependent Ecosystems (TGDEs) are all 'derived' from aerial photography and through vegetation type and have not been verified in the field. The potential TGDEs are described by DESI as being associated with 'Quaternary alluvial aquifers with a fluctuating, intermittent groundwater connectivity regime' (DESI 2018).

The results of the 2020 investigation indicate that the potential for impact to the Billy's Gully GDE system due to mining void development associated with IPEE is 'low to insignificant' on all variables assessed.

The majority of the potential TGDEs are mapped as being 'low confidence' with some 'moderate confidence' GDEs (Figure 5.12). Some 'high confidence' TGDEs mapped coincides with the Isaac River, which is located west of the Project area. Billy's Gully and Smoky Creek both coincides with 'moderate potential' TGDEs.

The potential GDEs in Billy's Gully and Smoky Creek are not considered to be in connection with the regional groundwater system, the natural salinity of the alluvium and Tertiary sediments is unlikely to be able to support these systems. It is likely that these potential GDEs rely on soil moisture and surface water during times of flow.

Springs

There are no registered springs within the vicinity of the IPC (https://www.data.qld.gov.au/dataset/springs).

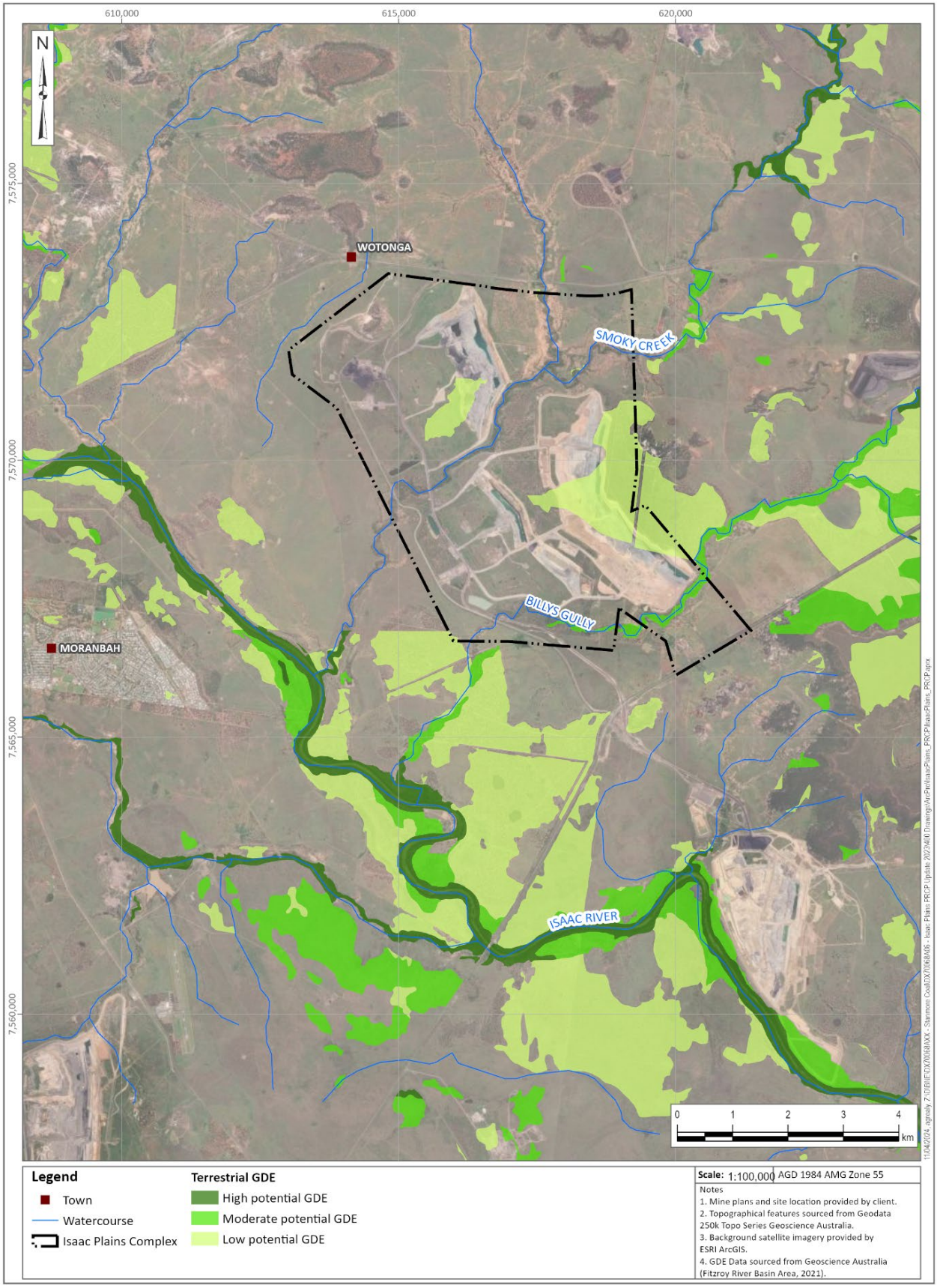

Figure 5.12 Location of Mapped potential Terrestrial GDEs in the Project Area (Adapted from 3D Environmental, 2020)

5.9 Hydrogeological Conceptual Model Summary

Based on a review of the available data, KCB has updated the understanding of the conceptual hydrogeological model for the site (Figure 4.5).

The relevant hydrogeological units of the IPC area and its surrounds broadly comprise:

- A shallow, highly weathered veneer of low permeability Tertiary sediments;
- Tertiary basalt comprising highly weathered, low permeability basaltic clay and a relatively permeably basalt aquifer;
- Low permeability Rewan Group sediments; and
- Permian sediments, comprising low permeability sediments and relatively permeable coal seams.

The main groundwater-bearing formations are the fresh Tertiary basalt and the coal seams of the Permian sediments. These formations have been significantly depressurised and impacted by mining and gas production activities at nearby operations. The Rewan Group is a low permeability formation that is a regionally recognised aquitard. The Tertiary sediments do not form a permanent, saturated aquifer, and persistent groundwater occurs only where these sediments extend below the regional water table.

The regional groundwater flow is generally from elevated areas in the northeast to lower lying areas in the southwest (i.e. the Isaac River). However, groundwater flow has been significantly altered by mining operations in the vicinity of the Project mining area. A zone of depressurisation exists above and around the surrounding mines and gas production wells. This zone locally influences groundwater flow directions and results in groundwater flowing towards these mines and gas production activities.

Groundwater quality within the Project mining area and its surrounds ranges from moderately saline to brine. Local groundwater is therefore generally unsuitable for potable, irrigation or stock watering uses.

6 NUMERICAL GROUNDWATER MODELLING OVERVIEW

6.1 Modelling Overview

A numerical groundwater model has been developed to support the Isaac Plains Complex (IPC) PRCP to predict changes in groundwater levels and flow during operations and into closure. The objectives of the model include:

- Estimating groundwater inflow / outflow in the final voids;
- Predicting the long-term steady-state water level in the final voids; and
- Predicting the extent and area of influence of groundwater level drawdown associated with the final voids.

The numerical model was originally developed as part of previous approval submissions for the Isaac Plains Underground and Isaac Plains East Expansion approvals between 2018 and 2020. The model has been recalibrated and remains fit for purpose for the use in the PRCP predictions.

The numerical groundwater model has been constructed and simulated with consideration of the Australian Groundwater Modelling Guidelines (Barnett et al. 2012a) and the requirements of the PRCP Guideline (DES 2023) and a Groundwater Modelling Report is presented in Appendix IV.

6.2 Model Construction

The 3D numerical groundwater flow model was developed using the MODFLOW-USG platform to represent the conceptual hydrogeological model described in Section 5.0.

The numerical model represents the key hydrostratigraphic units using 17 layers. The model grid was constructed from a base grid comprising 400 m x 400 m cells. Grid refinement has been undertaken over an area that encompasses the IPC and the neighbouring mine operations to the east, on the opposite side of the thrust fault, targeting the same coal seam. Across this area of model grid refinement, cell sizes are progressively reduced to 50 m x 50 m. The grid is further refined to 25 m grid cells over the area of the IPU.

The model was developed for the IPC mining sequence of open pits between January 2015 to January 2023, with future mining sequence, including the proposed IPU, and closure captured as part of the predictive scenarios.

6.3 Model Calibration

The Australian Groundwater Modelling Guidelines (Barnett et al. 2012b) were used to frame the calibration process. A detailed description of the model calibration is provided in Appendix IV.

Model calibration was performed by adjusting the model parameter values to improve simulation of historical observations of the system. The outcome of the calibration process also provides the initial conditions for transient predictive simulations used to estimate the magnitude and extent of drawdown associated with the equilibrated IPC post-closure conditions.

All observations that comprise the calibration dataset are water level measurements. These measurements were compiled from 18 monitoring bores for which reliable groundwater level

records were available over the transient simulation period. Monitoring data from 11 electronic dataloggers data were used for the 2018 model calibration, while data from 2019 to 2023 include manual monthly water level measurements.

6.4 Model Predictions

The calibrated groundwater model was used to predict groundwater inflows, changes in groundwater levels and the associated groundwater level drawdown extent in response to the remaining mining operations and post-closure. The upper surface of the model domain was updated to reflect the proposed post-closure landform, as shown in Figure 3.3. All active drains used to simulate underground and void dewatering were removed in the model following the cessation of mining operations to allow the system to recover and the simulation of post-closure groundwater conditions.

Recharge and evaporation were applied to the voids, so the results are considered conservative in nature. This simulation was conducted for a 1000-year duration to allow groundwater levels to recover to equilibrium / steady-state conditions. The simulated post-closure water levels are provided in Figure 6.1 for 50-, 100-, 500- and 1000-years post-closure. The post-closure groundwater elevations for 1,000 years post-closure is shown in Figure 6.2, and the figure also shows the groundwater flow directions. Predicted groundwater flow at 1,000 years post-closure remains towards the pits.

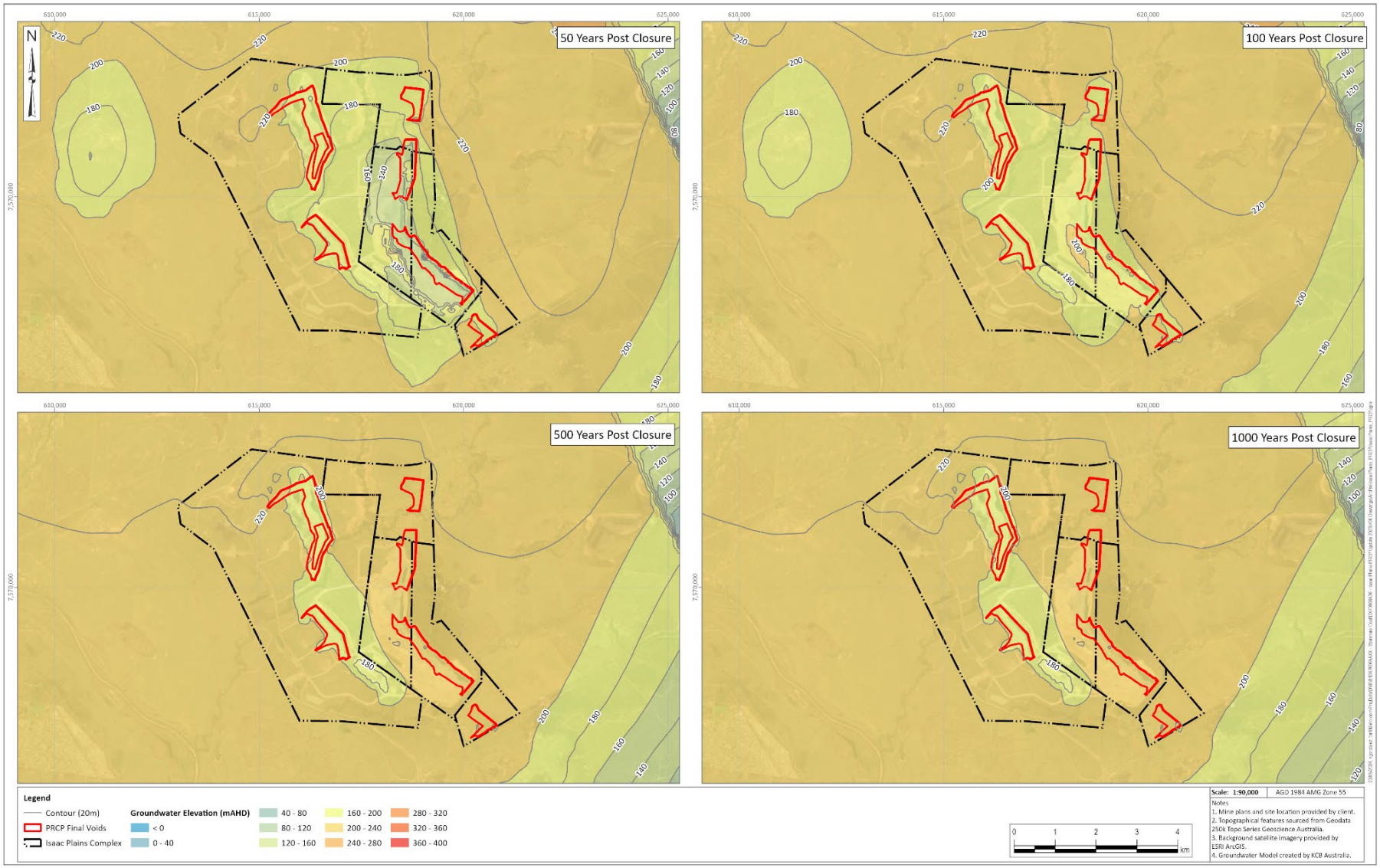

Figure 6.1 Water Table – 50, 100, 500 and 1000 Years Post-Closure

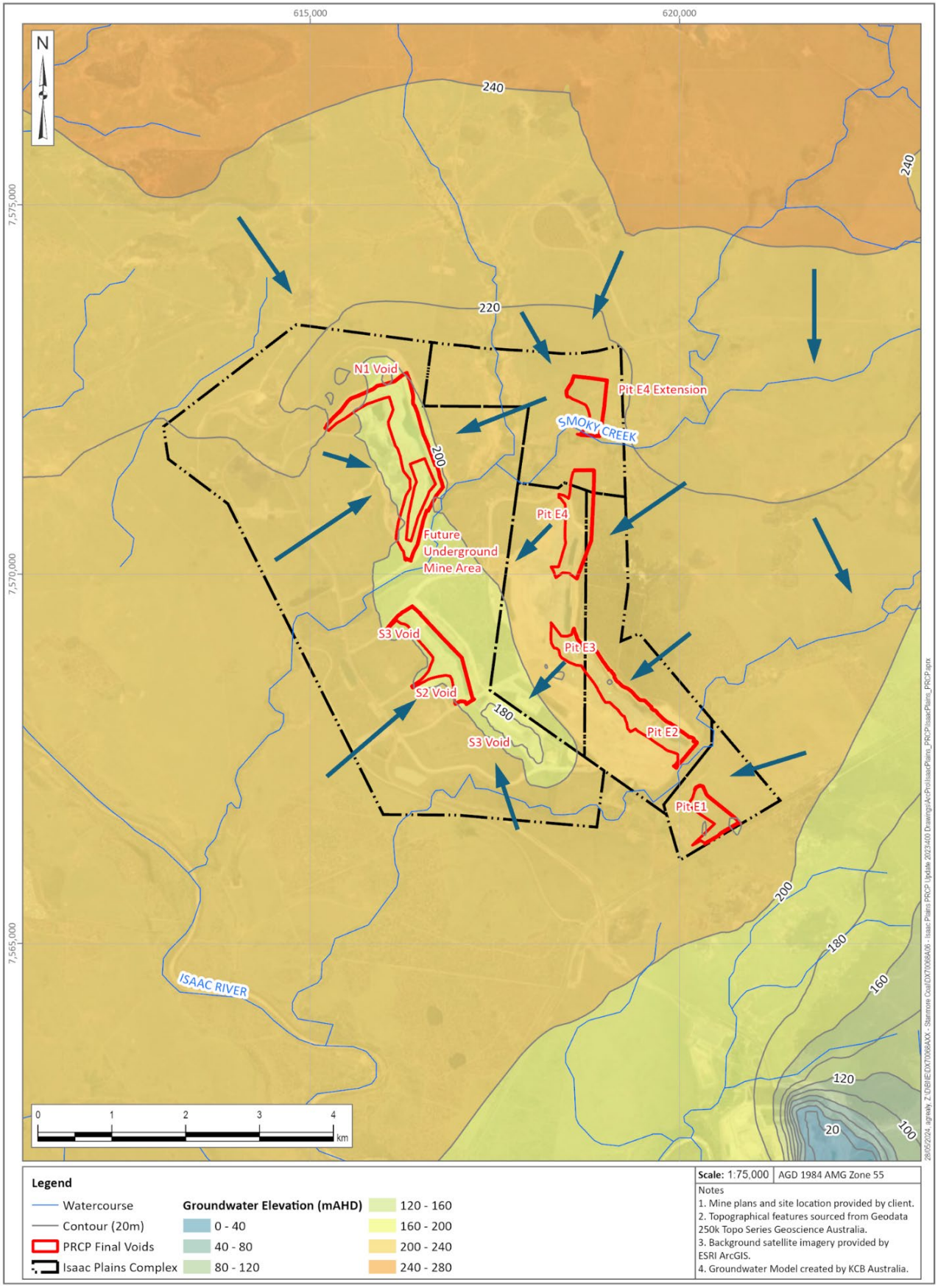

Figure 6.2 Post-Closure Water Table (1,000 Years) and Groundwater Flow Directions

7 IMPACT ASSESSMENT

7.1 Post-Closure Groundwater Levels

Post-closure groundwater flow is influenced by the groundwater level recovery following the mining operations. The rate of the groundwater level recovery and the final equilibrated groundwater level will be governed by the transient groundwater inflow into the pit voids, rainfall/runoff into the pit voids and evaporation from the pit lake surface. The pit void and underground dewatering that was undertaken as part of the mining operations has resulted in a localised drawdown in the groundwater level within the vicinity of the workings.

Groundwater flow is generally towards the voids, contributing to the recovery in groundwater levels across the IPC area (see Figure 6.1 and Figure 6.2). The model results indicate that the final void water levels stabilise within 700 years post-closure (Figure 7.1). Pit N1 is the first to recover and water levels stabilise as it has one of the lower pit elevations, it will receive inflow from the surrounding voids in the early stage of the closure period. This pit stabilises within 300 years of closure.

The predicted cumulative impact on groundwater levels from all the IPC voids suggests some flow between the voids until an equilibrium is reached, but no flow is expected away from the site (Figure 6.2).

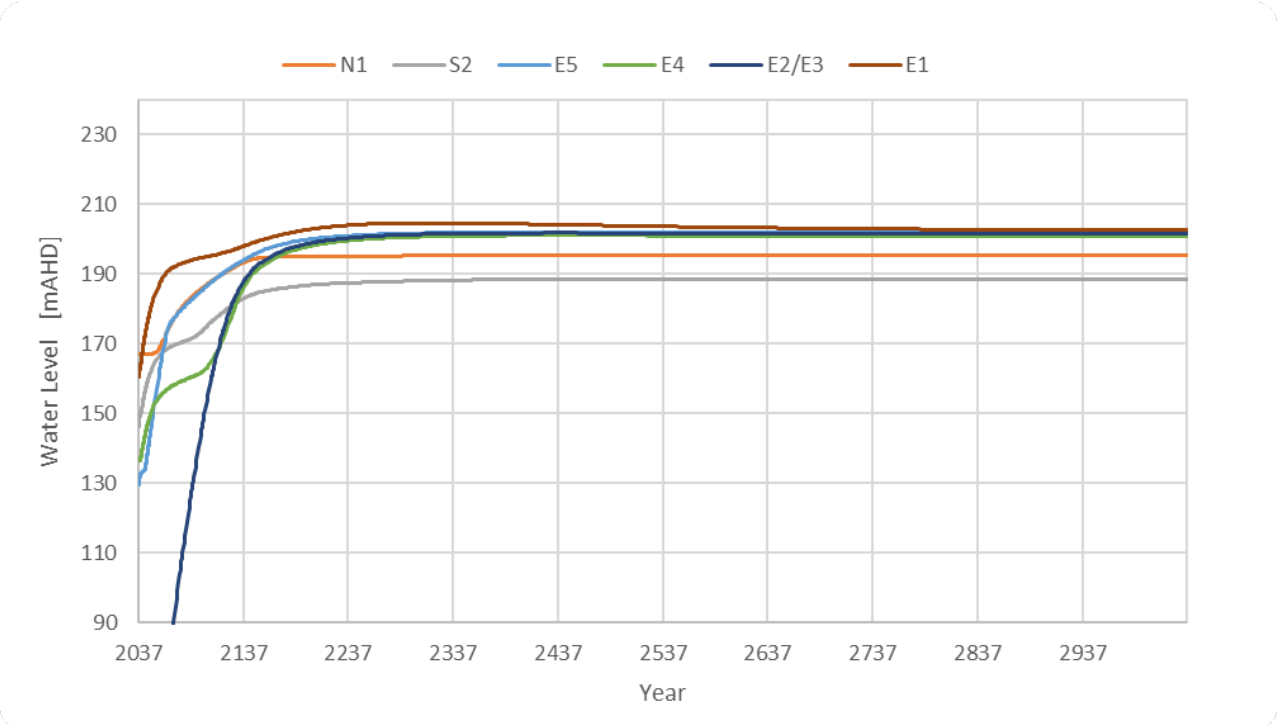

Figure 7.1 Final Void Water Levels Post-Closure

7.1.1 Pit Void Steady-State Water Levels

A range of final steady-state pit void water level elevations across the various pit voids is predicted with the current model. These elevations are summarised in Table 7.1 along with the source / sink trigger elevation for each pit void. This trigger elevation represents the groundwater

"spill point" for each pit void, where if the groundwater elevation is above the trigger elevation discharge from the pit void to the downstream environment will occur; conversely, if the groundwater elevation is below the trigger elevation localised groundwater flow towards the pit void will occur.

The assessment suggests that the final pit voids remain as sinks through the post-closure period.

Table 7.1 Post-Closure Steady-State Pit Void Water Levels

Pit Void	Equilibrated Post-Closure Void Water Elevation (mAHD)	Pit Void Source / Sink Trigger Elevation	Source / Sink Void Characteristic
N1	197.5	217.0	Sink
S2	190.8	213.8	Sink
E2/E3	204.9 & 203.7	232.0	Sink
E4	201.1	229.6	Sink
5	202.1	228.5	Sink
E1	203.8	217	Sink

Locally, groundwater flow between the pit voids would occur predominantly from the eastern pit voids (E2/3, E4, Pit 5) to the western pit voids (S2, N1) as the equilibrated pit void water level elevations in the western pits are lower than the eastern pit voids. The transfer of water between the pits (as described in WRM 2020) is not considered to have any discernible impacts on groundwater receptors within the vicinity of the Project as the equilibrated pit void water elevations are predicted to be below the source / sink trigger elevations of the pit voids (between 20 m to 28 m below source / sink trigger), and therefore, groundwater migration away from the IPC area is not predicted.

Figure 7.2 illustrates the predicted post-closure water levels at 1000 years after closure, with positions of void cross-sections showing transient recovering groundwater levels presented in Figure 7.3 to Figure 7.9.

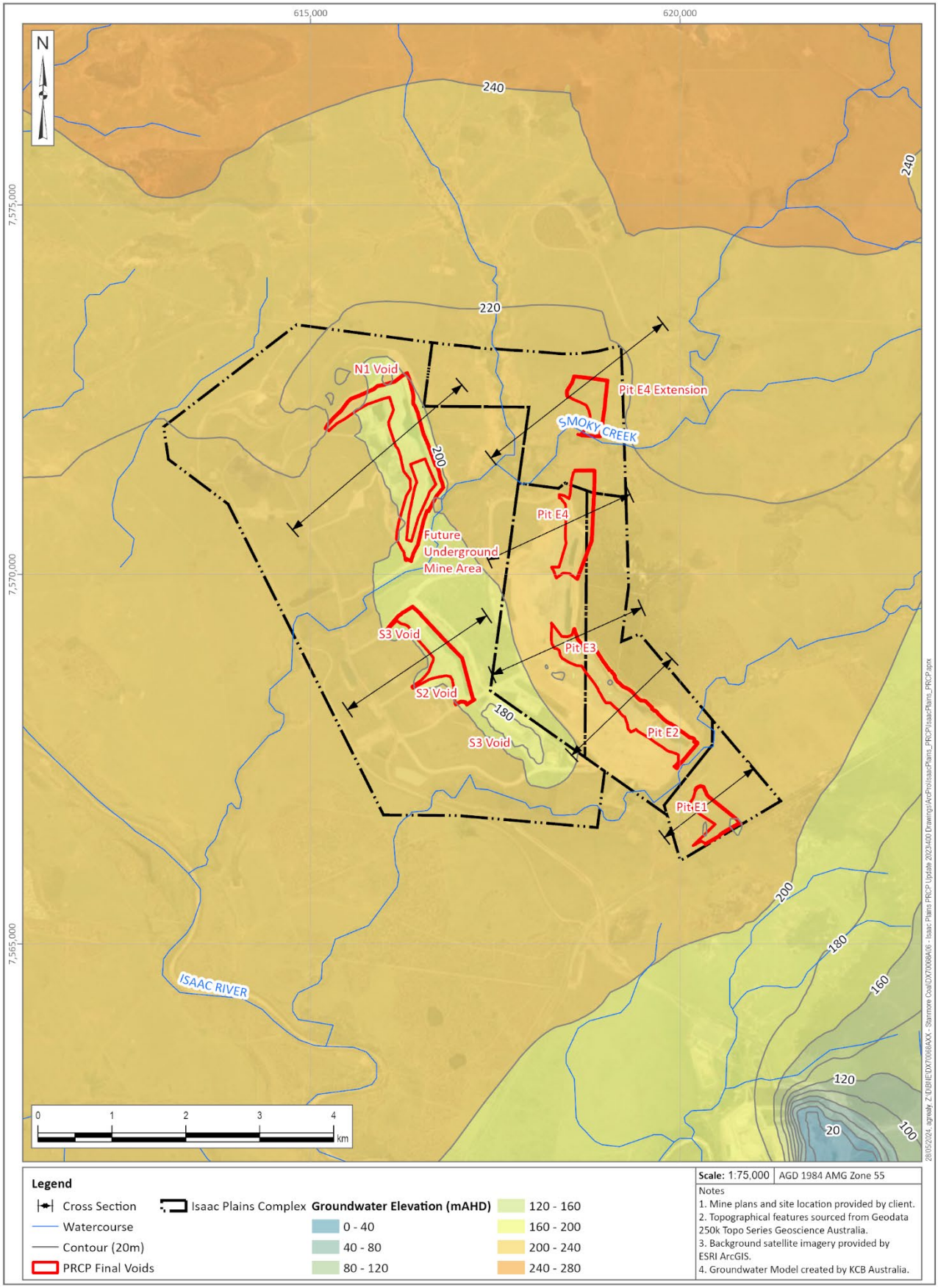

Figure 7.2 Post-Closure Water Elevations at 1000 years with Cross-Section Alignments

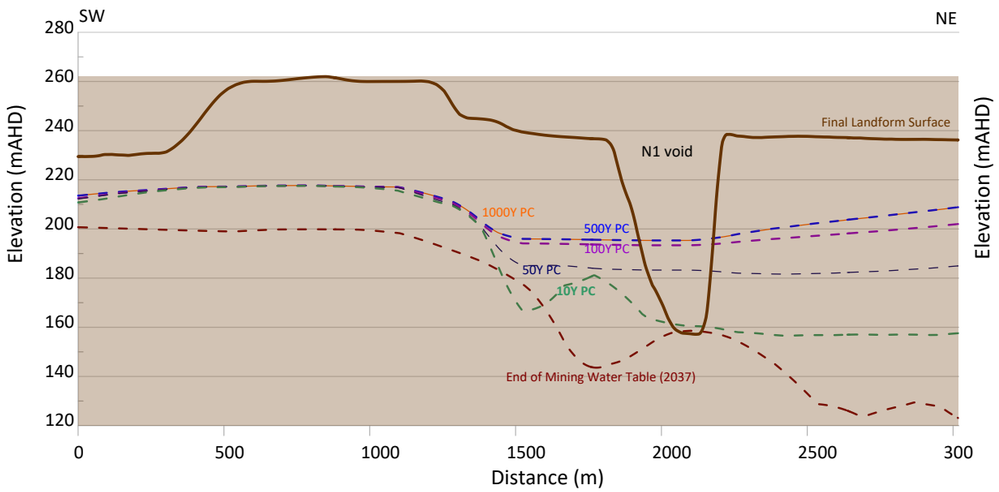

Figure 7.3 N1 Void Cross-section

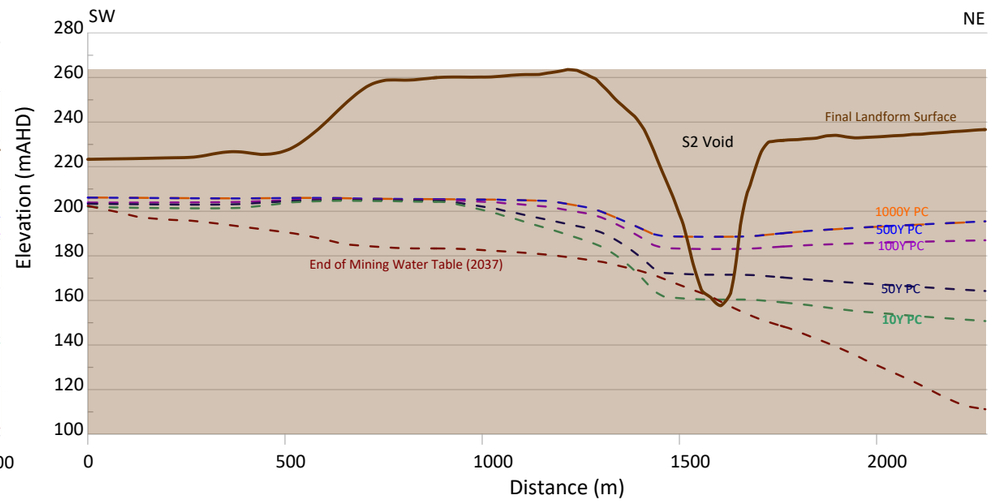

Figure 7.4 S2 Void Cross-section

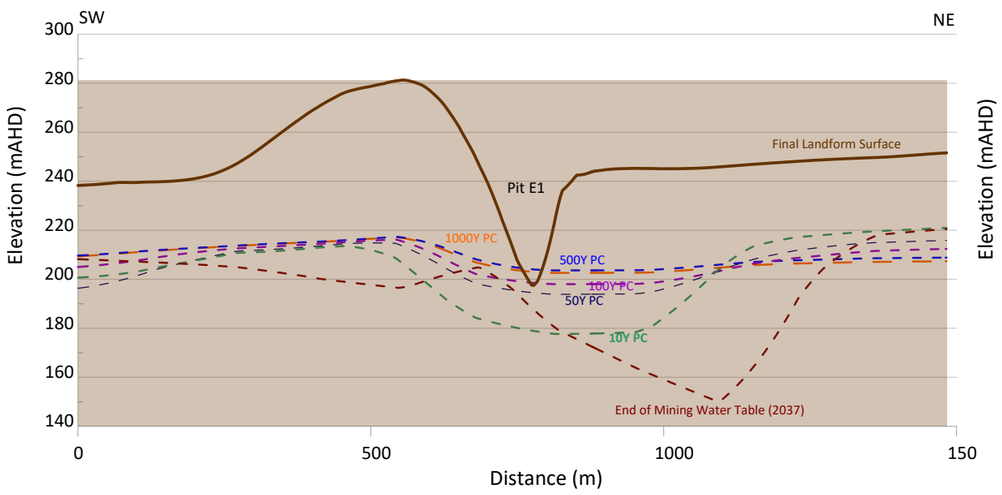

Figure 7.5 Pit E1 Cross-section

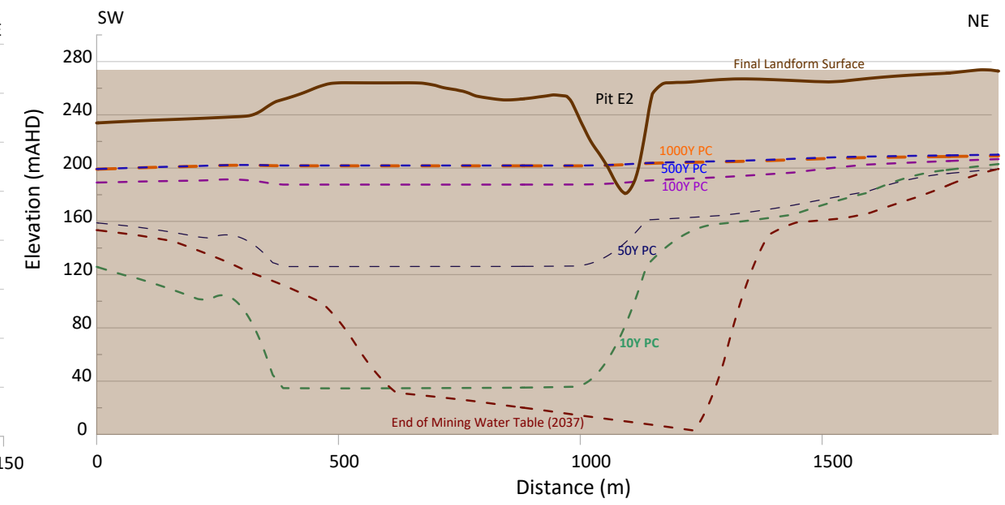

Figure 7.6 Pit E2 Cross-section

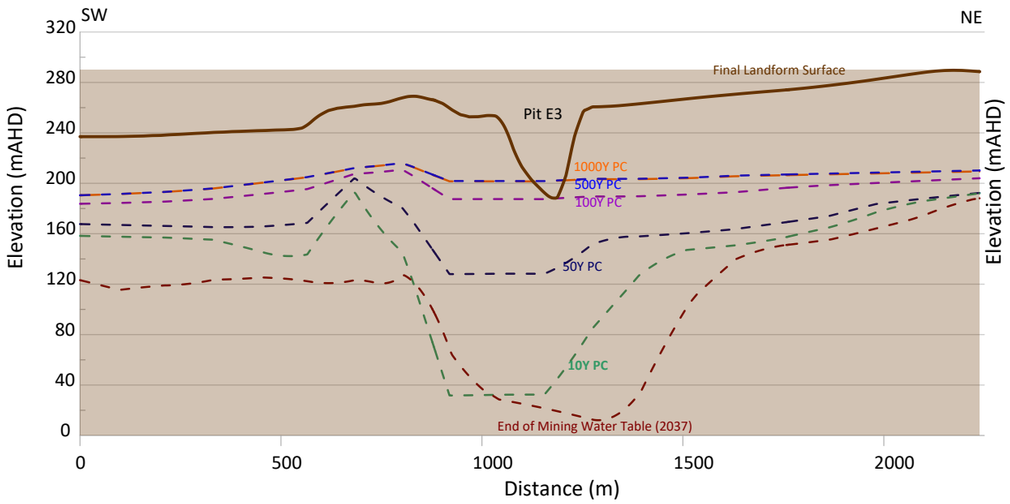

Figure 7.7 Pit E3 Cross-section

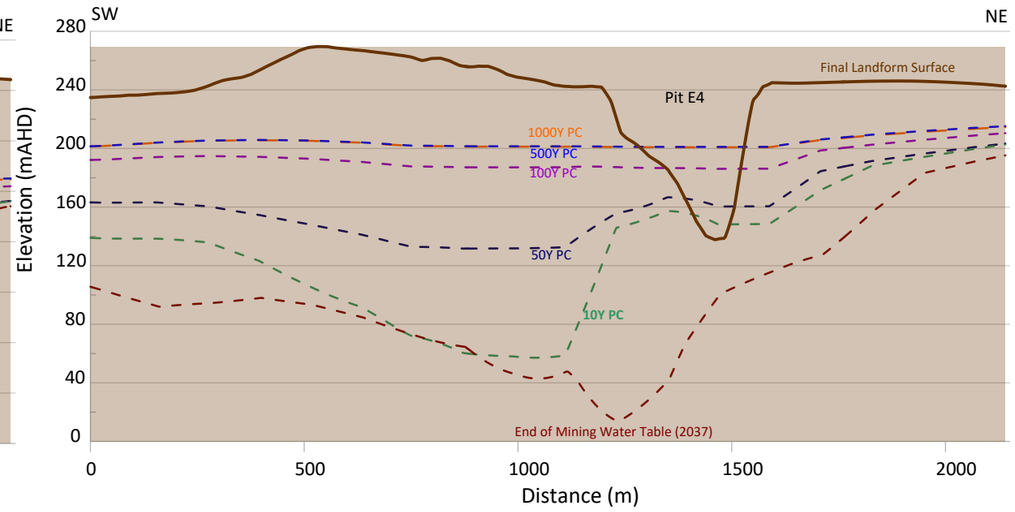

Figure 7.8 Pit E4 Cross-section

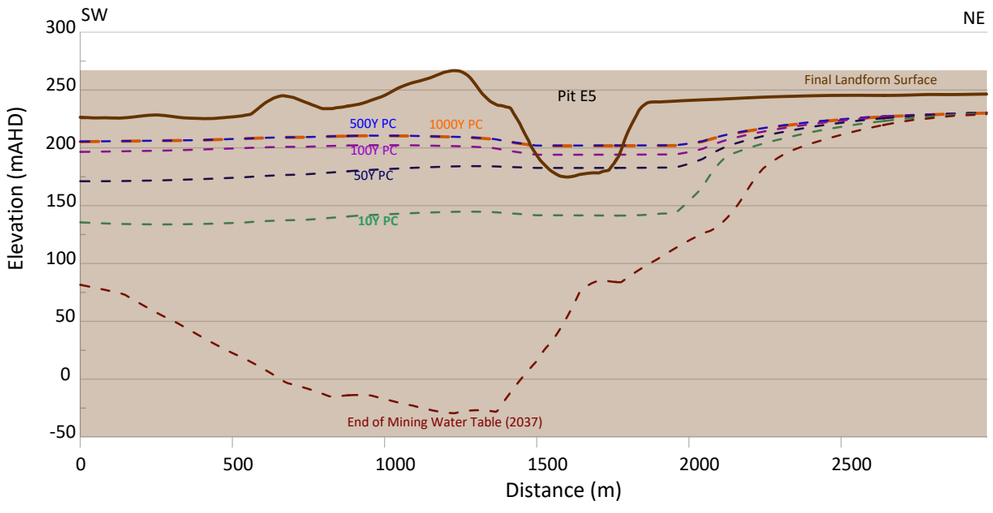

Figure 7.9 Pit E5 Cross-section

7.2 Post-Closure Groundwater Quality

As part of the surface water assessment, completed by WRM, long-term salinity for each of the voids were predicted and were provided to KCB for consideration in the hydrogeological assessment. The main contributor to the changes in the groundwater quality will be the evaporative concentration driven by evaporation from the pit voids.

The NUMA voids are predicted to be long-term groundwater sinks, rather than sources, as shown on Figure 6.2. It is unlikely that the saline evapo-concentrated water within the closure voids will result in the change of groundwater quality in the surrounding units.

7.3 Potential Impacts on Environmental Values

Groundwater associated with the hydrostratigraphic units underlying the IPC is generally of a poor quality with low yields and high salinity. There are limited beneficial uses for the groundwater, which is supported by the limited number of water supply bores in the vicinity of the IPC. One landholder bore was identified as a potential water supply bore, but this bore has been abandoned.

Information gathered during a bore census (KCB 2018) confirmed that there are no water supply bores in the Quaternary alluvium due to limited yields and/or high salinity. This provides additional evidence of the lack of suitability of groundwater use tor vegetation. The Broadlea Bore field located to the north-east of IPC targets the Tertiary basalt aquifer, the Project is not predicted to result in any depressurisation of the Tertiary basalt during operations and will therefore not impact during closure.

The majority of potential TGDEs mapped in the vicinity of IPC have been mapped as being ‘low confidence’ with some ‘moderate confidence’ GDEs. Some mapped ‘high confidence’ TGDEs coincides with the Isaac River, which is located west of the Project area. ‘Moderate potential’ TGDEs have been mapped along Billy’s Gully and Smoky Creek. These potential GDEs are not considered to be reliant on the groundwater system due to the high salinity of the Tertiary sediments and alluvium and is more likely to be sourcing soil moisture and surface water during times of flow. The closure of IPC is unlikely to have any discernible impacts to these potential GDEs.

8 CONCLUSIONS

The 2020 IPC numerical groundwater model was updated to include the proposed post-closure landform in order to simulate post-closure groundwater conditions. The mine has seven approved residual voids, or NUMAs, under the Environmental Authority (N1, S2, E1, E2/E3/E4, and E5). The groundwater model was used to predict the final void water elevations in the long-term post-closure modelling. The groundwater model simulated rainfall and evaporation to predict the water levels in the final voids post-closure.

Maximum groundwater drawdown occurs at the end of the approved operations, with groundwater levels recovering throughout the closure period. Locally, groundwater flow between the pit voids would occur predominantly from the eastern pit voids (E2/3, E4, Pit 5) to the western pit voids (S2, N1) as the equilibrated pit void water level elevations in the western pits are lower than the eastern pit voids. The transfer of water between the pits (as described in WRM 2020) is not considered to have any discernible impacts on groundwater receptors within the vicinity of the Project as the equilibrated pit void water elevations are predicted to be below the source / sink trigger elevations of the pit voids (between 20 m to 28 m below source / sink trigger). Groundwater migration away from the IPC area is not predicted, the final voids act as sinks.

Groundwater levels are predicted to have reached an equilibrium condition in ~700 years following the cessation of operations, with recovery of the underground working and pit voids, which were dewatered as part of mining activities. Pit N1 is the first to recover and water levels stabilise as it has one of the lower pit elevations, it will receive inflow from the surrounding voids in the early stage of the closure period. This pit stabilises within 300 years of closure.

Groundwater hosted in the hydrostratigraphic units underlying the IPC is generally of a poor quality with low yields and high salinity. There is a very low potential for groundwater contamination as a result of the Project.

Based on the predicted groundwater flow directions and the location of the TGDEs, it is predicted that there will be no discernible impacts to TGDEs. Stable isotope analysis completed as part of GDE study across the Project area (3D Environmental 2020) identified “there is no linkage between groundwater and surface water in the stream channel and baseflow is not supported” at Smoky Creek and Billy’s Gully.

The seven residual voids are predicted to experience groundwater inflow and act as groundwater sinks through the closure period and beyond. Based on the model predictions, impacts to environmental values of groundwater are not anticipated.

9 DOCUMENT CLOSURE

We would like to thank you for the opportunity to work on this assignment. Should you have any questions, please do not hesitate to contact the undersigned.

KCB AUSTRALIA PTY LTD.

Carly Waterhouse, RPGeo
Senior Hydrogeologist

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APPENDIX I

Monitoring Network

Appendix I
Groundwater Monitoring Network

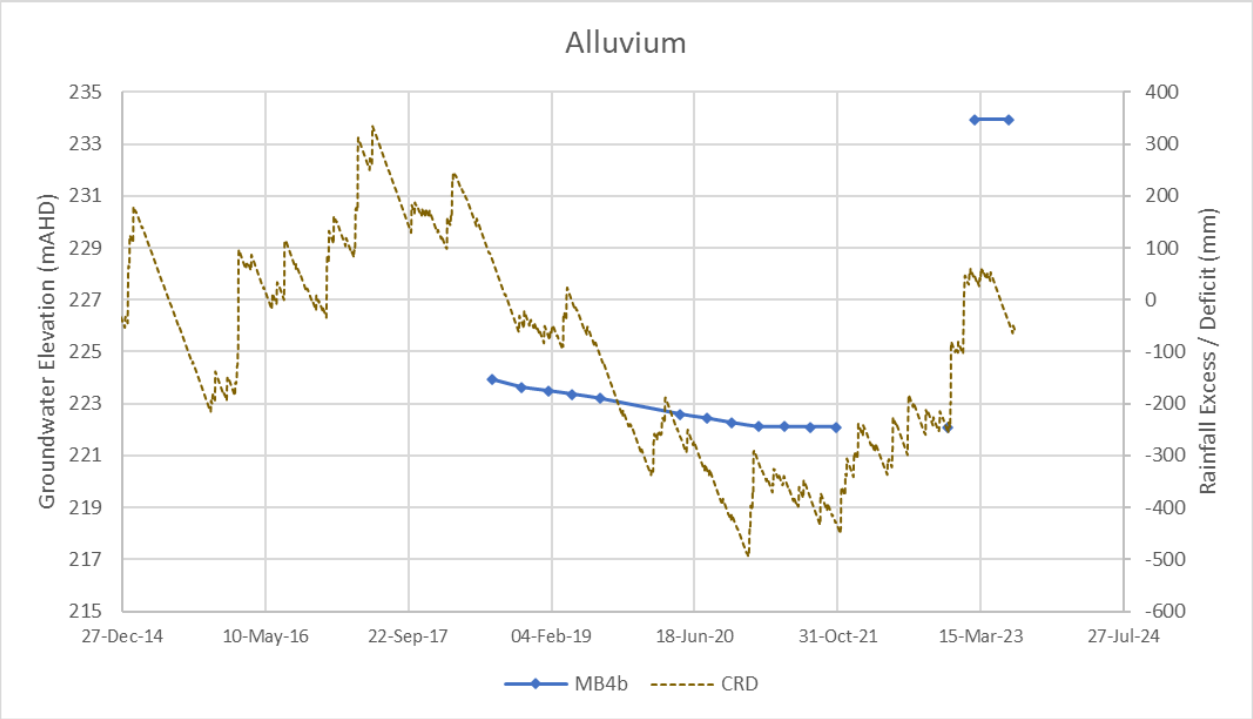
Monitoring Bore	Easting[1]	Northing[1]	Elevation (mAHD[2])	Screen from (mbgl)[3]	Screen to (mbgl)[3]	Screened Lithology	Hydrogeology Unit
Burton Coal (BC2)	620383	7573599	240.8	30.3	34.6	Sandstone / Mudstone	Rewan Group
Swamp Bore 1	621518	7568790	245.9	24.0	55.0	*	Rewan Group
MB1	618793	7572214	236.4	22.5	28.0	Sandstone	Rangal Coal Measures
MB2	619074	7573137	242.7	48.5	51.5	Siltstone / Coal	Rangal Coal Measures
MB3	619047	7568473	253	49.5	52.5	Siltstone / Coal	Rangal Coal Measures
MB4a	620351	7567479	237.6	7.8	10.7	Clayey silt	Quaternary colluvium/ Tertiary sediments
MB4b	619740	7567253	233.9	9.4	12.4	Sand	Alluvium
MB5	618507	7570878	235.7	36.4	39.2	Coal	Rangal Coal Measures
MB6	619260	7567365	235.3	6.5	12.5	Basalt	Tertiary basalt
MB7	617423	7568883	236.9	126.0	132.0	Coal	Rangal Coal Measures
MB8	619105	7571149	245.9	117.3	120.3	Coal	Rangal Coal Measures
MB9	620368	7568049	239.5	77.5	80.5	Shale / Coal / Sandstone	Rangal Coal Measures
MB10	620368	7568046	239.5	21.0	27.0	Basalt	Tertiary basalt
MB11	618832	7571924	232.3	3.0	4.0	Silt / Sand	Tertiary sediments
MB12	619210	7572000	234.9	104.0	110.0	Coal	Rangal Coal Measures
MB13	619367	7571035	249.7	95.0	97.0	Coal	Rangal Coal Measures
MB14	620263	7571132	254.7	30.0	33.0	Basalt	Tertiary basalt
MB15	620633	7568080	242.9	115.0	119.0	Coal	Rangal Coal Measures
MB16a	620559	7568417	245.1	4.5	7.0	Clay / Silt	Tertiary sediments
MB16b	620557	7568419	245.1	7.0	13.0	Basalt	Tertiary basalt
Burton Coal (BC1)	620267	7573421	253	*	*	*	*
Swamp Bore 2	621744	7569149	249	*	*	*	*

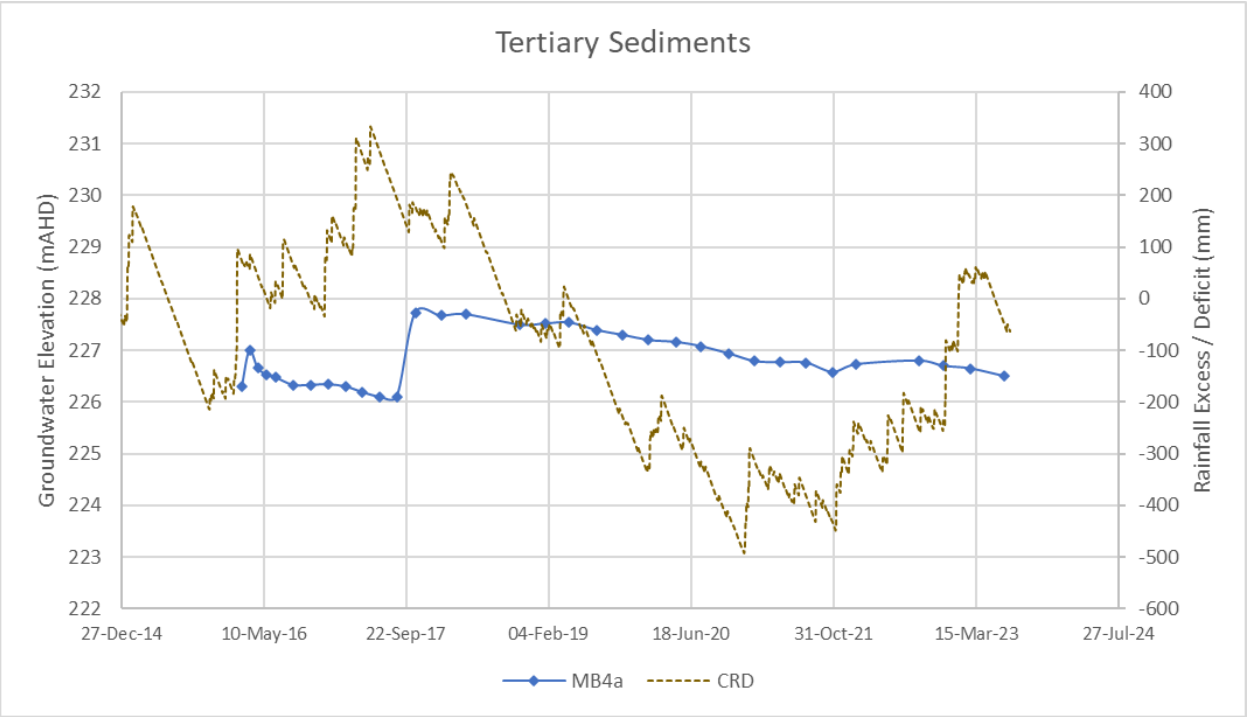
[1] Coordinates are in GDA94 Zone 55
[2] mAHD – meters above Australian Height Datum
[3] mbGL - meters below ground level
*Information not available/Unknown

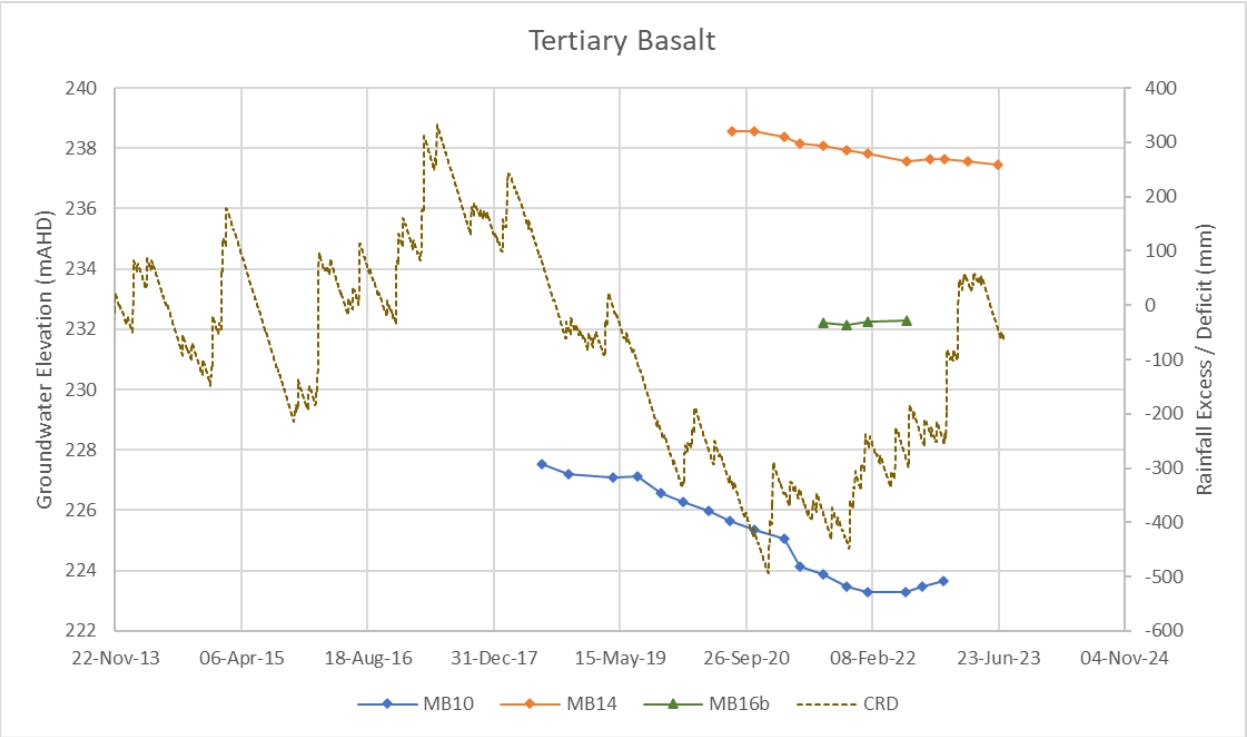
APPENDIX II

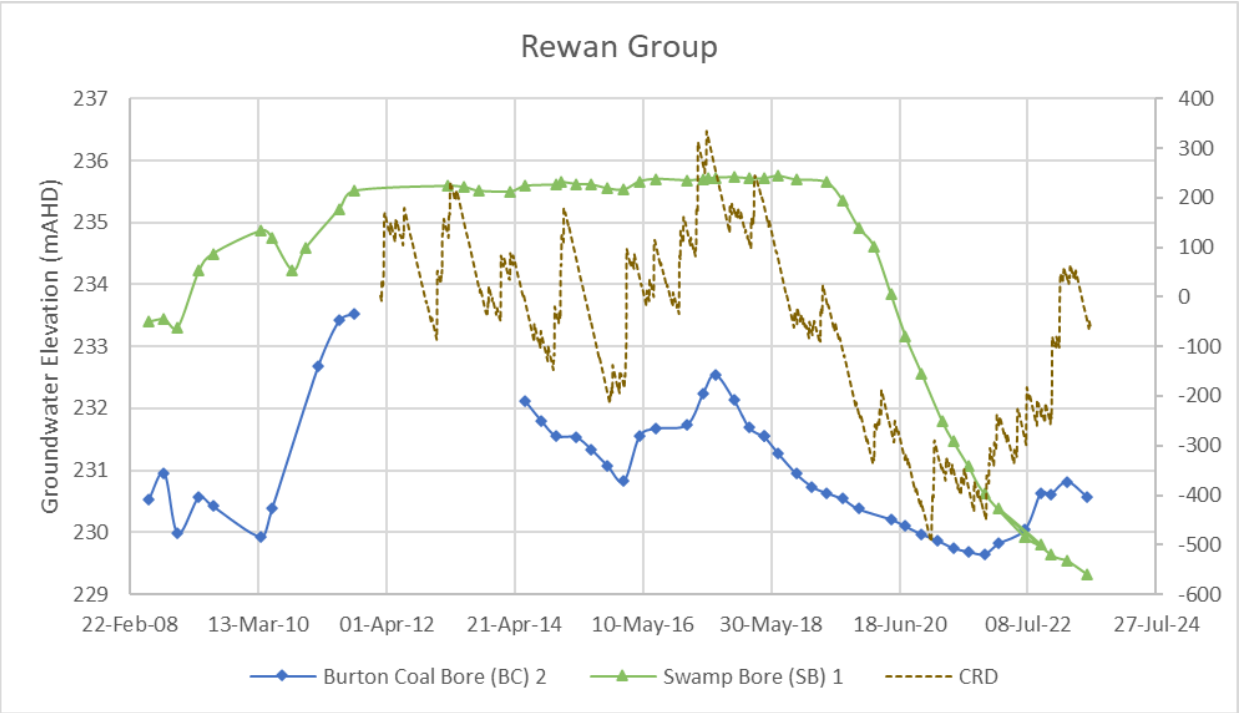
Groundwater Elevation

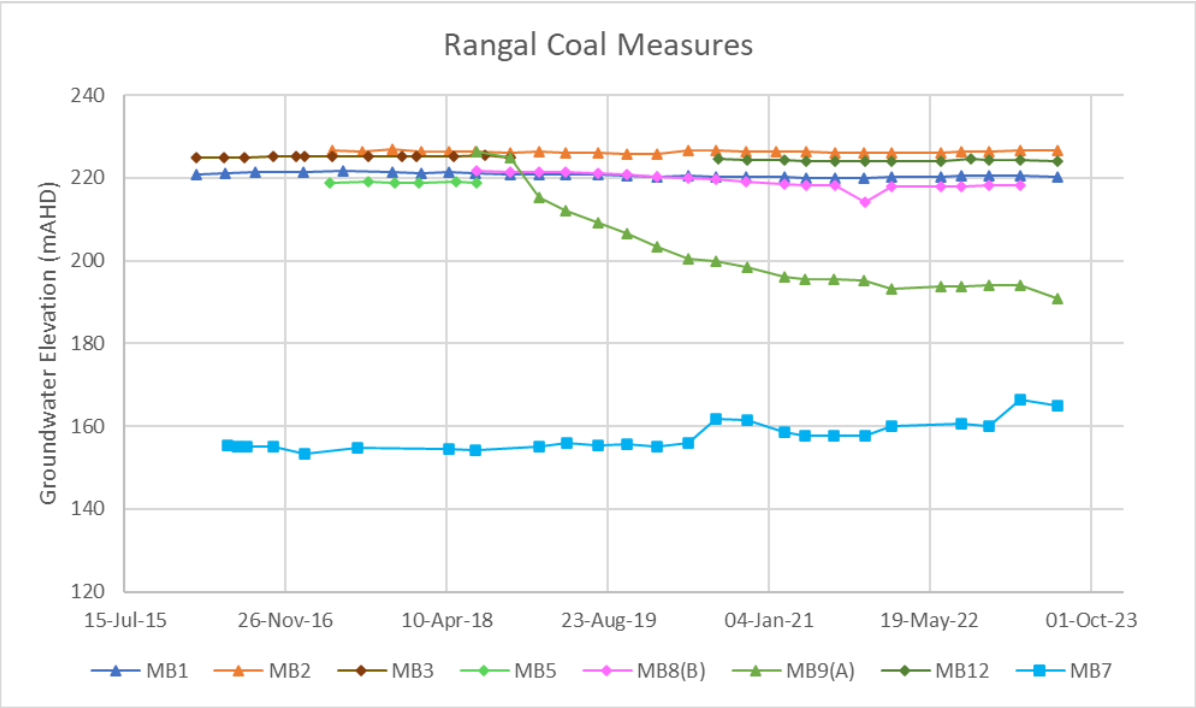
Appendix II
Groundwater Elevation Graphs






Tertiary Basalt
Groundwater Elevation (mAHD)
Rainfall Excess / Deficit (mm)
240
238
236
234
232
230
228
226
224
222
400
300
200
100
0
-100
-200
-300
-400
-500
-600
22-Nov-13
06-Apr-15
18-Aug-16
31-Dec-17
15-May-19
26-Sep-20
08-Feb-22
23-Jun-23
04-Nov-24
MB10
MB14
MB16b
CRD


Rewan Group
Groundwater Elevation (mAHD)
237
236
235
234
233
232
231
230
229
400
300
200
100
0
-100
-200
-300
-400
-500
-600
22-Feb-08
13-Mar-10
01-Apr-12
21-Apr-14
10-May-16
30-May-18
18-Jun-20
08-Jul-22
27-Jul-24
Burton Coal Bore (BC) 2
Swamp Bore (SB) 1
CRD

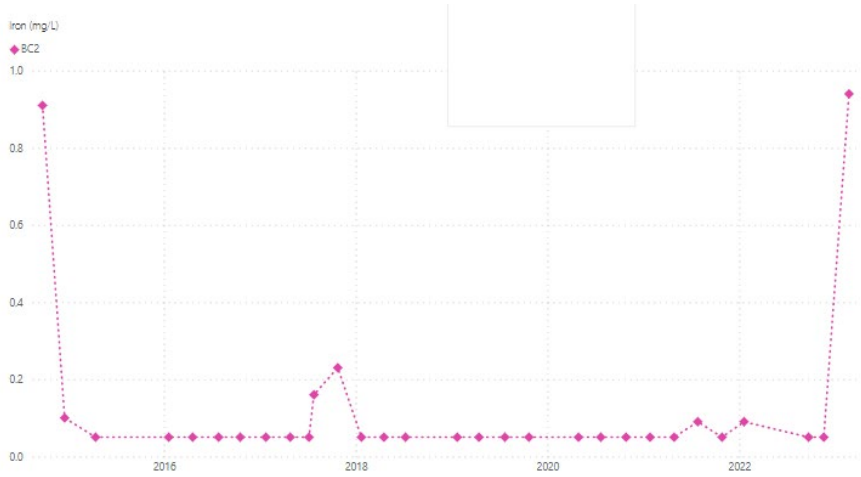

Rangal Coal Measures
Groundwater Elevation (mAHD)
240
220
200
180
160
140
120
15-Jul-15
26-Nov-16
10-Apr-18
23-Aug-19
04-Jan-21
19-May-22
01-Oct-23
MB1
MB2
MB3
MB5
MB8(B)
MB9(A)
MB12
MB7

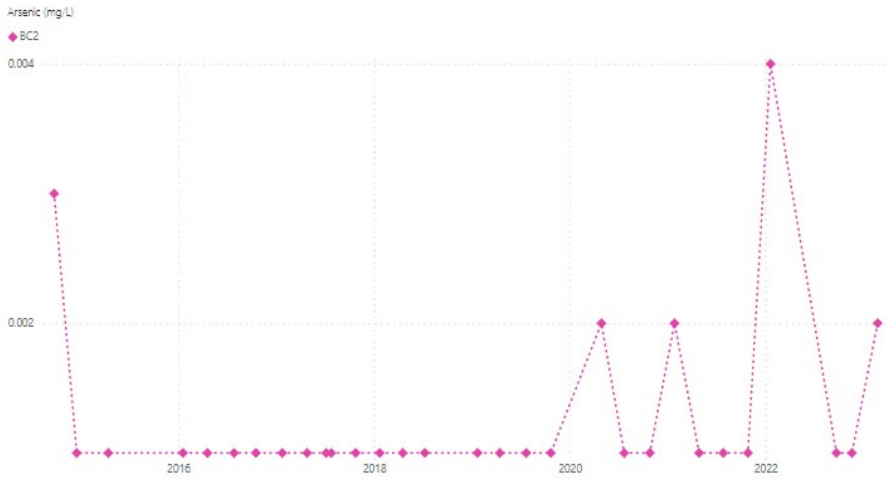
APPENDIX III

Groundwater Chemistry

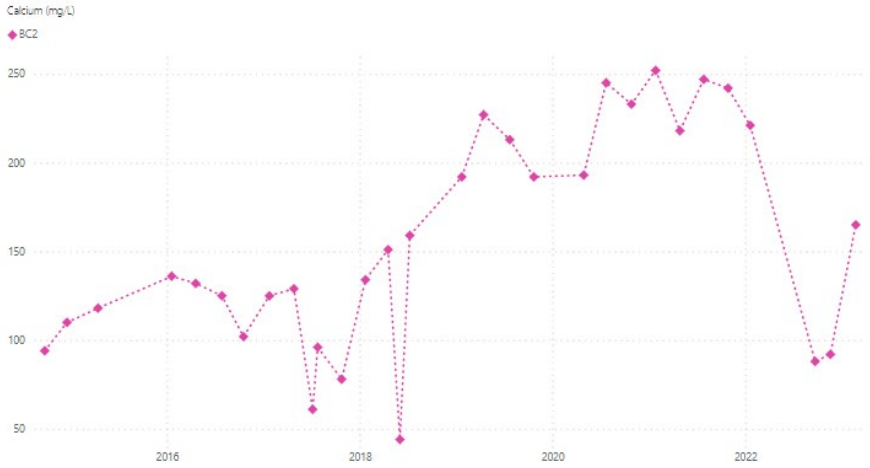
Appendix III
Groundwater Chemistry

Sulfate as SO4 - Turbidimetric (mg/L)
BC2
140
120
100
80
60
40
2016
2018
2020
2022


Iron (mg/L)
BC2
1.0
0.8
0.6
0.4
0.2
0.0
2016
2018
2020
2022


Arsenic (mg/L)
BC2
0.004
0.002
2016
2018
2020
2022

Chloride (mg/L)
BC2
2,500
2,000
1,500
1,000
500
2016
2018
2020
2022


Calcium (mg/L)
BC2
250
200
150
100
50
2016
2018
2020
2022

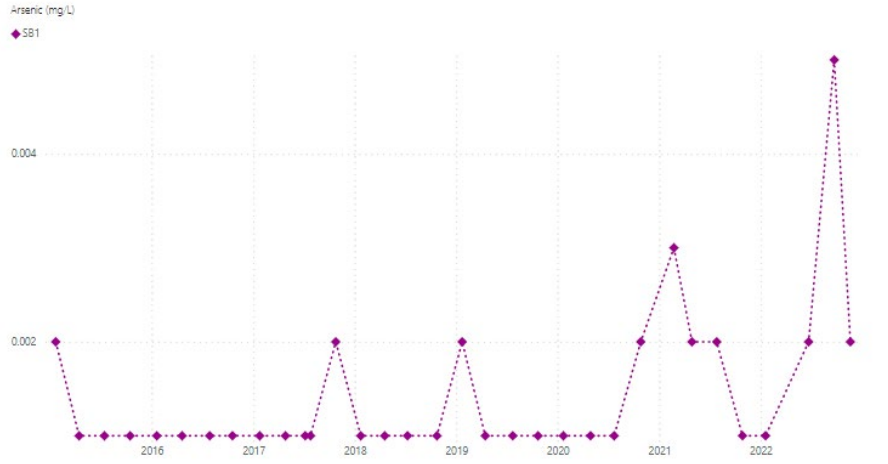
Sodium (mg/L)
BC2
1,200
1,000
800
600
400
2016
2018
2020
2022

Electrical Conductivity (Lab) (µS/cm)
SB1
9,500
9,000
8,500
2016
2017
2018
2019
2020
2021
2022

pH (Lab) (-)
SB1
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
2016
2017
2018
2019
2020
2021
2022

Sulfate as SO4 - Turbidimetric (mg/L)
SB1
150
140
130
120
110
2016
2017
2018
2019
2020
2021
2022

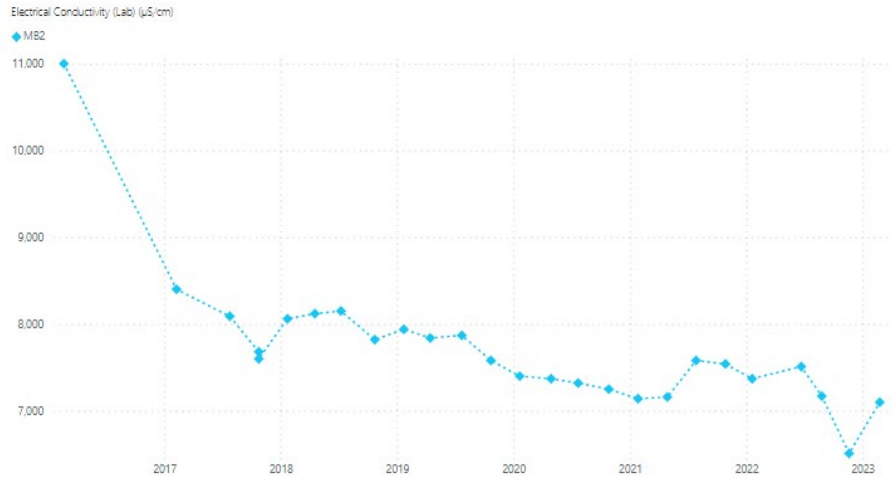
Iron (mg/L)
SB1
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2016
2017
2018
2019
2020
2021
2022


Arsenic (mg/L)
SB1
0.004
0.002
2016
2017
2018
2019
2020
2021
2022

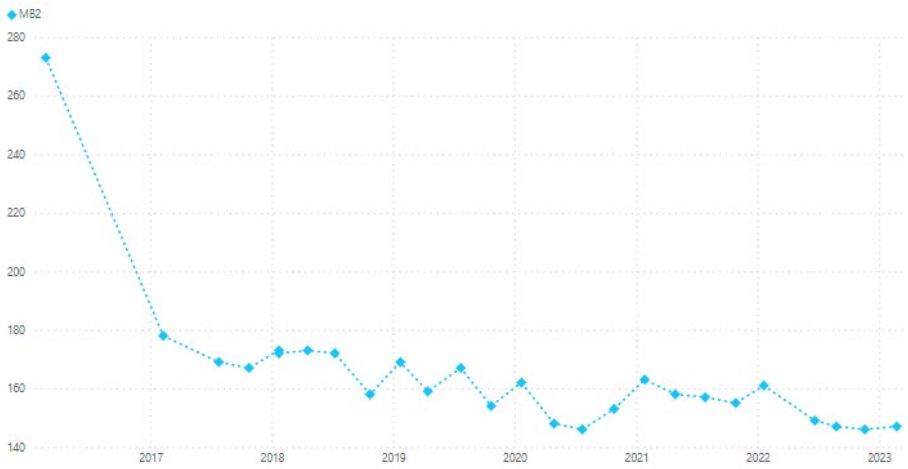
Chloride (mg/L)
SB1
3,300
3,200
3,100
3,000
2,900
2016
2017
2018
2019
2020
2021
2022

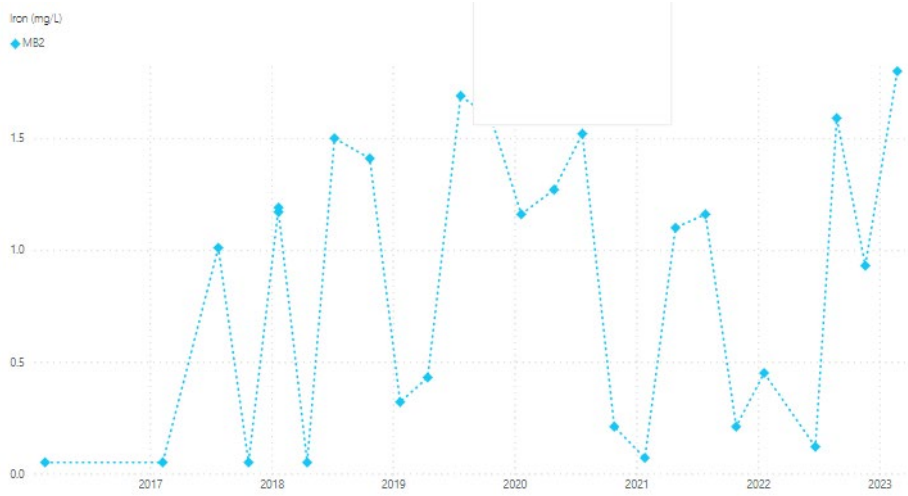
Calcium (mg/L)
SB1
620
600
580
560
540
520
500
480
2016
2017
2018
2019
2020
2021
2022

Sodium (mg/L)
SB1
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
2016
2017
2018
2019
2020
2021
2022

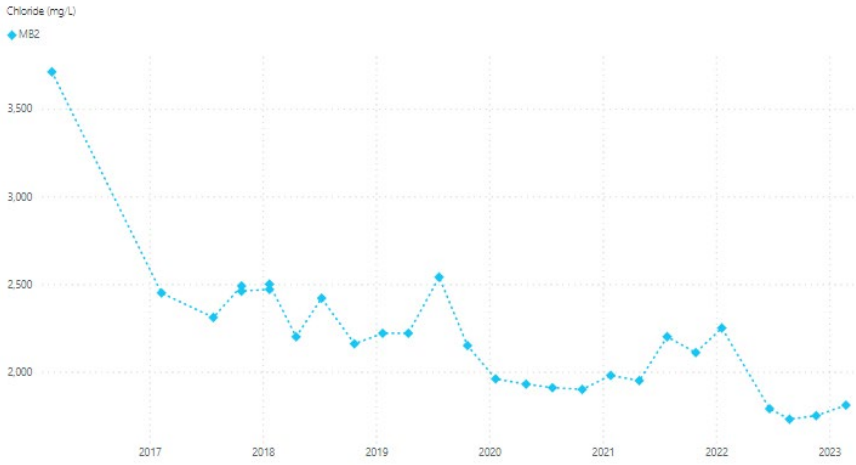

Electrical Conductivity (Lab) (µS/cm)
MB2
11,000
10,000
9,000
8,000
7,000
2017
2018
2019
2020
2021
2022
2023

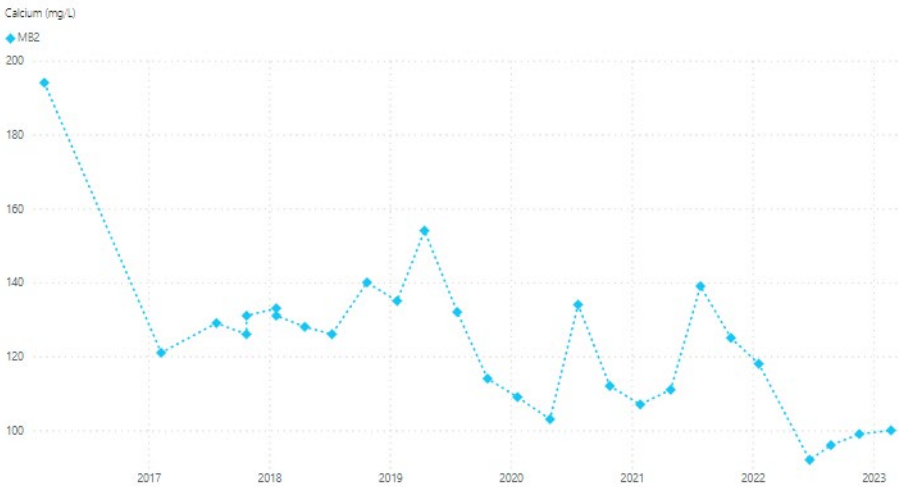
pH (Lab) (-)
MB2
8.2
8.0
7.8
7.6
7.4
7.2
2017
2018
2019
2020
2021
2022
2023

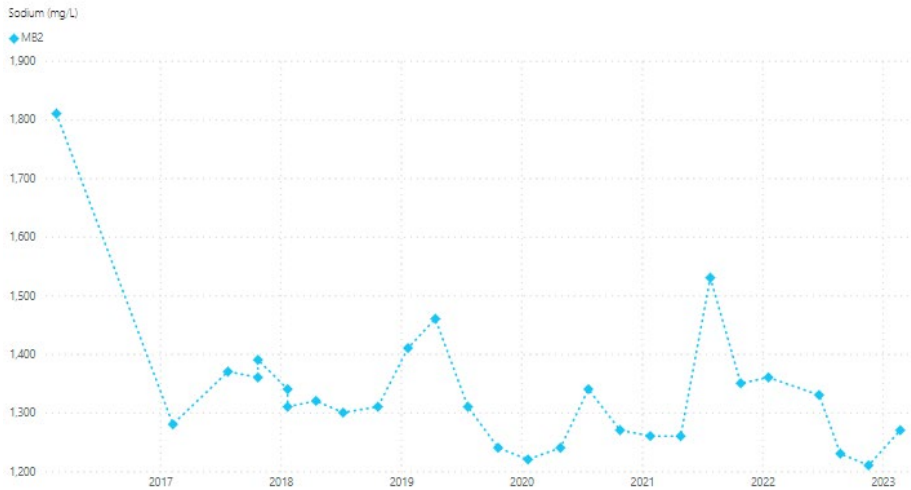

MB2
280
260
240
220
200
180
160
140
2017
2018
2019
2020
2021
2022
2023


Iron (mg/L)
MB2
1.5
1.0
0.5
0.0
2017
2018
2019
2020
2021
2022
2023

Arsenic (mg/L)
MB2
0.04
0.03
0.02
0.01
0.00
2017
2018
2019
2020
2021
2022
2023


Chloride (mg/L)
MB2
3,500
3,000
2,500
2,000
2017
2018
2019
2020
2021
2022
2023

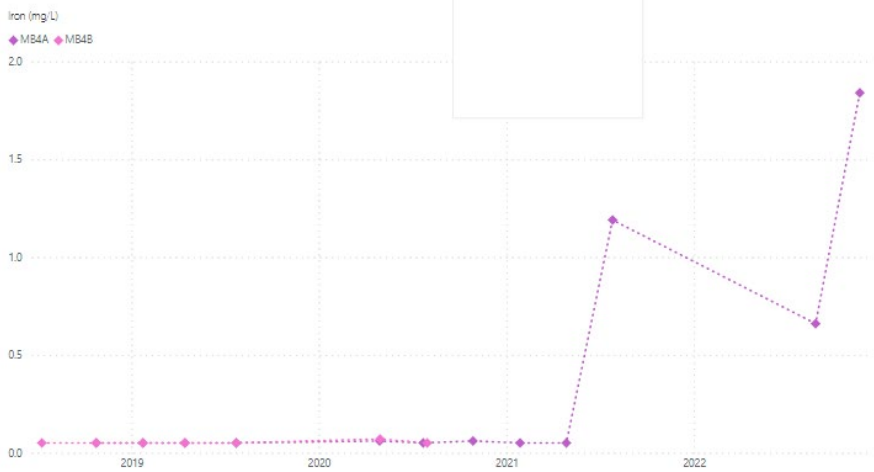

Calcium (mg/L)
MB2
200
180
160
140
120
100
2017
2018
2019
2020
2021
2022
2023

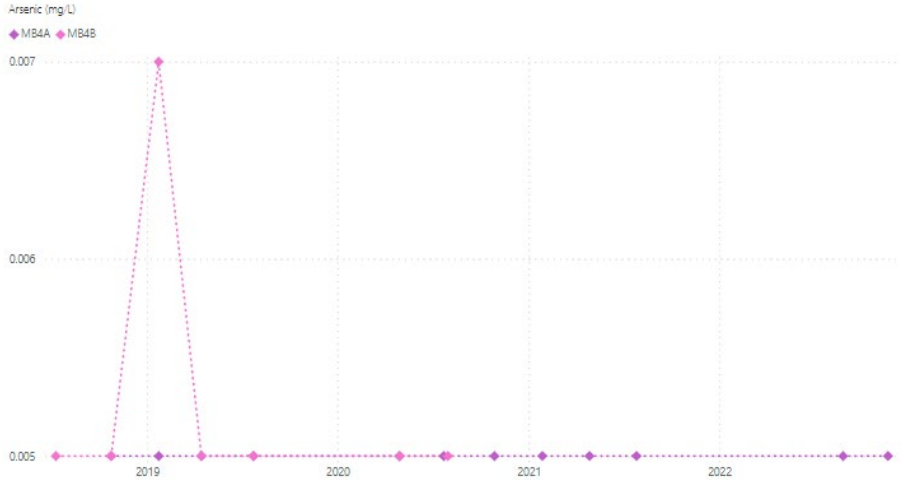

Sodium (mg/L)
MB2
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
2017
2018
2019
2020
2021
2022
2023

Electrical Conductivity (Lab) (µS/cm)
MB4A
MB4B
50,000
45,000
40,000
35,000
30,000
2019
2020
2021
2022

pH (Lab) (-)
MB4A
MB4B
8.0
7.5
7.0
2019
2020
2021
2022

Sulfate as SO4 - Turbidimetric (mg/L)
MB4A
MB4B
1,000
800
600
400
2019
2020
2021
2022

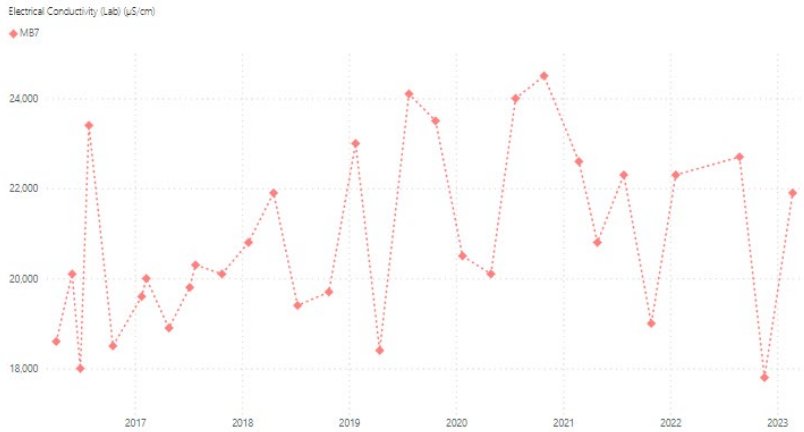

Iron (mg/L)
MB4A
MB4B
2.0
1.5
1.0
0.5
0.0
2019
2020
2021
2022


Arsenic (mg/L)
MB4A
MB4B
0.007
0.006
0.005
2019
2020
2021
2022

Chloride (mg/L)
MB4A
MB4B
22,000
20,000
18,000
16,000
14,000
12,000
10,000
2019
2020
2021
2022

Calcium (mg/L)
MB4A
MB4B
800
600
400
200
0
2019
2020
2021
2022

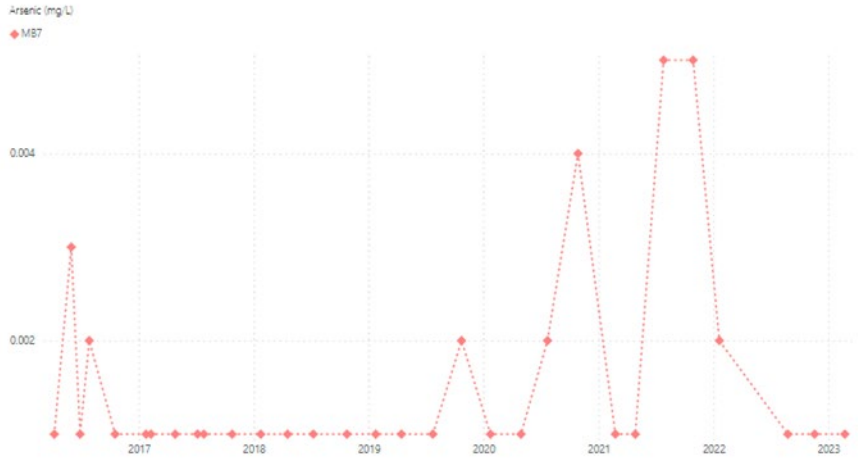
Sodium (mg/L)
MB4A
MB4B
12,000
11,000
10,000
9,000
8,000
7,000
6,000
2019
2020
2021
2022


Electrical Conductivity (Lab) (µS/cm)
MB7
24,000
22,000
20,000
18,000
2017
2018
2019
2020
2021
2022
2023

MB7
8.0
7.5
7.0
6.5
6.0
5.5
5.0
2017
2018
2019
2020
2021
2022
2023

Sulfate as SO4 - Turbidimetric (mg/L)
MB7
700
600
500
400
300
200
100
0
2017
2018
2019
2020
2021
2022
2023

Iron (mg/L)
MB7
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2017
2018
2019
2020
2021
2022
2023

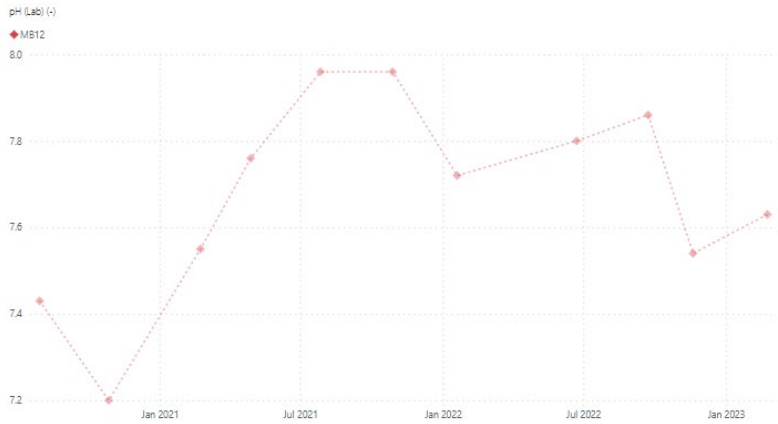

Arsenic (mg/L)
MB7
0.004
0.002
2017
2018
2019
2020
2021
2022
2023

Chloride (mg/L)
MB7
9,000
8,500
8,000
7,500
7,000
6,500
6,000
2017
2018
2019
2020
2021
2022
2023

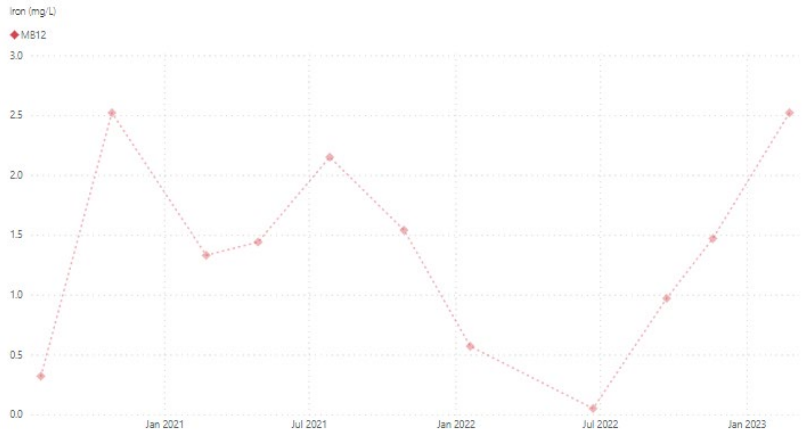
Calcium (mg/L)
MB7
800
700
600
500
400
2017
2018
2019
2020
2021
2022
2023

Sodium (mg/L)
MB7
4,500
4,000
3,500
3,000
2017
2018
2019
2020
2021
2022
2023

Electrical Conductivity (Lab) (µS/cm)
MB12
13,000
12,500
12,000
11,500
Jan 2021
Jul 2021
Jan 2022
Jul 2022
Jan 2023

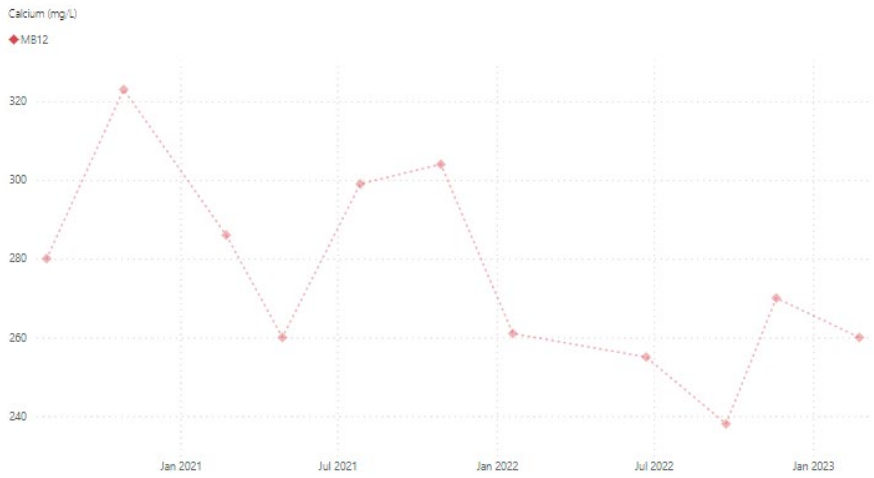

pH (Lab) (-)
MB12
8.0
7.8
7.6
7.4
7.2
Jan 2021
Jul 2021
Jan 2022
Jul 2022
Jan 2023

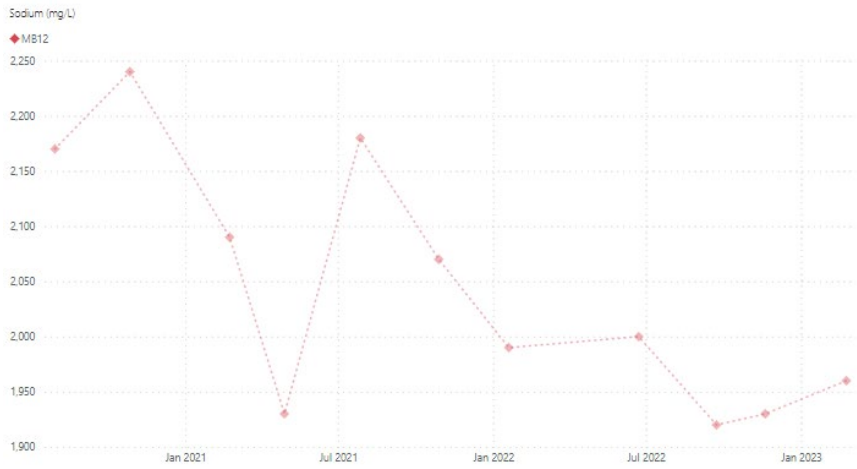
Sulfate as SO4 - Turbidimetric (mg/L)
MB12
350
300
250
200
Jan 2021
Jul 2021
Jan 2022
Jul 2022
Jan 2023


Iron (mg/L)
MB12
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan 2021
Jul 2021
Jan 2022
Jul 2022
Jan 2023

Arsenic (mg/L)
MB12
0.03
0.02
0.01
0.00
Jan 2021
Jul 2021
Jan 2022
Jul 2022
Jan 2023

Chloride (mg/L)
MB12
4,600
4,500
4,400
4,300
4,200
4,100
Jan 2021
Jul 2021
Jan 2022
Jul 2022
Jan 2023


Calcium (mg/L)
MB12
320
300
280
260
240
Jan 2021
Jul 2021
Jan 2022
Jul 2022
Jan 2023


Sodium (mg/L)
MB12
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1,900
Jan 2021
Jul 2021
Jan 2022
Jul 2022
Jan 2023

APPENDIX IV

Numerical Groundwater Model Report

Appendix IV
Numerical Groundwater Modelling

IV-1 MODEL OBJECTIVES

A numerical groundwater model has been developed to support the Isaac Plains Complex (IPC) Progressive Rehabilitation and Closure Plan (PRCP) to predict changes in groundwater levels and flow during operations, into closure and post-closure. The objectives of the model include:

- Estimating groundwater inflow / outflow in the final voids.
- Predicting the long-term steady-state water level in the final voids.
- Predicting the extent and area of influence of groundwater level drawdown associated with the final voids.

The model is required to cover the IPC with sufficient distance outside of the IPC to simulate the full extent of drawdown, pit recovery, and permit inclusion of boundary conditions at a distance such that the boundary conditions represent the regional groundwater flow conditions across the site.

The numerical model was originally developed as part of previous approval submissions for the Isaac Plains Underground Project and Isaac Plains East Expansion Project approvals between 2018 and 2020. The model has been recalibrated and remains fit for purpose for use in the PRCP predictions.

The numerical groundwater model has been constructed and simulated with consideration of the Australian Groundwater Modelling Guidelines (Barnett et al. 2012) and the requirements of the PRCP Guideline (DES 2023).

IV-2 MODEL CONSTRUCTION

IV-2.1 Model Code

The 2020 model for IPC (by KCB) was developed using MODFLOW-SURFACT Version 4.0. The model has been updated to MODFLOW-USG for this assessment. MODFLOW-USG is a centre finite volume code, which supports the construction of structured and unstructured model grids and contains robust solution methods and simulation capabilities, including the ability to handle complex, variably saturated / unsaturated flow. This enables effective representation of features such as river flow, water storages, in-pit storage interaction with the groundwater regime and localised subsidence-induced fracturing.

IV-2.2 Units and Datum

The time unit for the model is days and the length unit is meters. In the horizontal direction the model uses the AGD 1984 AMG Zone 55 projection, while the vertical datum is the Australian Height Datum (AHD) in meters.

IV-2.3 Model Domain Extent and Cells

The model grid was constructed from a base grid comprising 400 m x 400 m cells. Grid refinement is used over an area that encompasses the IPC and the neighbouring mine operations to the east of the thrust fault, which are targeting the same coal seam. Across the model domain, the model grid cells are refined in areas of importance to increase the resolution and understanding of changes in groundwater levels, flow conditions and flow rates. This refinement results in a reduction in cell sizes progressively down to 50 m x 50 m. In the vicinity of the project site, the grid is refined down to 25 m grid cells.

The model domain is rotated by 13 degrees to the west to better align the principal axis of the model with the strike of the thrust fault and to reduce numerical complexity associated with the model simulation. Figure IV-2.1 presents the rotated model domain and associated grid refinement.

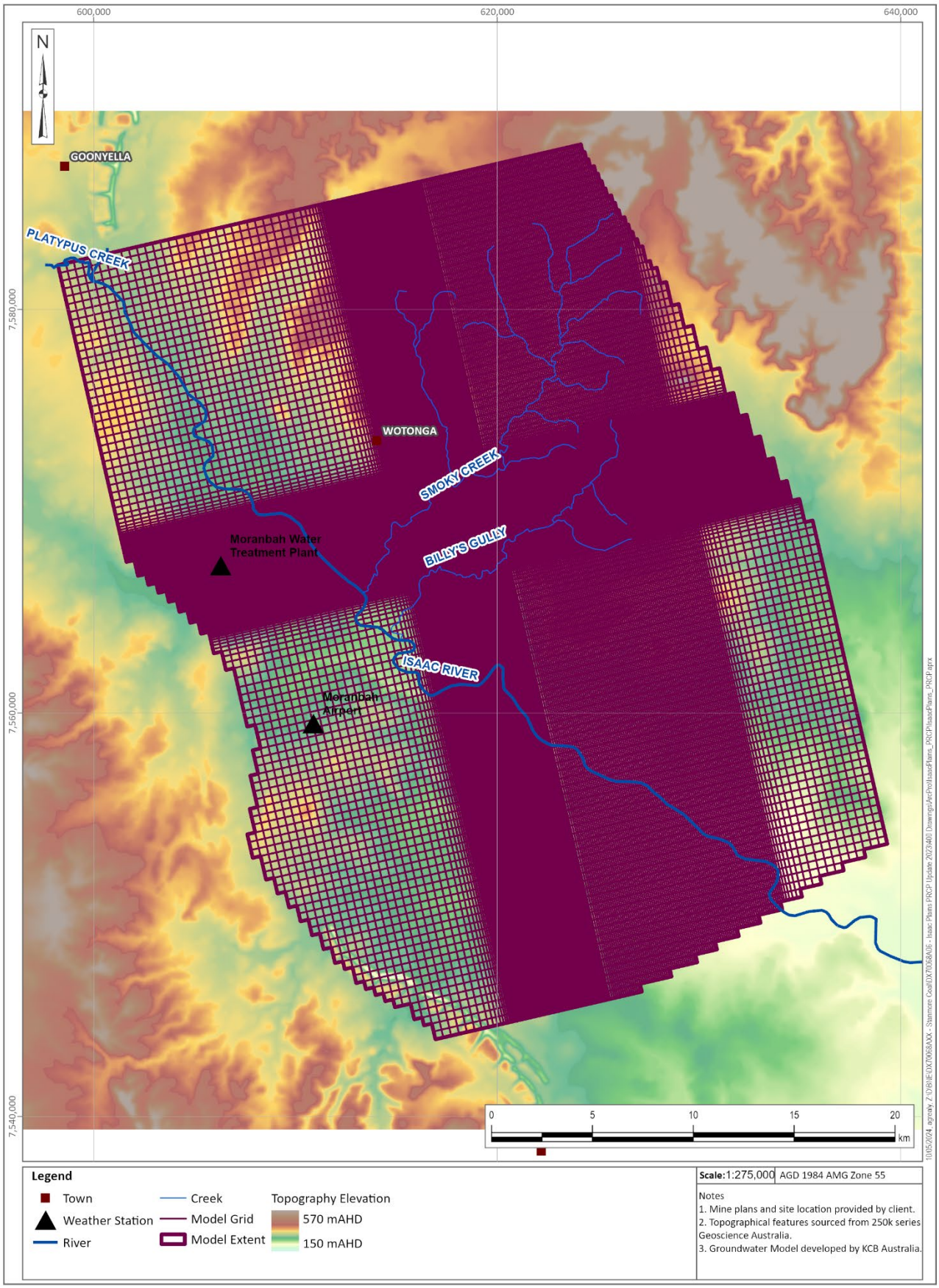


Figure IV-2.1 Model Grid Refinement

IV-2.4 Model Layering

The hydrostratigraphy of the study area was represented using 17 model layers that are continuous across the model domain. Discontinuity of the units is accommodated by applying hydraulic parameters of the underlaying units where appropriate. The uppermost model surface is defined by a digital elevation model (DEM) derived from 1 second Arc SRTM data provided by Stanmore. This DEM was blended with updated LiDAR derived elevations over the IPC, which was also provided by Stanmore.

Table IV-2.1 presents the model layers and the hydrostratigraphic units that are represented by each layer. The top two layers are used to represent the unconfined to semi-confined Quaternary and Tertiary units.

Both the Triassic Rewan Group and the Fort Cooper Coal Measures are distributed over five layers, on opposite sides of the thrust fault, to accommodate the extra layers that arise from displacements in the hydrostratigraphic units across the fault.

Table IV-2.1 Summary of Model Layers

Model Layer	Geology West of Isaac Thrust Fault	Geology East of Isaac Thrust Fault
1	Alluvium, Tertiary Sediments, Basalt	Alluvium, Tertiary Sediments, Basalt
2	Tertiary Sediments, Basalt	Tertiary Sediments, Basalt
3	Weathering Profile, Basalt	Weathering Profile
4	Pseudo layer - Rewan Group	Rewan Group
5	Pseudo layer - Rewan Group	Rangal Coal Measures - Overburden
6	Pseudo layer - Rewan Group	Rangal Coal Measures: Leichardt Seam
7	Pseudo layer - Rewan Group	Rangal Coal Measures - Interburden
8	Rewan Group	Pseudo layer – Rangal Coal Measures: Interburden
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14	Fort Cooper Coal Measures	Fort Cooper Coal Measures
15	Moranbah Coal Measures - Overburden	Moranbah Coal Measures - Overburden
16	Moranbah Coal Measures: Goonyella Middle Seam	Moranbah Coal Measures: Goonyella Middle Seam
17	Moranbah Coal Measures - Underburden	Moranbah Coal Measures - Underburden

The layer surfaces remain unchanged from the 2020 model, with layers derived from the following:

- Contours provided by Stanmore from the geological block models on both sides of the thrust fault and including depth of cover above the top of the Leichardt Seam, Leichardt seam floor and roof and base of Tertiary units.
- Borehole logs from Geological Survey of Queensland drilled investigation holes.
- Publicly available CSG drilling logs accessed from the QDEX database.
- Surfaces and data from the Bowen Basin Supermodel 2000.
- Outcrop locations of Permian formations from surface geology mapping.

IV-2.5 Boundary Conditions

Boundary conditions are mathematical statements within the model domain and along boundaries of the domain that specify the dependent variable (head) or the derivative of the dependent variable (flux). The following boundary conditions were established in the model:

Recharge

Rainfall Recharge was applied in zones based on the extents of outcropping geological units, using the RCH package of MODFLOW. Recharge is applied as the proportion of rainfall that passes through the unsaturated zone and arrives at the groundwater system. Within the numerical model recharge has been calculated as a percentage of historically recorded monthly rainfall totals. Seven recharge zones are defined, each of which has a unique recharge rate that reflects the hydraulic properties of the unit through which it infiltrates. The percentage of rainfall that enters the model as recharge in each zone was adjusted during calibration. The zones are defined by the extents/outcrop of Quaternary and Tertiary sediments, Tertiary basalt and Permian sediments, and are shown in Figure IV-2.2.

Evapotranspiration

Evapotranspiration can be a significant component of the water budget for the groundwater system. In this model, it has been implemented using the MODFLOW EVT package. A uniform extinction depth has been applied across the domain and set at 1.5 m below the natural surface, below which evaporative losses from the groundwater surface are zero. Where the groundwater elevation is above this level, water is removed from the system at a maximum rate of 1,200 mm/annum. This value is adopted from the average areal potential evapotranspiration map (BOM 2008) which is based on a standard 30-year climatology from 1961-1990.

General Head Boundary

General Head Boundary cells (GHB package) were applied around the active perimeter of the model domain. They are applied to all layers of the model. Use of this boundary type allows for the regional groundwater flow system to be better replicated in this semi-regional model. Conductance values applied to the GHB cells were calculated to be consistent with hydraulic conductivity values for each hydrostratigraphic unit and the dimensions of the boundary cells. A reference head for these cells was obtained from steady-state model heads in a pre-development scenario. This boundary is sufficiently distant from the study area so as not to materially influence model performance and results.

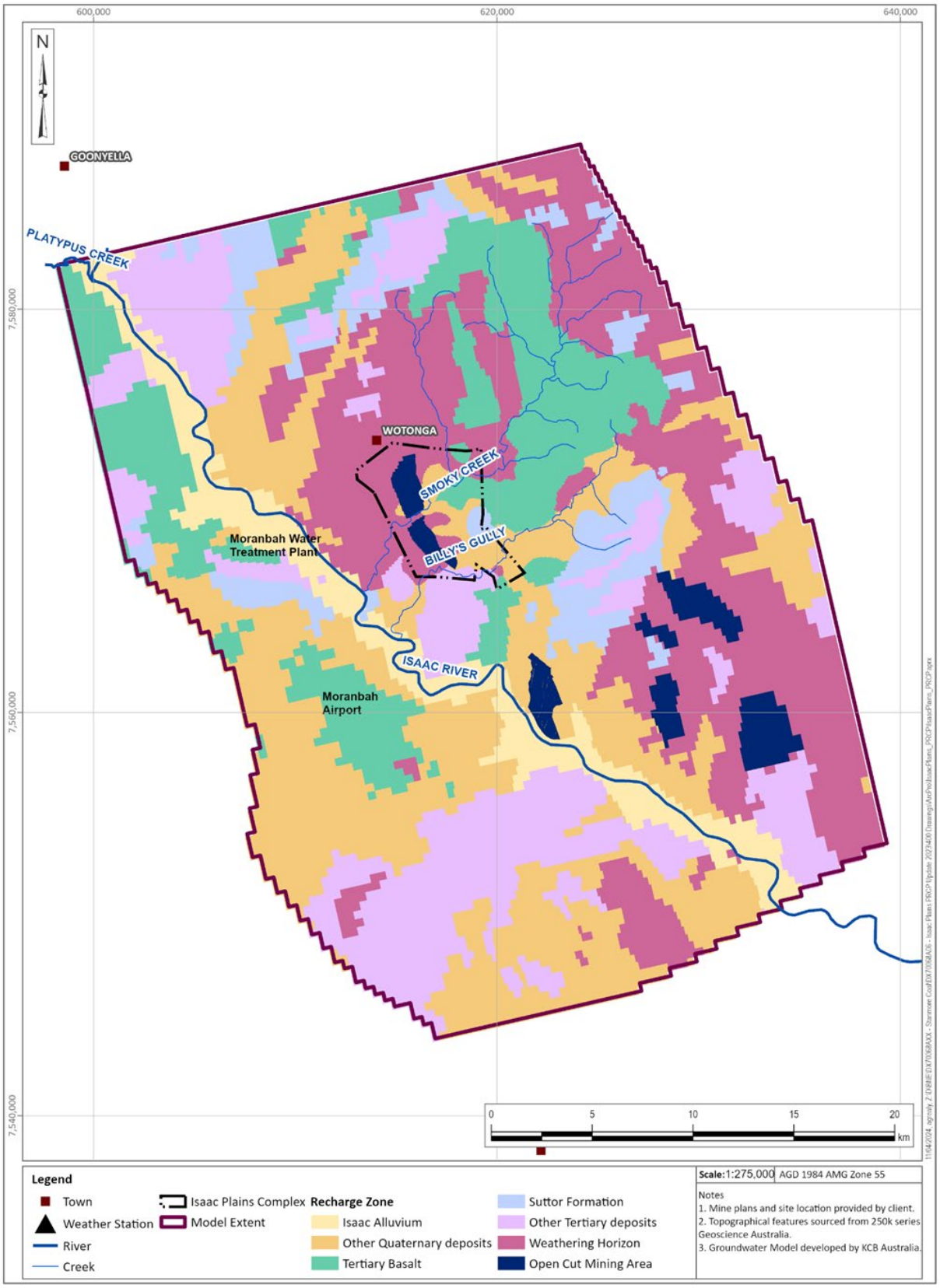

Figure IV-2.2 Recharge Zones Applied in the Model

Drains

The major watercourses in the model domain are represented using the MODFLOW drains package (DRN). The surface drainage system of the area is ephemeral in nature. When stream flows do occur, they are usually rapid and persist for short durations (1-2 days). Under these circumstances use of drains along these reaches is considered appropriate. In these cells the reference head was specified as the elevation of the model surface and a conductance was calculated to be consistent with the hydraulic conductivity and dimensions of the cell in which they are placed.

Drains cells have also been used to simulate open-cut and underground mining activities. For open-cut mining, drains are placed in all layers above and including the target seam layer. For the representation of underground mining, drains are placed in the target seam only. Reference heads were specified as the elevation at the bottom of the layer in which drain cells were placed, while conductance values for these cells were nominally set higher than 10 m^2/d.

No Flow Boundary

The default, no flow boundary condition is applied along the base of the model domain which coincides with the interface between the Moranbah Coal Measures and the Back Creek Group.

IV-2.6 Model Timing

The following model timing was incorporated:

- Calibration: January 2015 to June 2023
- Operations: June 2023 to December 2036
- Closure: January 2037 to January 3037 (1,000 years).

The 2020 model calibration focused on parameter estimation over the period January 2015 to April 2020, the current model update extended the calibration to 2023. The model incorporates a monthly stress period.

IV-2.7 Calibration Overview

Model calibration was performed by adjusting the model parameter values to better replicate the historical observations of the system. The outcome of the calibration process also provides the initial conditions for transient predictive simulations used to assess potential impacts of closure on the groundwater regime.

IV-2.7.1 Calibration Approach

The location of the IPC within this area of the Bowen Basin has numerous adjacent mining operations that have been in operation for some time. The 2020 model calibration focused on parameter estimation over the period January 2015 to April 2018. The 2023 model update extended the calibration to include data from 2018 to June 2023.

The 2020 calibration model was initially simulated in steady-state conditions with boundary conditions applied to replicate known mining development at the beginning of 2020. This includes the open pits of the Isaac Plains Mine; Moranbah North Mine underground mine; Poitrel,

Millenium and Daunia open pit mines; and Carborough Downs underground mine. The 2020 steady-state model remains valid, and no changes were implemented as part of the current calibration.

Following this initial model conditioning period, the model transitions to transient mode in which monthly stress periods are applied. This stress period length allows the inclusion of seasonal, climatic variations in rainfall records. All observations used as calibration targets pertain to the transient component of the simulation.

Automatic parameter estimation was implemented with the use of PEST (Doherty, 2016a). In all, 82 adjustable parameters were used, including hydraulic conductivities, storage properties and recharge factors.

IV-2.8 Calibration Targets

All observations that comprise the calibration dataset are water level measurements. These measurements were compiled from 18 monitoring bores for which reliable groundwater level records were available over the transient simulation period. Monitoring data from 11 electronic dataloggers data were used for the 2020 model calibration, while data from 2020 to 2023 include manual monthly water level measurements.

IV-2.9 Calibration Results

IV-2.9.1 Summary

Figure IV-3.1 presents a comparison between observed groundwater level records and the simulated groundwater levels. During calibration, all measurements of the calibration dataset were given equal weighting, thereby seeking to extract maximum information from the calibration dataset in inference of parameters.

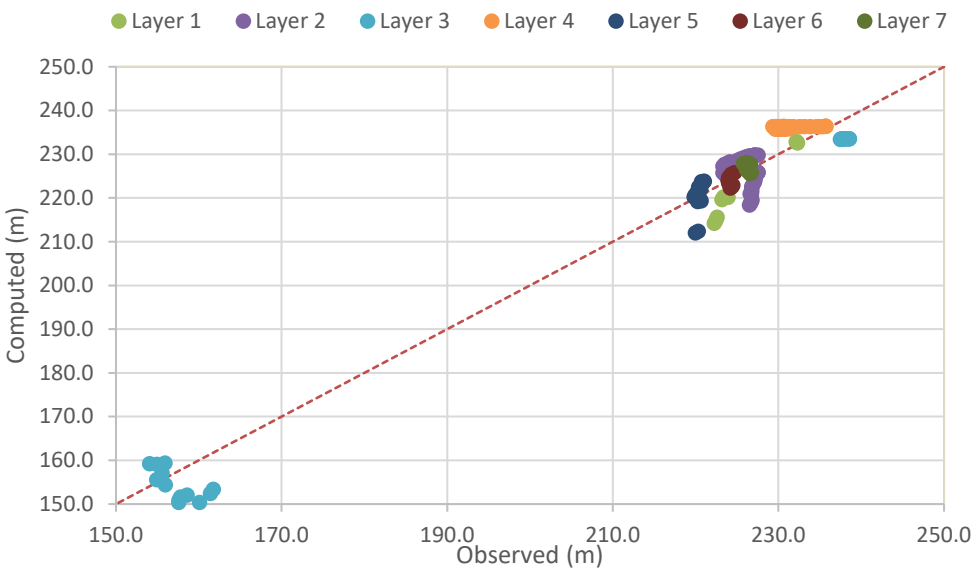

Figure IV-2.3 Transient Calibration Observed versus Computed Heads

Table IV-3.1 presents the calibration performance statistics from the calibration process. A key metric from the performance statistics is the scaled root Mean Square (SRMS) of errors which is 4%. This value is within the guidance limits recommended by the Australian Groundwater Modelling Guidelines (Barnett et al. 2012) of 10% SRMS.

Table IV-3.2 Summary Model Calibration Performance

Statistical Metric	Value
RMS error (m)	4.6
Scaled RMS (%)	5.5
Mean Sum of Residuals (m)	0.1

IV-2.9.2 Modelled Hydrographs

Hydrographs showing observed versus simulated groundwater levels are provided in Figure IV-3.2.

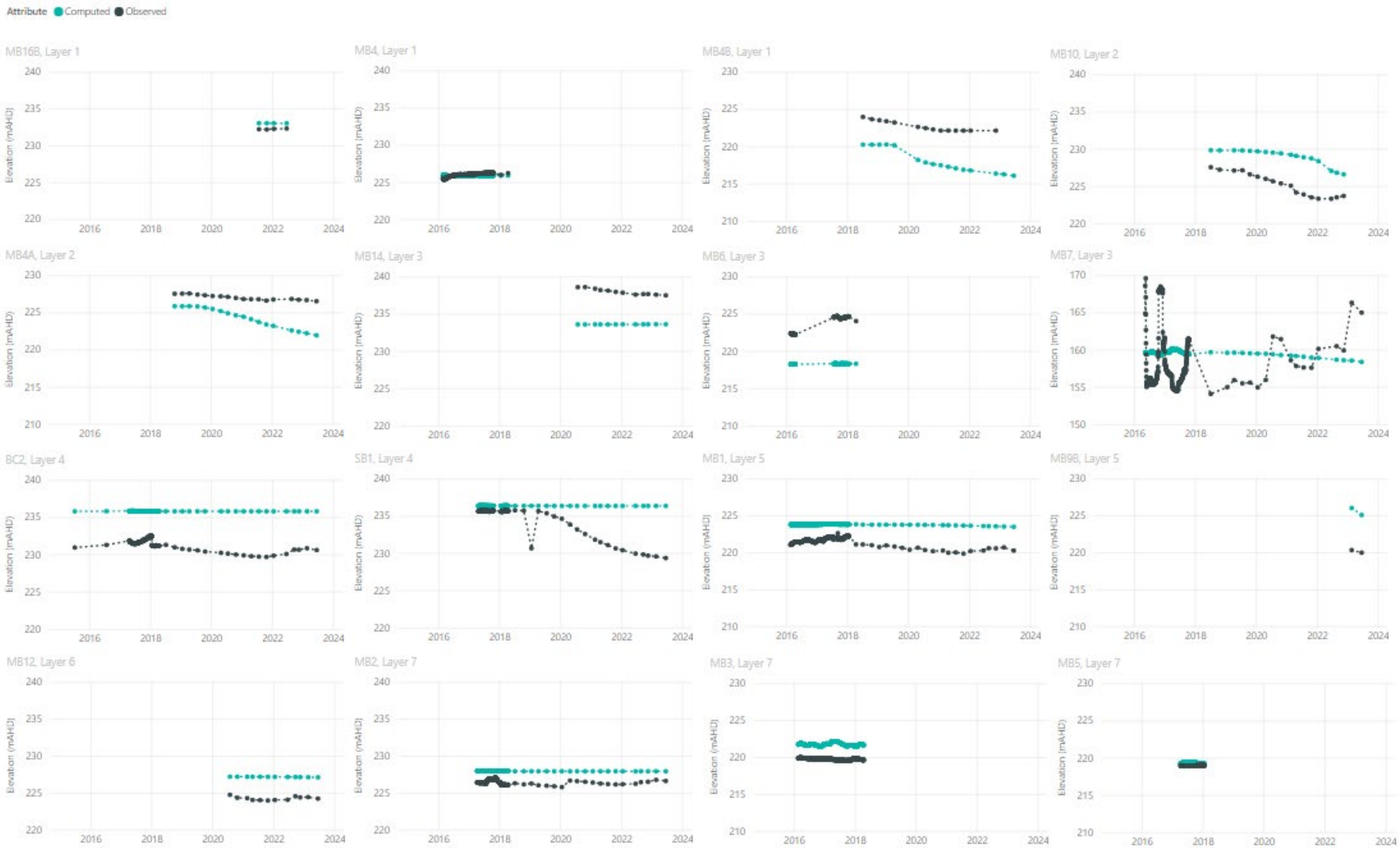

Figure IV-2.4 Groundwater Bore Hydrographs for the Transient Calibration – Simulated and Observed Hydrographs

IV-2.9.3 Calibrated Parameters

Table IV-3.2 summarises calibrated hydraulic property values for each hydrostratigraphic unit represented in the model. Hydraulic conductivity values of the Permian-age coal seams vary in accordance with the specified depth dependent relationship. As such the values presented in Table IV-3.2 for the Leichardt, Vermont and Goonyella Middle Seams are average values arising in the vicinity of the proposed project. Similarly, the vertical hydraulic conductivity values presented in this table also represent average values for the aforementioned coal seams.

Table IV-3.3 Summary Calibrated Hydraulic Properties

Geological Unit	Calibrated Kxy (m/d)	Calibrated Kz (m/d)	Calibrated Specific Yield (-)	Calibrated Specific Storage (m^{-1})
Isaac River Alluvium	4.2000	0.8650	1.55E-01	1.02E-04
All other Quaternary Deposits	0.5195	0.5195	4.98E-02	2.00E-05
Tertiary Basalt	0.3086	0.1582	5.02E-02	1.90E-04
Suttor Formation	0.0196	0.0020	5.00E-04	1.80E-05
All other Tertiary deposits	0.0102	0.0102	4.01E-04	1.61E-05
Weathered Horizon	0.6859	0.3551	3.98E-04	1.70E-05
Rewan Group	0.0153	0.0144	4.09E-04	1.59E-05
Rangal Coal Measures - Overburden/Interburden	0.0023	0.0003	4.01E-04	1.65E-05
Rangal Coal Measures: Leichardt Seam	0.2500*	0.0220*	4.00E-04	1.62E-05
Rangal Coal Measures: Vermont Seam	3.80E-04*	3.03E-05*	4.00E-04	1.60E-05
Fort Cooper Coal Measures	1.65E-03	3.11E-04	4.00E-04	1.60E-05
Moranbah Coal Measures - Overburden/Interburden	2.08E-04	2.17E-05	4.00E-04	1.60E-05
Moranbah Coal Measures: Goonyella Middle Seam	2.10E-05*	3.10E-06*	1.07E-02	5.65E-06
Thrust Fault	1.00E-04	1.20E-04	5.00E-02	6.67E-06

Note: Hydraulic Conductivity values for coal seams are depth dependant; "*"indicates that reported values are average values across proposed project site.

Recharge to the model domain was calculated as a percentage of recorded rainfall within the model domain during each stress period of the calibration model run. During the steady-state conditioning period, long-term average annual rainfall was converted to daily rainfall, while during the quarterly, transient periods, recorded quarterly rainfall totals were used to calculate average daily rainfall for that period. The percentage of this average daily rainfall that results as recharge were estimated during calibration and these are provided in Table IV-3.3.

Table IV-3.4 Summary Calibrated Recharge Rates

Modelled Recharge Zone	Percentage (%) of Rainfall
Quaternary Alluvium	0.53
Other Quaternary deposits	0.72
Tertiary Basalt	0.56
Suttor Formation	0.14
Other Tertiary deposits	0.25
Weathered Horizon	0.04

IV-2.9.4 Sensitivity Analysis

As part of the 2020 IPC model (KCB, 2020), a sensitivity analysis was performed to assess the response of the model to varying hydraulic properties.

Parameters that were assessed during predictive sensitivities were grouped and varied in the following manner:

- Horizontal (Kh) and vertical (Kv) hydraulic conductivity of all layers was varied by 50% above and below their calibrated values; and
- Specific storage (Ss) and specific yield (Sy) values for all layers was varied by 50 % above and below their calibrated values.

For the current model update an additional sensitivity analysis scenario was undertaken to assess the response of the model to a change in recharge, which was varied in accordance with the following:

- Recharge (Re) varied by a 50% decrease (half) and a 100% increase (double) from the calibrated values.

IV-3 MODEL PREDICTIONS

IV-3.1 Predictions Overview

Simulations to support the PRCP included two stages:

1. Simulation of the remaining operations from the end of the calibration period (June 2023) to the end of operations (December 2036).
2. Simulation of post-closure for a period of 1,000 years.

IV-3.2 Remaining Operations Simulation

IV-3.2.1 Model Set-Up

A predictive simulation was undertaken until the end of operations in 2036 using the calibrated transient model. This included the remaining proposed open-cut and underground mining operations.

The simulation comprised quarterly stress periods for a seven-year duration starting at the final time step of the transient calibration. Boundary conditions were retained from the transient model.

IV-3.2.2 Final Water Table

Figure IV-4.1 presents the predicted water table elevation for the end of operations at IPC in 2036. This figure presents areas of drawdown associated with the mining activities in proximity to the underground mining areas and voids.

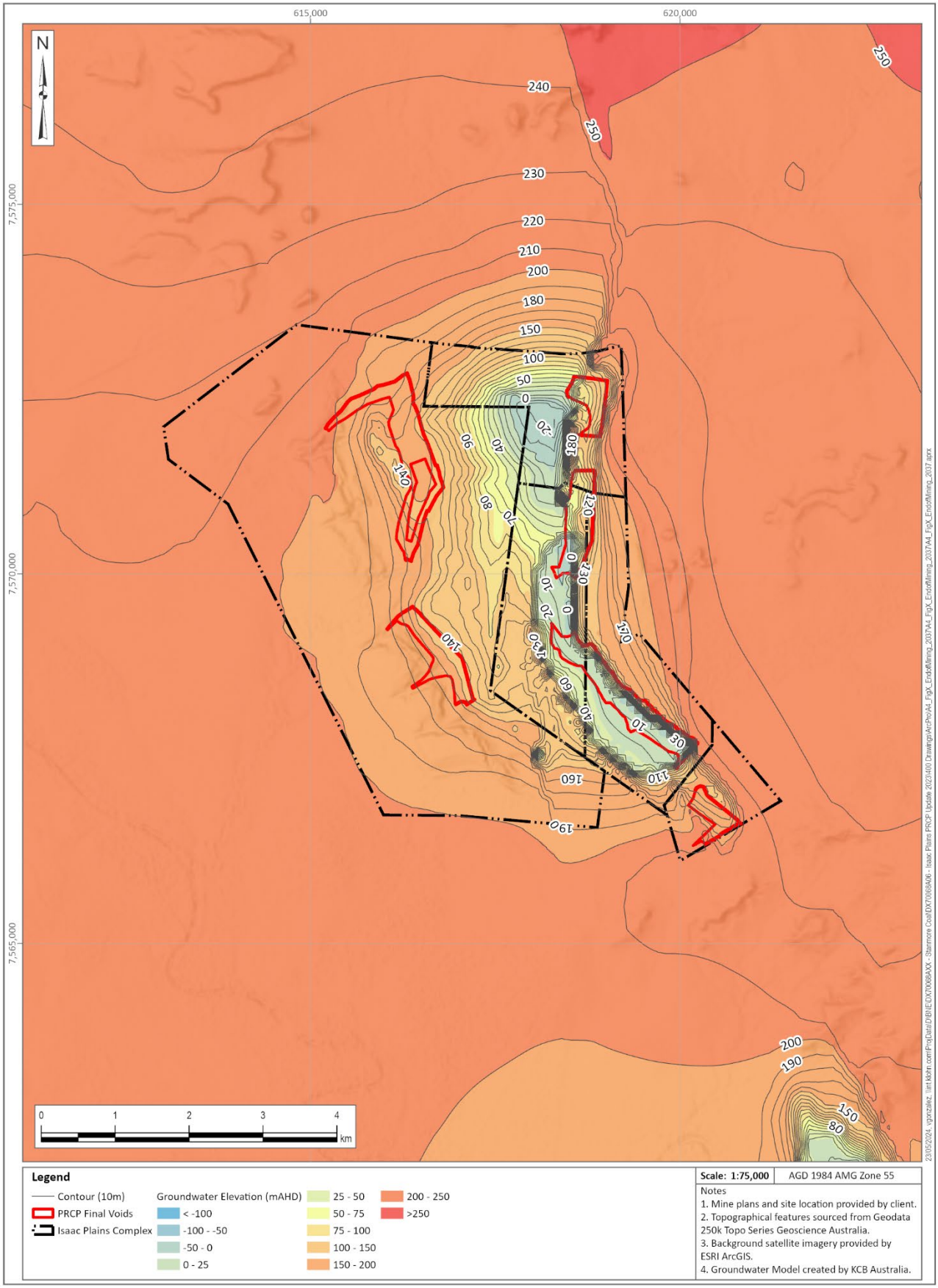

Figure IV-3.1 End of Operations Water Table Elevation (2036)

IV-3.3 Post-Closure Conditions

The simulation of post-closure groundwater conditions was undertaken to assess the groundwater conditions associated with recovery and the proposed post-closure landforms.

The model was modified as follows:

- The top surface of the model was updated to reflect the proposed post-closure landform, as shown in Figure IV-4.2.
- All active drains used to simulate underground and void dewatering were removed in the model to allow the system to recover.
- Recharge and evapotranspiration (1233 mm/year) were applied to the voids. Note that evaporation exceeds rainfall in all months of the year.
- Void backfill/spoil was included in the closure modelling and represented by a hydraulic conductivity of 5 m/day.

This simulation was conducted for a 1,000-year duration to allow groundwater levels to recover to equilibrium / steady-state conditions. The post-closure water table provided in Figure IV-4.3 for 50-, 100-, 500-, and 1,000 years post-closure.

An assessment of the source / sink trigger elevation for each of the pit void was undertaken previously (KCB 2020, WRM 2020). This trigger elevation represents the “spill point” for each pit void, where any water level elevation above the trigger elevation represented discharge from the pit void to the downstream environment, while any water level elevation below the trigger elevation resulted in localised groundwater flow towards the pit void. These predicted source / sink trigger elevations for each pit void are also provided in Table IV-4.1.

Table IV-4.1 Post-Closure Steady-state Pit Void Water Levels

Pit Void	Post-Closure Void Water Elevation (mAHD)	Pit Void Source / Sink Trigger Elevation
N1	197.5	217.0
S2	190.8	213.8
E2/E3	204.9 & 203.7	232.0
E4	201.1	229.6
5	202.1	228.5
E1	203.8	217

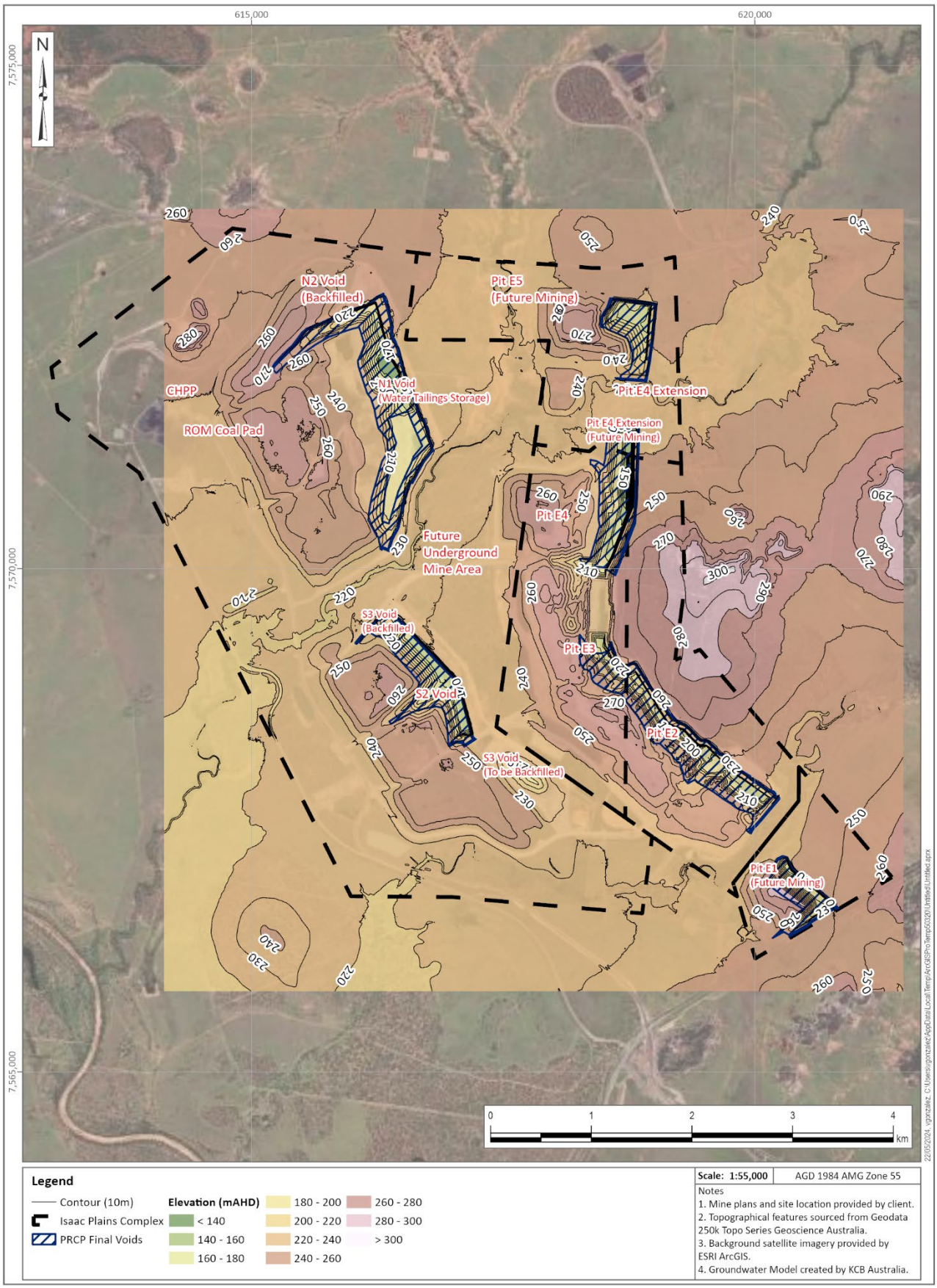

Figure IV-3.2 Final Landform Surface Topography

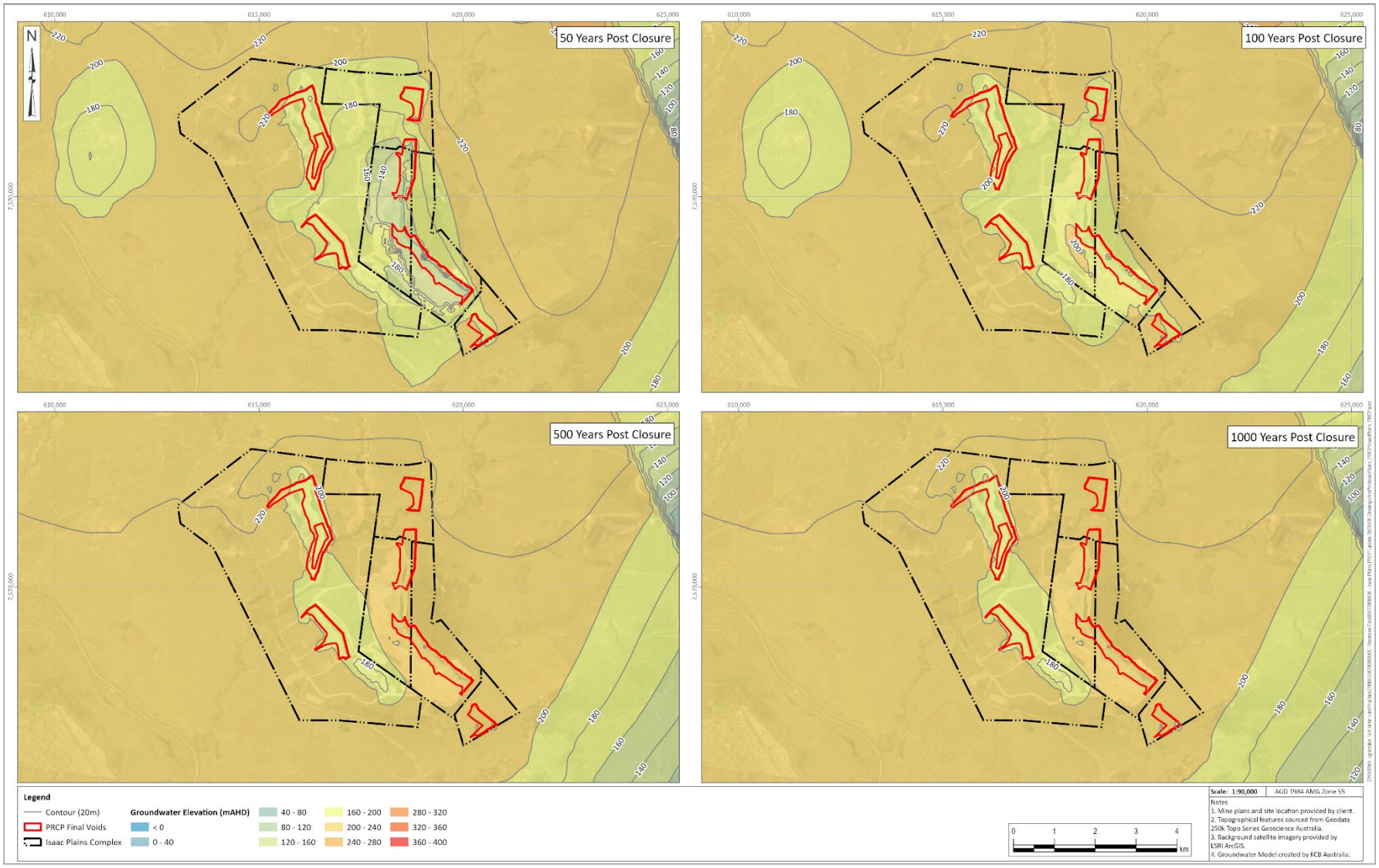

Figure IV-3.3 Post-Closure Water Table – 50, 100, 500 and 1,000-Years Post-Closure

The final void water levels for the post-closure period (2037 to 3037) are present in Table IV-4.1 and water level recovery is illustrated in Figure IV 3.4. The final void water levels stabilise within 700 years post-closure.

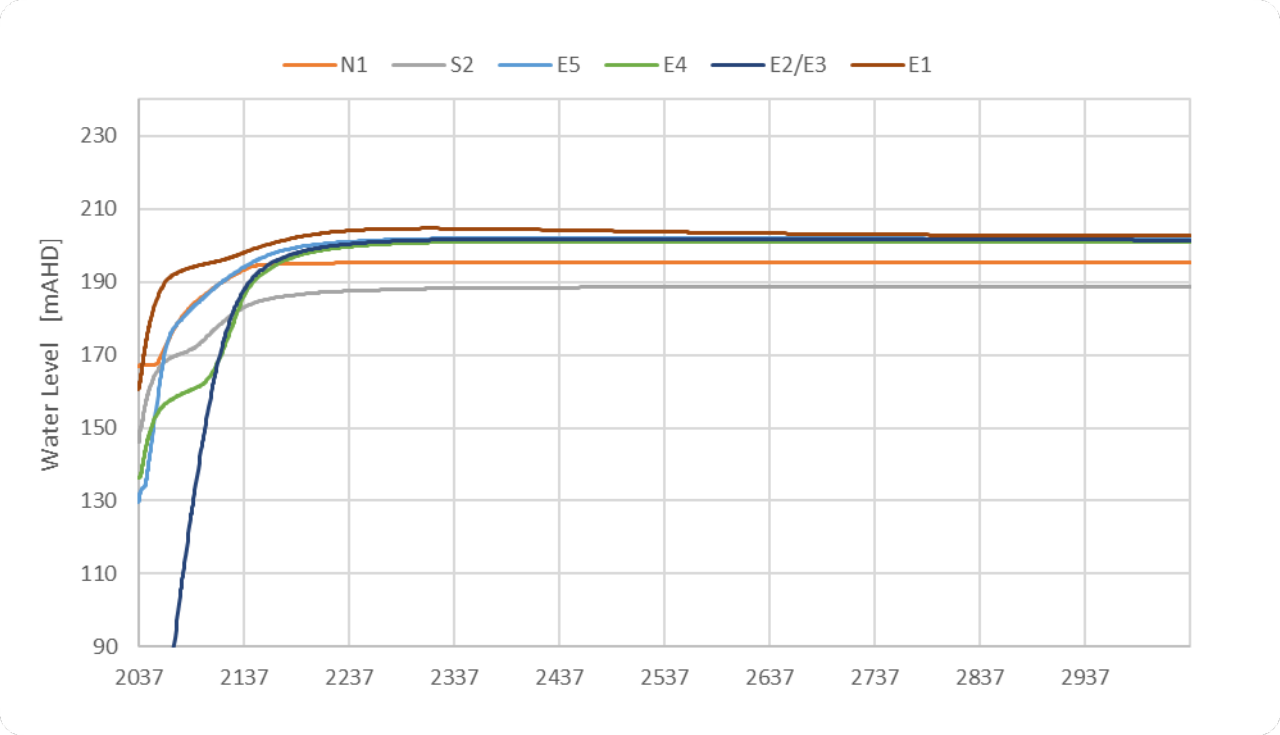

Figure IV 3.4 Final Void Water Levels Post-Closure

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APPENDIX P GEOTECHNICAL ASSESSMENT FINAL VOIDS

STANMORE RESOURCES LIMITED

GEOTECHNICAL ASSESSMENT OF ISAAC PLAINS AND ISAAC PLAINS EAST FINAL VOIDS FOR REHABILITATION PURPOSES

January 2025

GeoTek Solutions Pty Ltd
ABN 84 090 367 409

STANMORE RESOURCES LIMITED

GEOTECHNICAL ASSESSMENT OF

ISAAC PLAINS AND ISAAC PLAINS EAST FINAL VOIDS FOR

REHABILITATION PURPOSES

January 2025

GeoTek Solutions Pty Ltd
Report Ref.: gts_ip&ipe_2025_prcp_geotech, v1

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SUMMARY

This report presents the results of stability analyses of currently proposed final landforms within the Isaac Plains (IP) and Isaac Plains East (IPE) mines for inclusion in the PRCP. A previous report was prepared in 2022 (GeoTek Solutions, 2022). The current report has been expanded to include IPE1 and 5 which were not previously considered. In addition, there have been some changes to the proposed final landforms and estimated water levels in the voids and this has required a revision of the earlier analyses and report.

The nominated target geotechnical factor of safety (FOS) for the final voids landforms is 1.50. Where the calculated values have not achieved this value, alternatives have been explored and recommendations are provided.

All of the highwalls in fresh rock achieved a FOS ≥ 1.50.

Over steepened, highly weathered and soil horizons at the top of highwalls typically have FOS values < 1.50. However, these horizons are usually just a few metres thick. For mining purposes, they were designed to batter angles of around 45° and could be re-shaped or be allowed to erode back to a geotechnically stable slope of around 27° (1V in 2H).

All of the overburden dumps in which the base of the spoil is not inundated by a final void lake have critical FOS values ≥ 1.50.

All of the overburden dumps in which the base of the spoil is inundated to a substantial depth have a critical FOS <1.50 for circular modes of failure. When the 2022 iteration of this report was produced it became evident that where a FOS of 1.5 was not achieved the cheapest and lowest risk solution was to stove down the spoil at angles in the range of 18° to 25°Consequently, this is the only solution that is explored in this report where the minimum FOS was not achieved initially.

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LIST OF ABBREVIATIONS

Abbreviation	Description
AMG84z55	Australian Map Grid 1984, Zone 55
FOS	Factor of Safety
GLE/M-P	Generalised Limit Equilibrium/Morgenstern-Price
GTS	GeoTek Solutions Pty Ltd
GWL	Groundwater Level
ID	Isaac Downs
IP	Isaac Plains
IPC	Isaac Plains Complex includes IP and IPE
IPE	Isaac Plains East
mAHD	Metres above Australian Height Datum
POF	Probability of Failure
PRCP	Progressive Rehabilitation and Closure Plan
Stanmore	Stanmore Resources Ltd
TSF	Tailings Storage Facility
YT	Yarrabee Tuff

1 INTRODUCTION

The Isaac Plains (IP) and Isaac Plains (IPE) coal mines are located approximately 170 km southwest of Mackay. Collectively the two mines are referred to as the Isaac Plains Complex (IPC). Each mine contains multiple discrete pits as shown in Figure 1. Mining is complete in IP. Within IPE mining is being undertaken in IPE5 at the northern end of the mine and there is a remote possibility that IPE1 at the southern end of the mine may be mined in the future.

Stanmore is producing an updated PRCP. A previous report was prepared in 2022 (GeoTek Solutions, 2022). The current report has been expanded to include IPE1 and IPE5 which were not previously considered. In addition, there have been some changes to the proposed final landforms and estimated water levels in the voids and this has required a revision of the earlier analyses and report. This report presents the results of stability analyses of the proposed final landforms. The work has been carried out to check for geotechnical factors of safety (FOS) and, where the calculated FOS is less than 1.50, to provide suggestions to achieve the required stability factors. From a FOS perspective, the critical landforms are spoil dumps which become submerged and saturated by rising groundwater in the final voids lakes.

Thirty-two (32) cross-sections were analysed at locations shown in Figure 1.

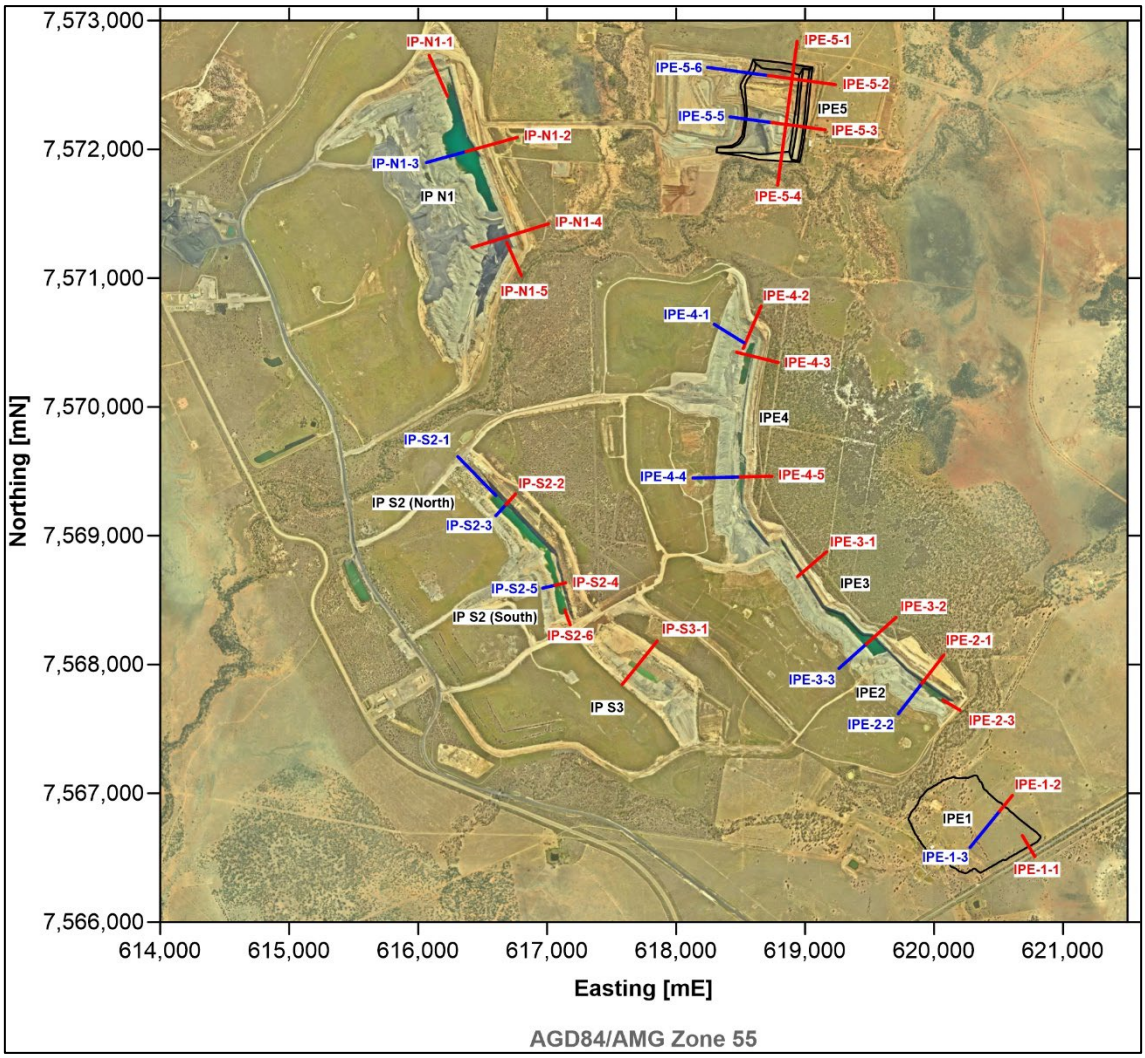


Figure 1. Plan of IP and IPE showing locations of cross-sections analysed for stability (9 September 2024; photo courtesy of Stanmore).

2 GEOLOGY

The target coal at IPC has principally been the Leichhardt Seam and some of the underlying Vermont Seam plies. The coal occurs within the upper Permian age Rangal Coal Measures. A simple stratigraphy is presented in Figure 2.

The Vermont Seam occurs at varying depths beneath the Leichhardt Seam and the Vermont Seam is divided into the Vermont Upper and Vermont Lower, separated by the Yarrabee Tuff (YT). The YT is not ubiquitous having been eroded from some areas, presumably soon after it had been deposited as an ash fall.

The Leichhardt overburden consists mainly of siltstone with interbedded sandstone. A massive claystone bed, typically within 20 m of the top of the last coaly band may mark the upper limit of the Permian strata and the Great Extinction. The sandstone above the claystone marker horizon is assigned to the Triassic Rewan Group.

There is a veneer of unconsolidated Cenozoic sediments. Localised Tertiary age basalt occurs, notably in IPE2 and IPE5.

The Isaac Plains Thrust subcrops between IP and IPE. It is a regional east-over-west thrust fault with a throw in the order of 200 m. It is probably an extension of the larger Burton Range Thrust. Apart from some fault disruptions, the strata dip uniformly towards the east at angles of around 4°: The shallow dip and low frequency of major faults has favoured the use of a dragline for overburden removal in the larger pits.

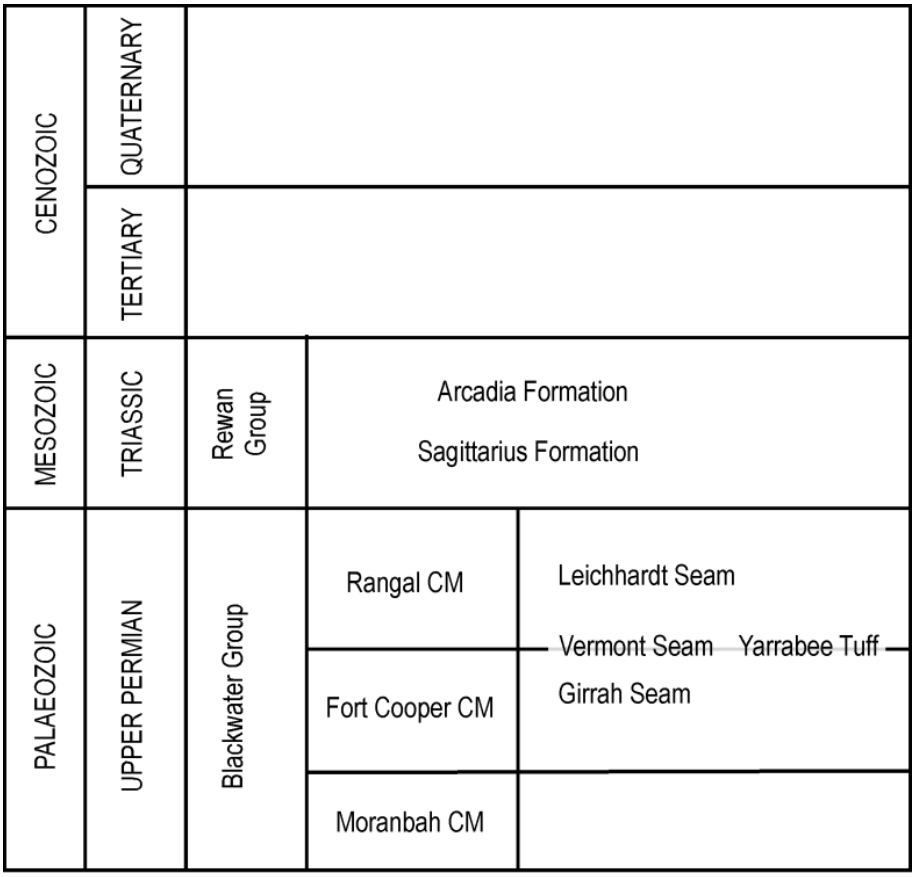


Figure 2. Generic stratigraphy for the Isaac Plains and Isaac Plains East mines.

3 FINAL VOIDS WATER LEVELS

Revised final voids water levels were received from Stanmore (Email 13/06/2024) and are shown in Table 1. No analysis has been provided for IP-S3 because it is planned to backfill the existing void.

For the purposes of the stability analyses the estimated maximum water levels after 100 years have been used in the stability analyses.

Table 1. Predicted final voids long-term water levels.

Pit	Final Void Water Level (mAHD)
IP-N1	197.5
IP-S2	190.8
IPE-1	203.8
IPE-2	204.9
IPE-3	203.7
IPE-4	201.1
IPE-5	202.1

All the pits were originally designed with a target FOS ³ 1.20 for both the highwalls and lowwalls during mining. This is standard industry practice (Read & Stacey, 2009).

Quarterly inspections carried out by GeoTek Solutions since 2012 have confirmed that both lowwalls and highwalls have performed to expectation.

The lowwalls have remained stable overall but have eroded where they have remained unvegetated and exposed to intense rainfall. The highwalls have remained stable overall. The finer grained strata in the Leichhardt overburden have weathered and undercut more resistant bands of sandstone resulting in some blocks of sandstone dropping out of the highwalls. This is likely to continue. The upper horizons of highly weathered rock and unconsolidated sediments have eroded causing their slope angles to retreat to longer term stable angles of around 30 to 35°. The soily horizons, which generally form a thin surficial layer, are expected to continue to erode, particularly when affected by concentrated surface flow.

In the absence of any major structure the fresh sedimentary strata exposed in the highwalls are considered to be stable with FOS values normally in excess of 1.50 to 1.80 because of the high strength of the strata. The finer grained lithologies exposed in the highwalls are susceptible to weathering and in the long term the weathering will undercut more resistant bands of sandstone but will not detract from overall stability. The upper strata consist of highly weathered in situ rock and/or unconsolidated sediments and are likely to be susceptible to circular modes of failure, particularly where the batters have been cut at steep angles which is common.

4 STABILITY ANALYSIS METHOD

Geological grids and topography triangulations were provided by Stanmore. The surface topography that was used is:
Documents > 02. Survey Data > Aerial Surveys > Isaac Plains Complex - September 2024 > IsaacPlains_LiDAR_20240909_AMG84.00t.

The file extends to ID and so was cropped to IP and IPE to make it more manageable and named:
IP&IPE_PRCP_240909_Topo.00t

Other triangulations that files that were used were:
IPE5_Final_Void_241030.00t
IPE1_Final_Void_230706.00t.

Thirty-two (32) cross-sections were created along the existing pit voids in IP and IPE, as shown in Figure 1.

The cross-sections were digitised and imported into the industry standard 2D limit equilibrium slope stability program Slide2 v9.036 (Rocscience, 2024).

Shear strength values for the various horizons are based substantially on Simmons & McManus (2004), extensive prior experience at IP and IPE, and more broadly from across the Bowen Basin. Table 2 shows the material properties used in the stability analyses.

Table 2. Material properties used in the stability analyses.

Material Name	Colour	Unit Weight (kN/m^3)	Strength Type	Cohesion (kPa)	Friction (deg)	Water Surface	Hu Type
Cat 2.5 U Spoil		18	Mohr-Coulomb	40	29	Water Surface	Automatically Calculated
Cat 2.5 S Spoil		20	Mohr-Coulomb	17.5	24	Water Surface	Automatically Calculated
Cat 3U Spoil		18	Mohr-Coulomb	50	30	Water Surface	Automatically Calculated
Cat 3S Spoil		20	Mohr-Coulomb	20	25	Water Surface	Automatically Calculated
HW Sedimentary Rock		20	Mohr-Coulomb	30	27	Water Surface	Automatically Calculated
DW Sedimentary Rock		22	Mohr-Coulomb	100	30	Water Surface	Automatically Calculated
FR Sedimentary Rock		24	Mohr-Coulomb	450	42	Water Surface	Automatically Calculated
FR Coal		15	Mohr-Coulomb	30	35	Water Surface	Automatically Calculated
Weak Layer		20	Mohr-Coulomb	5	12	Water Surface	Automatically Calculated
DW Sedimentary Rock Blasted		22	Mohr-Coulomb	40	30	Water Surface	Automatically Calculated
FR Sedimentary Rock Blasted		22	Mohr-Coulomb	100	30	Water Surface	Automatically Calculated

U=Unsaturated; S=Saturated; FR=Fresh; DW=Distinctly Weathered; HW=Highly Weathered

Existing dumps have been characterised as comprised of Cat 2.5 spoil.

Spoil failures during production are most likely to be non-circular type failures on a weak basal plane. Once the spoil becomes inundated within a final void lake, circular failure is considered the more likely mode of failure. Selecting a circular mode of failure in the stability analyses results in a lower i.e., more conservative FOS and this method of analysis has been used for the spoil.

Circular failure analysis was also used for the highwalls. It is recognised that this is imperfect but in the absence of alternative practical options is considered to be reasonable and the method has been used many times previously to provide indicative stability factors for highwalls.

The circular failure surfaces were generated using the GLE/Morgenstern-Price (GLE/M-P) method of analysis and the search for the critical surfaces was carried out using the Auto Refine search method that is embedded in Slide2. Searches were also run using the Auto Grid search method as a check for the integrity of the results and, as expected, almost identical results were obtained from both search methods in terms of identification of the critical failure surface and its FOS.

5 SUMMARY OF FOS RESULTS

The results of the stability analyses are summarised in
Table 3. Results have been colour coded as:

FOS < 1.19 red

FOS 1.20 – 1.49 orange

FOS ≥ 1.50 green

Table 3 shows the FOS calculated for the existing geometry and where the FOS did not achieve a value of 1.50 the existing geometry was modified.

In the case of waste dumps, the existing profiles were modified by reducing the slope angles until a value ≥ 1.50 was achieved. It had been found that utilising adequate toe buttresses was a much more expensive solution than reducing the spoil slopes to a sufficiently flat angle.

In the case of highwalls the issue was primarily within the over-steepened soil and highly weathered horizons. These can be remediated by flattening the horizon to 27° or by allowing sufficient space for the ground to erode to this angle. Exclusion bunds or fences would need to be set far enough back from the existing crest to allow for such crest retreat.

Selected output plots displaying the results are presented in Section 6 below.

Table 3. Table of critical FOS values.

Cross-Section	GWL (mAHD)	Wall	Description	Failure Surface	FOS
IP N1 Pit					
IP-N1-1	197.5	Endwall	Existing endwall	Circular	1.65
IP-N1-2	197.5	Highwall	Existing highwall	Circular	2.39
IP-N1-3	197.5	Lowwall	Existing lowwall	Circular	1.01
IP-N1-3	197.5	Lowwall	Existing lowwall - regraded to 18°	Circular	1.52
IP-N1-4	197.5	Highwall	Existing highwall	Circular	2.31
IP-N1-5	197.5	Endwall	Existing endwall	Circular	2.02
IP S2 Pit					
IP-S2-1	190.8	Endwall	Existing endwall - backfill batter 33°	Circular	1.32
IP-S2-1	190.8	Endwall	Existing endwall - backfill batter regraded to 27°	Circular	1.53
IP-S2-2	190.8	Highwall	Existing highwall - final void lake	Circular	1.58
IP-S2-3	190.8	Lowwall	Existing lowwall	Circular	1.10
IP-S2-3	190.8	Lowwall	Existing lowwall - batter regraded to 20°	Circular	1.50
IP-S2-4	190.8	Highwall	Existing highwall - final void lake	Circular	1.68
IP-S2-5	190.8	Lowwall	Existing lowwall - batter at 31°	Circular	1.14
IP-S2-5	190.8	Lowwall	Existing lowwall - batter regraded to 20°	Circular	1.55
IP-S2-6	190.8	Endwall	Existing softwalled endwall	Circular	1.36
IP-S2-6	190.8	Endwall	Existing softwalled endwall - highly weathered horizon batter regraded to 27°	Circular	1.66
IP S3 Pit					
IP-S3-1	190.8	Lowwall	Lowwall backfilled - floor level increased to 200 mAHD – slope regraded to 25%	Circular	3.04
IP-S3-1	190.8	Highwall	Highwall backfilled - floor level increased to 200 mAHD – slope regraded to 15%	Circular	3.88

Cross-Section	GWL (mAHD)	Wall	Description	Failure Surface	FOS
IPE 1 Pit					
IPE-1-1	203.8	Endwall	Proposed endwall backfilled to bench level - Tertiary basalt batter 36°	Circular	2.89
IPE-1-2	203.8	Highwall	Proposed highwall - final void lake	Circular	2.47
IPE-1-3	203.8	Lowwall	Proposed lowwall - batter at 37°	Circular	0.99
IPE-1-3	203.8	Lowwall	Proposed lowwall - batter regraded to 23°	Circular	1.51
IPE 2 Pit					
IPE-2-1	204.9	Highwall	Existing highwall - final void lake	Circular	3.02
IPE-2-2	204.9	Lowwall	Existing lowwall	Circular	1.19
IPE-2-2	204.9	Lowwall	Existing lowwall - batter regraded to 20°	Circular	1.50
IPE-2-3	204.9	Endwall	Existing endwall - final void lake	Circular	2.47
IPE 3 Pit					
IPE-3-1	203.7	Highwall	Existing highwall - final void lake	Circular	2.27
IPE-3-2	203.7	Highwall	Existing highwall - final void lake	Circular	2.00
IPE-3-3	203.7	Lowwall	Existing lowwall	Circular	1.33
IPE-3-3	203.7	Lowwall	Existing lowwall	Non-Circular	1.57
IPE-3-3	203.7	Lowwall	Existing lowwall spoil - batter regraded to 25°	Circular	1.51
IPE-3-3	203.7	Lowwall	Existing lowwall spoil - batter regraded to 25°	Non-Circular	1.79

Cross-Section	GWL (mAHD)	Wall	Description	Failure Surface	FOS
IPE 4 Pit					
IPE-4-1	201.1	Lowwall	Existing lowwall - lower batter	Non-Circular	2.11
IPE-4-1	201.1	Lowwall	Existing lowwall - upper batter	Non-Circular	1.68
IPE-4-2	201.1	Endwall	Existing endwall - partially backfilled with final void lake	Circular	2.20
IPE-4-3	201.1	Highwall	Existing highwall - final void lake	Circular	2.59
IPE-4-4	201.1	Lowwall	Existing lowwall easternmost external batter	Non-Circular	1.39
IPE-4-4	201.1	Lowwall	Existing lowwall easternmost external batter - batter regraded to 31°	Non-Circular	1.55
IPE-4-4	201.1	Lowwall	Existing lowwall eastern internal batter	Circular	1.62
IPE-4-4	201.1	Lowwall	Existing lowwall western internal batter	Non-Circular	1.68
IPE-4-5	201.1	Highwall	Existing highwall - final void lake	Circular	2.28
IPE 5 Pit					
IPE-5-1	202.1	Highwall	Proposed northern wall - final void lake	Non-Circular	3.20
IPE-5-2	202.1	Endwall	Proposed eastern wall - final void lake	Circular	2.49
IPE-5-3	202.1	Endwall	Proposed southern wall - backfilled	Circular	2.65
IPE-5-4	202.1	Lowwall	Proposed western lowwall - final void lake	Circular	2.14
IPE-5-4	202.1	Lowwall	Proposed western lowwall - backfilled	Circular	1.78

6 DISCUSSION OF INDIVIDUAL RESULTS

In the following sub-sections, the results for individual pits are discussed and alternative designs presented, where necessary, to achieve FOS ≥ 1.50.

6.1 IP N1 Pit

6.1.1 IP-N1-1 Endwall

The existing endwall has a minimum calculated FOS = 1.65. This meets the minimum required FOS ≥ 1.50. Weaker horizons within the distinctly weathered horizon may weather and erode but without any significant consequences.

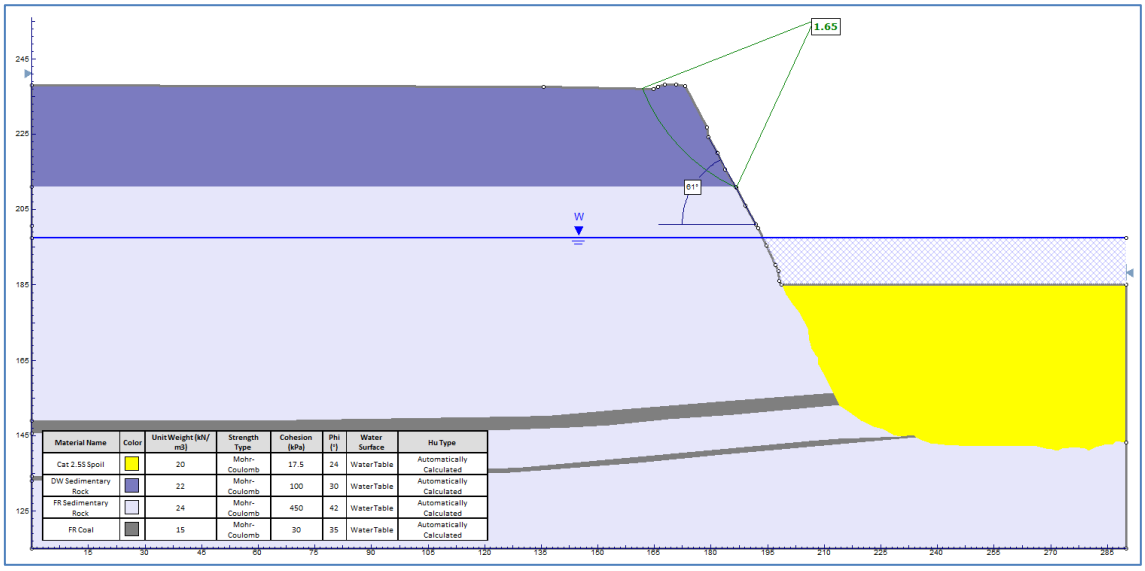


Figure 3. IP-N1-1 existing endwall. Critical FOS = 1.65 (GWL = 197.5 mAHD).

6.1.2 IP-N1-2 Highwall

The existing highwall has a critical FOS = 2.39. This meets the minimum required FOS ≥ 1.50.

The upper stratum of highly weathered sedimentary rock has FOS = 2.84. Over time it is expected that the existing batter of approximately 43° will erode back to around 27°.

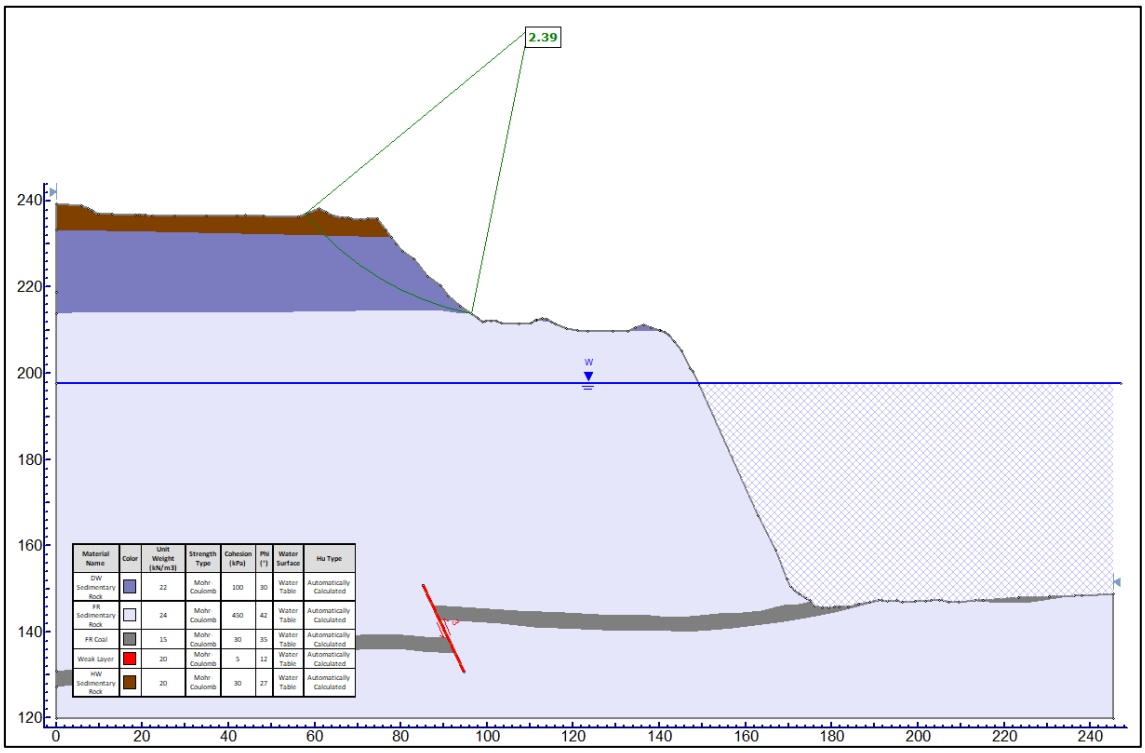


Figure 4. IP-N1-2 existing final highwall. Critical FOS = 2.39 (GWL = 197.5 mAHD).

6.1.3 IP-N1-3 Lowwall

The existing lowwall geometry has a minimum FOS = 1.01 when the void is inundated owing to a thick layer of saturated Cat 2.5 spoil.

The most economical way to achieve a higher FOS is to dozer push the existing spoil, as shown in Figure 5. The following FOS values were calculated for a range of batter angles:

23° FOS = 1.25.

20° FOS = 1.36.

18° FOS = 1.52.

The reason for these lower FOS values compared with other spoil slopes is that the comparatively thick layer of saturated Cat 2.5 spoil is supporting a substantial load of unsaturated Cat 2.5 spoil.

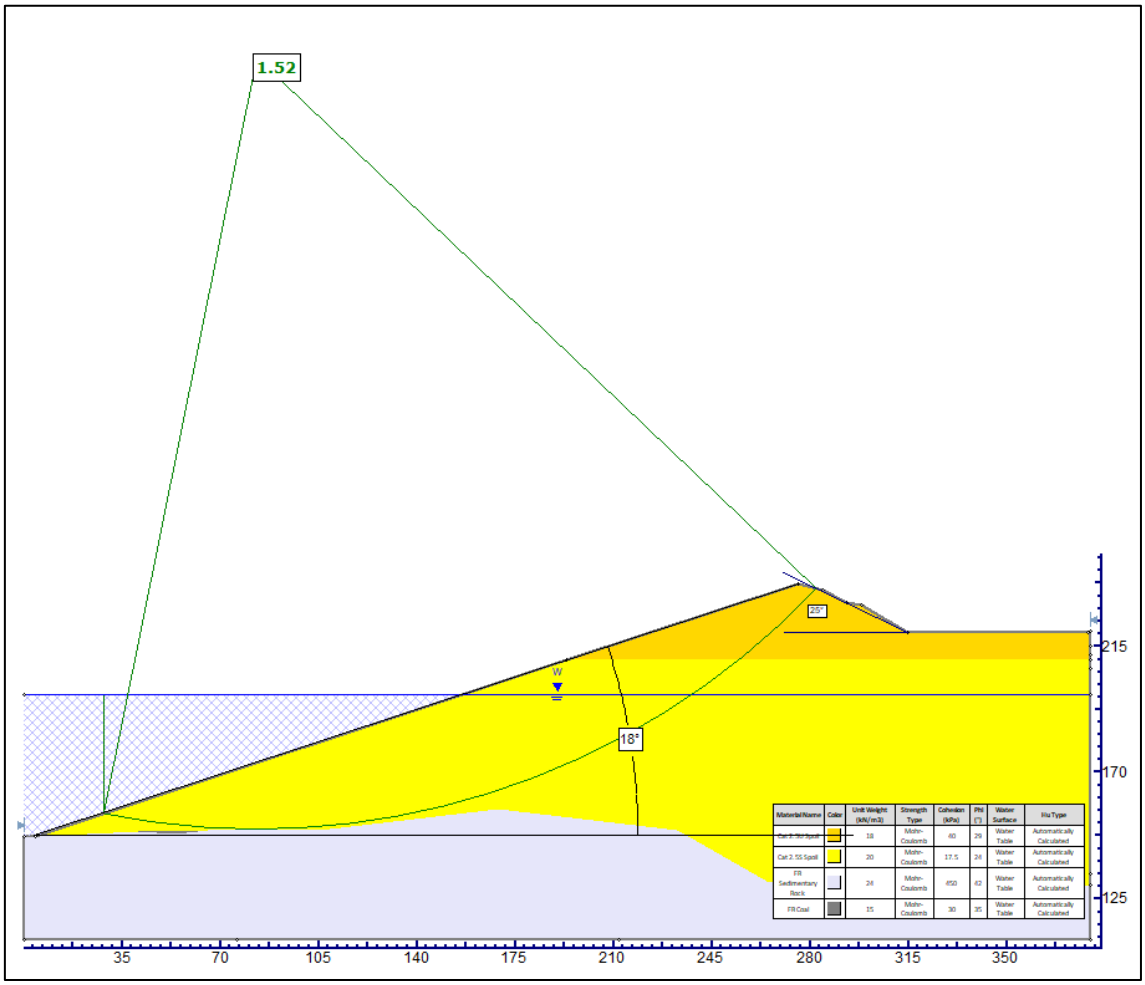


Figure 5. IP-N1-3 existing lowwall regraded to 18°. Critical FOS = 1.52 (GWL = 197.5 mAHD).

6.1.4 IP-N1-4 Highwall

The existing highwall has an overall FOS = 3.60.

The highly and distinctly weathered strata have a minimum FOS = 2.31.

There is an approximately 3 m thick highly weathered horizon at the top of the wall. Its current batter angle is 34°. Over time it is likely to erode back to 27°, i.e., the crest would retreat by about 2.2 m. Such erosion is considered inconsequential. Alternatively, the batter could be trimmed back to 27° as part of the rehabilitation.

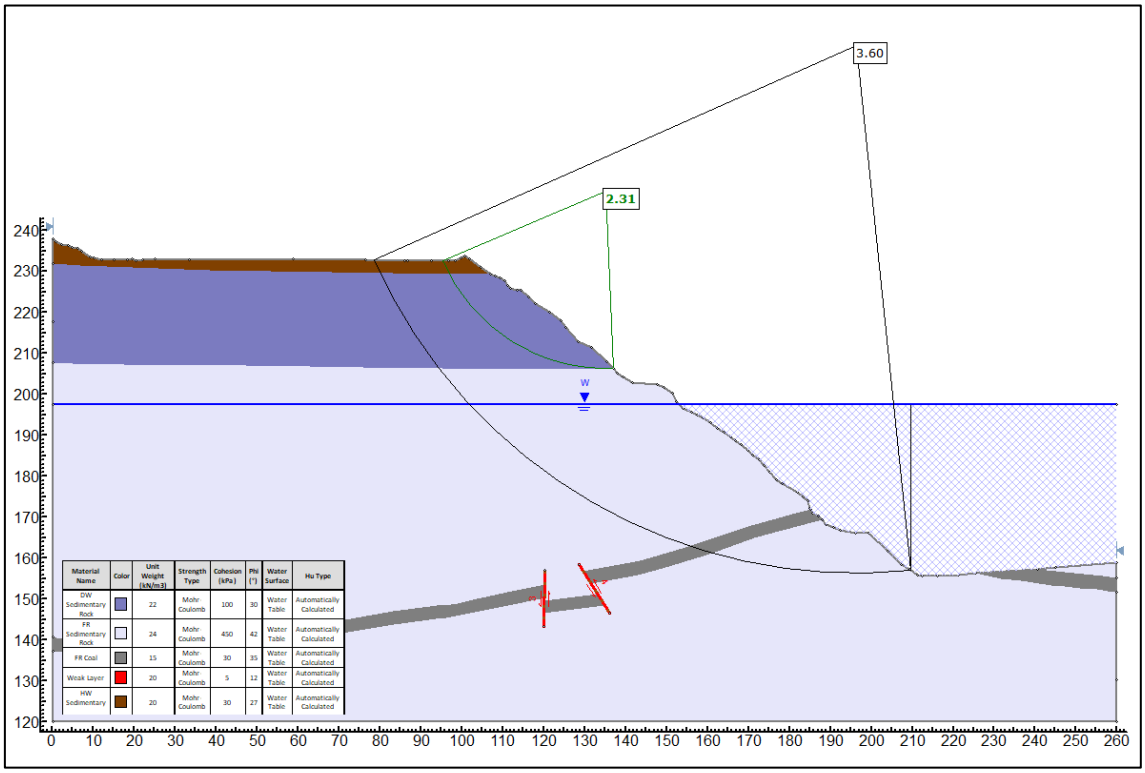


Figure 6. IP-N1-4 existing highwall overall FOS = 3.60. Weathered horizon critical FOS = 2.31 (GWL = 197.5 mAHD).

6.1.5 IP-N1-5 Endwall

The existing endwall has a minimum overall FOS = 4.35.

There is an approximately 10 m thick highly weathered horizon at the top of the wall. It has a critical FOS = 2.02, as shown in Figure 7. Its current batter angle is 40°. Despite its relatively high FOS, it is considered that over time it is likely to erode back to 27° i.e., the crest would retreat by about 11 m. Alternatively, the batter could be trimmed back to 27° as part of the rehabilitation.

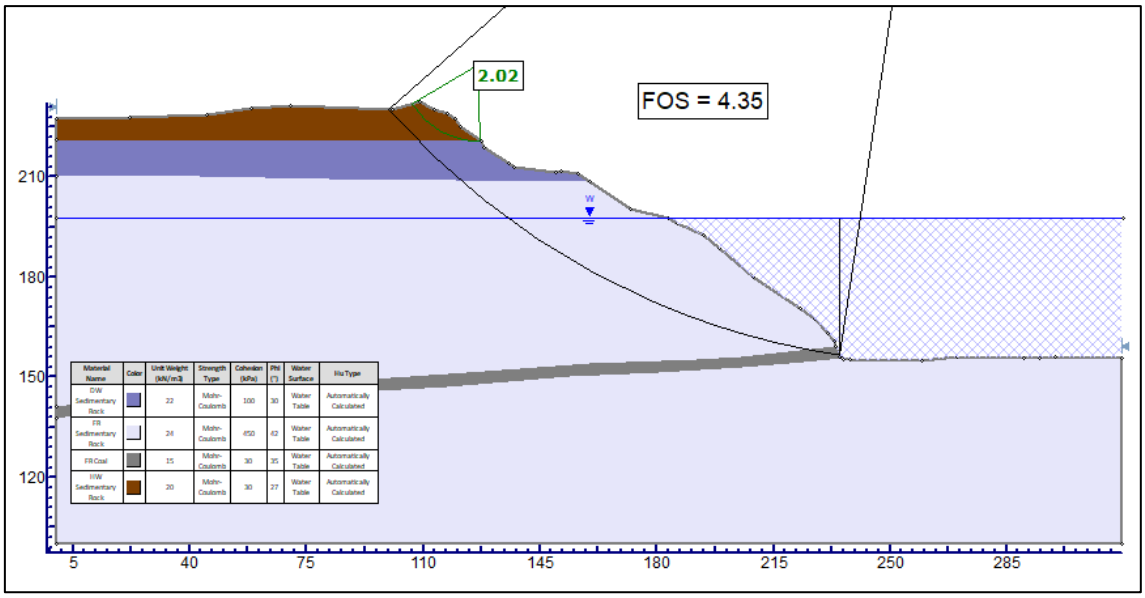


Figure 7. IP-N1-5 existing endwall overall FOS = 4.35. Weathered horizon critical FOS = 2.02 (GWL = 197.5 mAHD).

6.2 IP S2 Pit

6.2.1 IP-S2-1 Endwall

The existing endwall is backfilled with Cat 2.5 spoil at a batter angle of approximately 33°. It has a critical FOS = 1.32, as shown in Figure 8.

Dozer pushing the batter to 27° results in a critical FOS = 1.53, as shown in Figure 9.

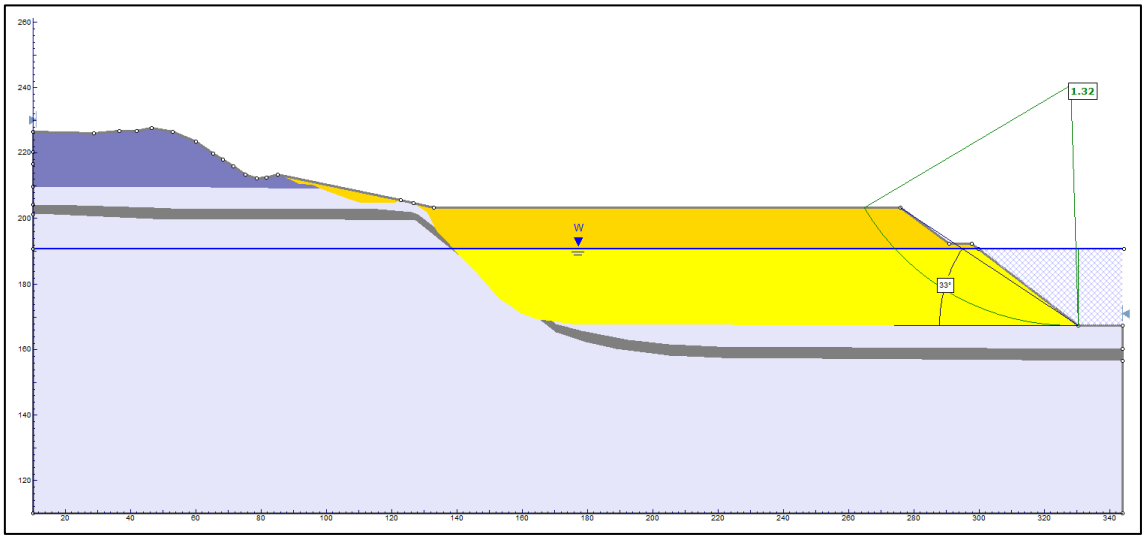


Figure 8. IP-S2-1 existing endwall backfill at 33° overall batter. Critical FOS = 1.32 (GWL = 190.8 mAHD).

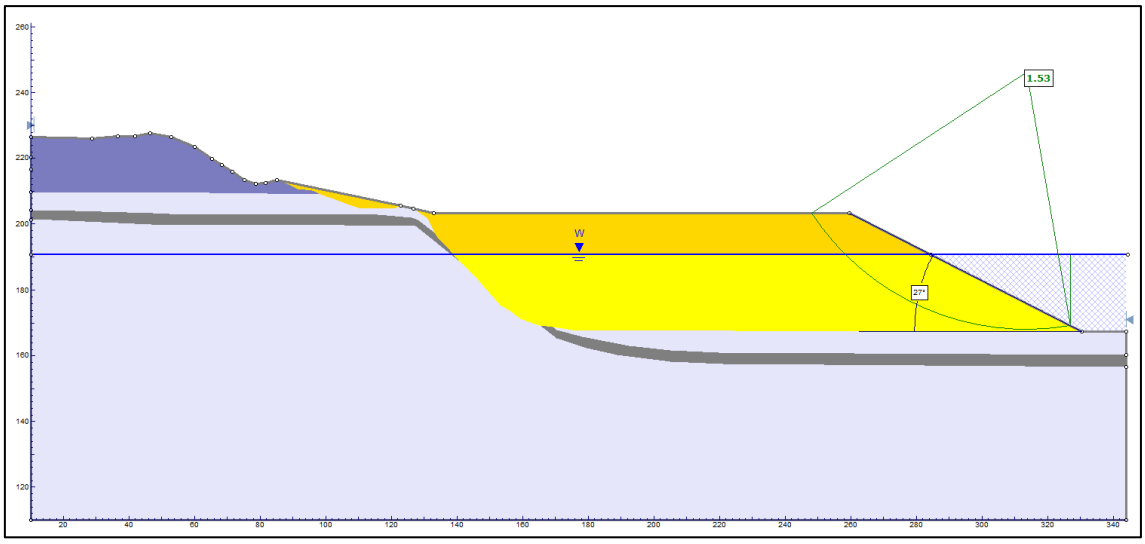


Figure 9. IP-S2-1 existing endwall backfill regraded to 27°. Critical FOS = 1.53 (GWL = 190.8 mAHD).

6.2.2 IP-S2-2 Highwall

The existing highwall has an overall FOS = 2.41.

The critical failure surface passes through the upper distinctly and highly weathered horizons with a FOS = 1.58.

There is an approximately 6.5 m thick, highly weathered horizon at the top of the wall. It has a minimum FOS of 1.82. The overall batter angle of the highly weathered horizon is 62°. In time, it is likely that the highly weathered strata will erode back to about 27°, i.e., the crest would retreat by about 10 m.

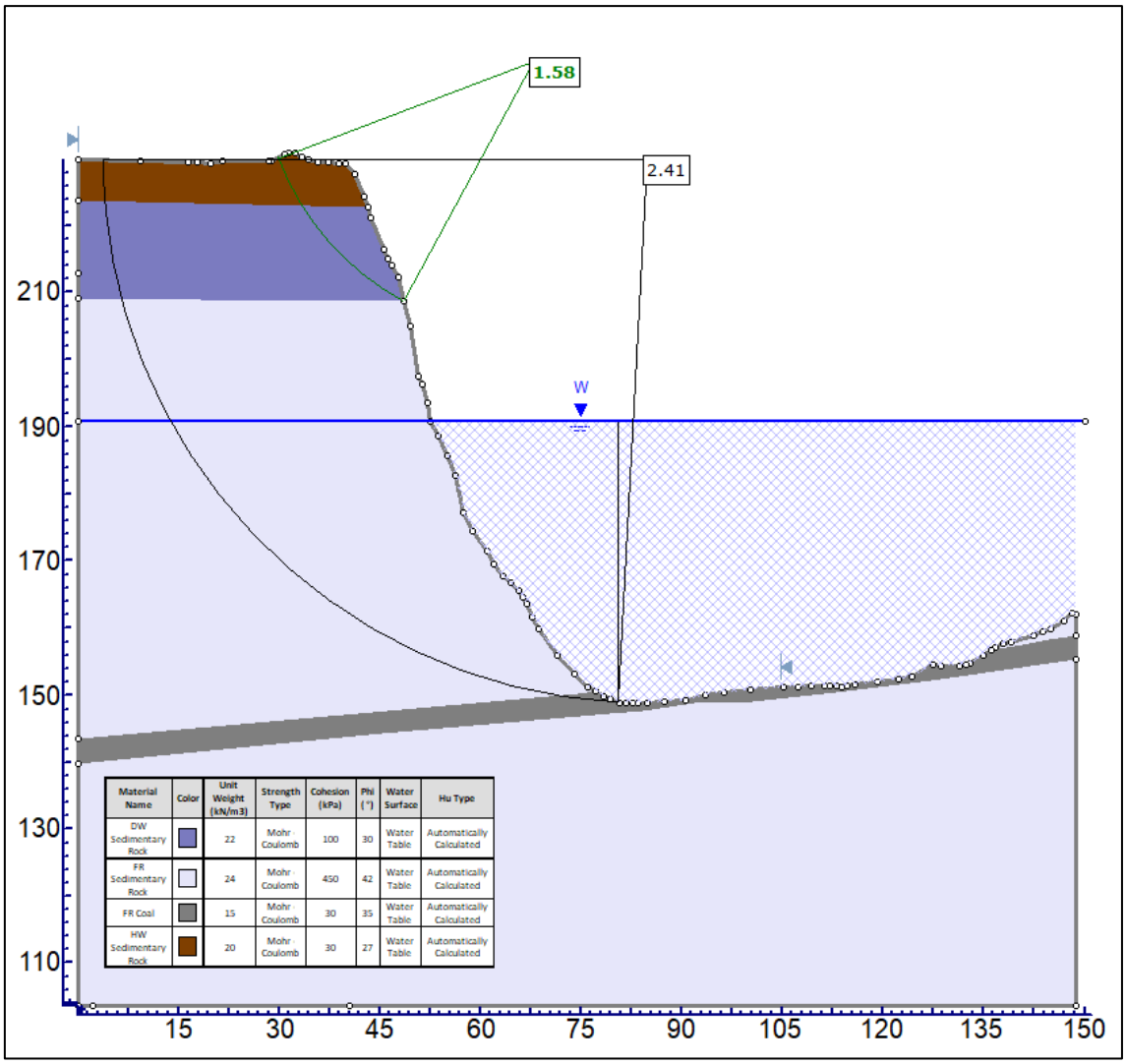


Figure 10. IP-S2-2 existing highwall final void lake overall FOS = 2.41. Weathered horizon critical FOS = 1.58 (GWL = 190.8 mAHD).

6.2.3 IP-S2-3 Lowwall

The existing final void geometry on cross-section IP-S2-3 is shown in Figure 11. The Cat 2.5 spoil lowwall steps up with several changes in slope angle. The calculated FOS = 1.10 owing to the presence of the final void lake and saturation of the spoil.

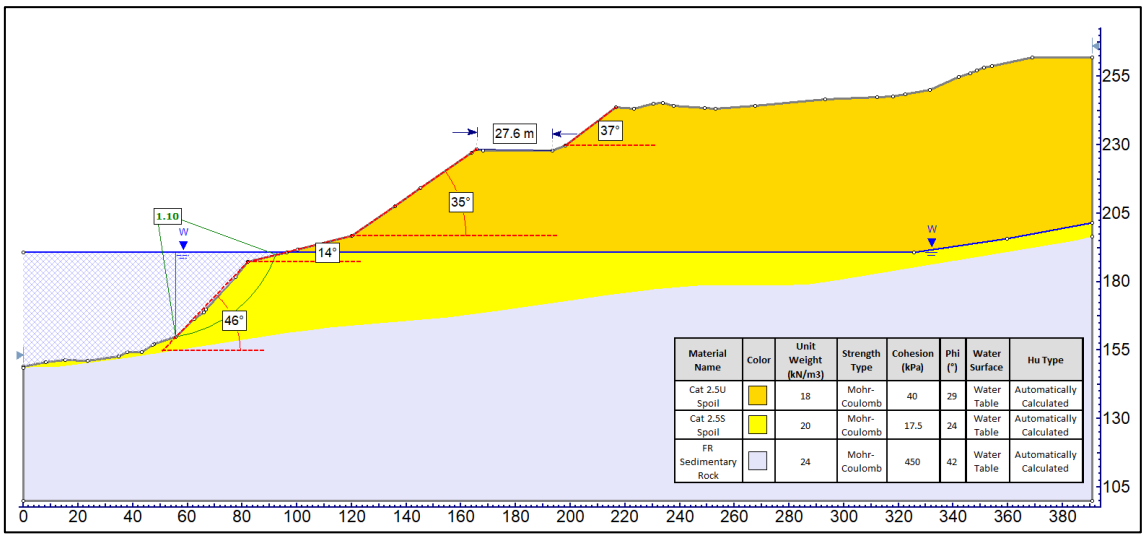


Figure 11. IP-S2-3 existing lowwall. Critical FOS = 1.10 (GWL = 190.8 mAHD).

Several buttress scenarios were analysed but they did not provide a satisfactory FOS.

Alternative approaches could include:

Push the lowwall batter down to an angle of 20°, as shown in Figure 12. The FOS for this option is 1.50.

Allow the dump to saturate and slump back to a saturated angle of repose which will have a similar effect as dozing the wall down to 20° and would establish a FOS = 1.50 backscarp about 40 m back from the existing crest.

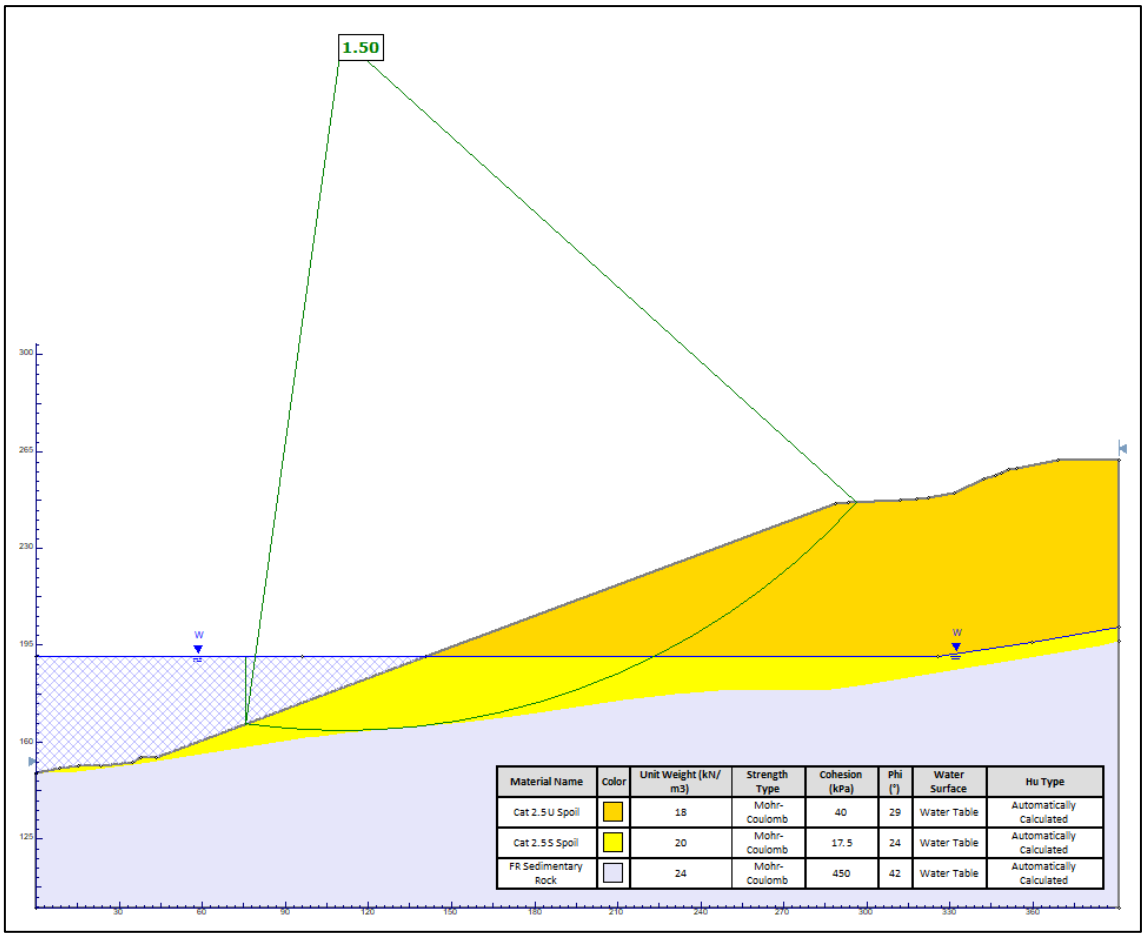


Figure 12. IP-S2-3 existing lowwall batter regraded to 20°. FOS = 1.50 (GWL = 190.8 mAHD).

6.2.4 IP-S2-4 Highwall

The existing highwall has an overall FOS ≥ 2.20.

The critical failure surface passes through the upper distinctly and highly weathered horizons with a FOS = 1.68.

There is an approximately 6 m thick, highly weathered horizon at the top of the wall. It has a minimum FOS of 1.73. The overall batter angle of the highly weathered horizon is up to 80°. In time, it is likely that the highly weathered strata will erode back to about 27°, i.e., the crest would retreat by about 10 m.

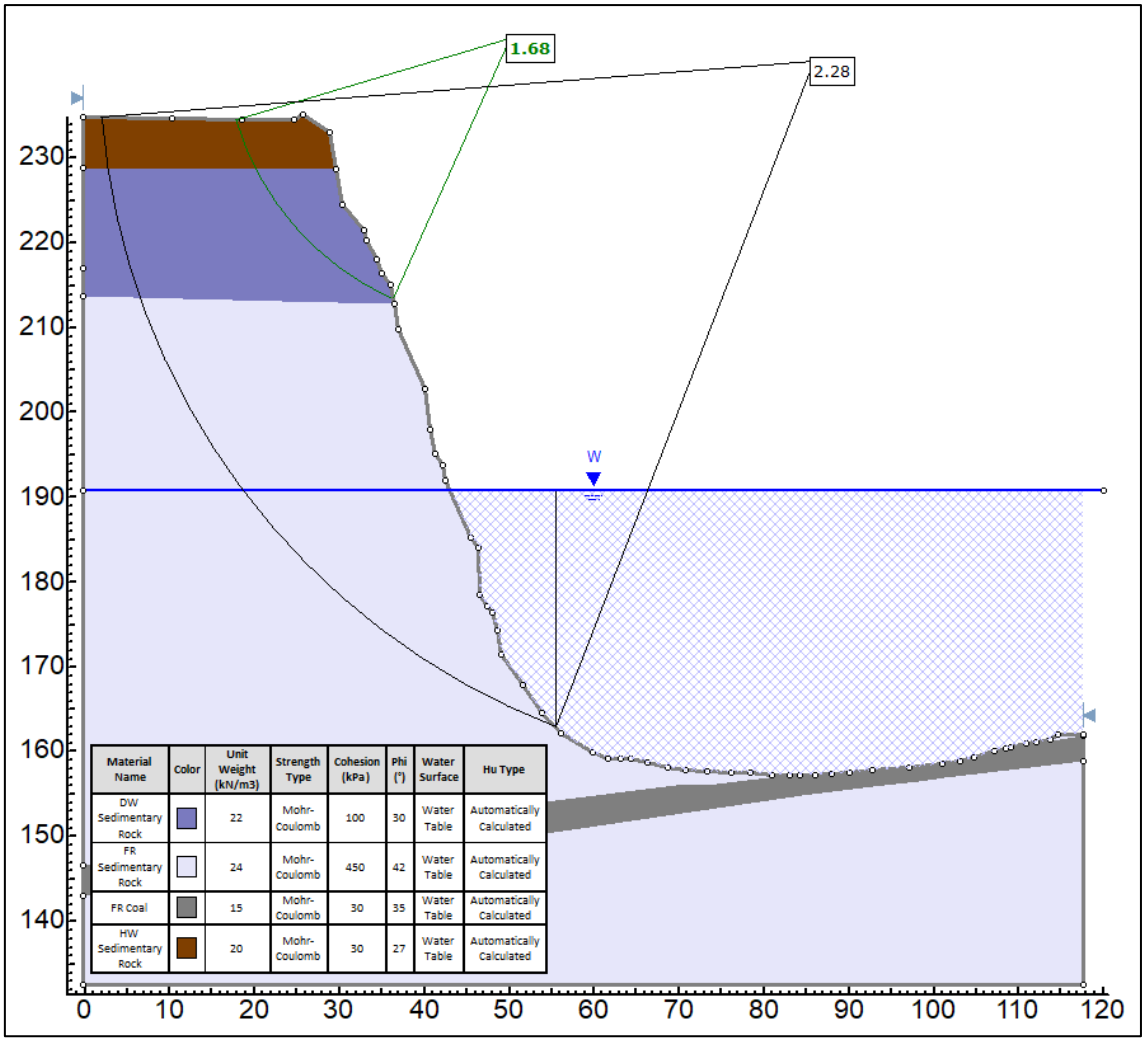


Figure 13. IP-S2-4 existing highwall final void lake overall FOS = 2.28. Weathered horizon critical FOS = 1.68 (GWL = 190.8 mAHD).

6.2.5 IP-S2-5 Lowwall

The existing final void geometry shows the Cat 2.5 spoil lowwall with several batters at angles between 31° and 33°. The calculated FOS = 1.14 is due to the final void lake causing a thick saturated spoil layer

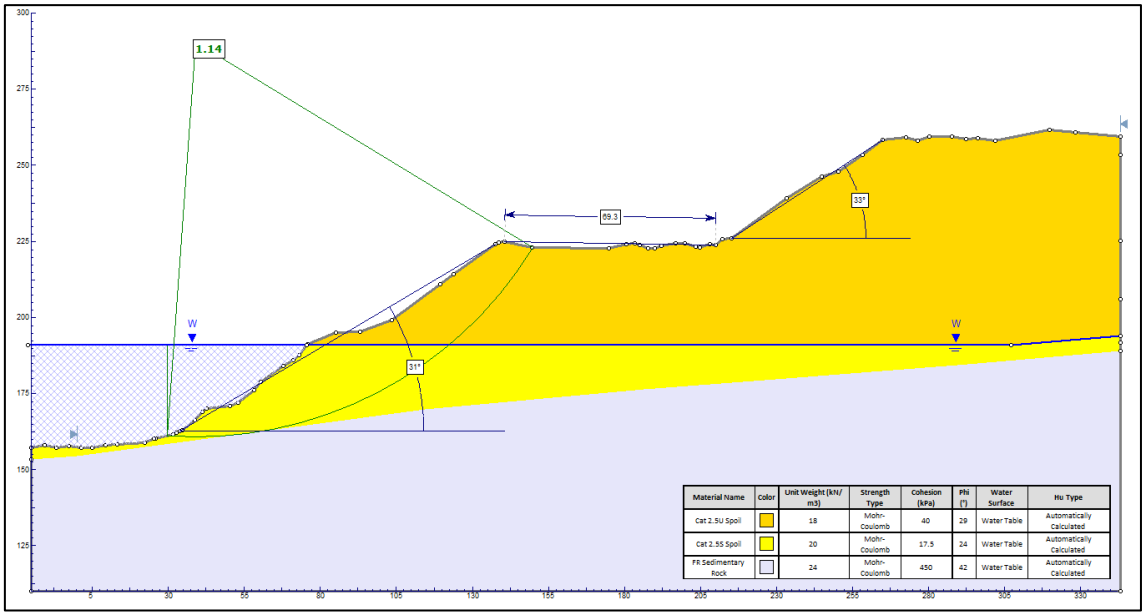


Figure 14. IP-S2-3 existing lowwall. Critical FOS = 1.14 (GWL = 190.8 mAHD).

The most economical way of increasing the FOS is to dozer push the existing spoil, as shown in Figure 15. The following FOS values were calculated for a range of batter angles:

22° FOS = 1.43.

20° FOS = 1.55.

The reason for these lower FOS values compared with other spoil slopes is that the comparatively thick layer of saturated Cat 2.5 spoil is supporting a substantial load of unsaturated Cat 2.5 spoil.

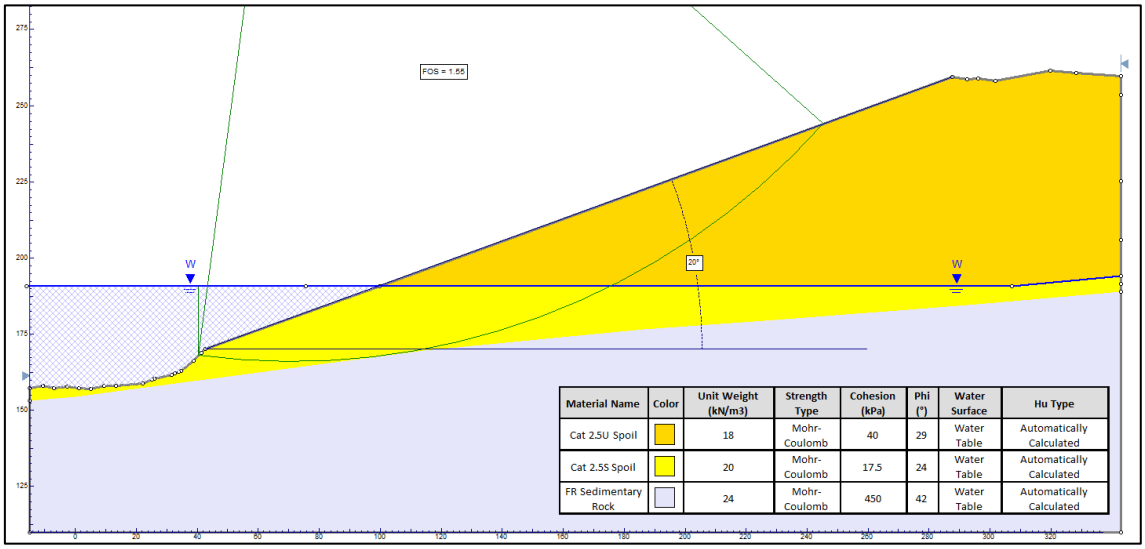


Figure 15. IP-S2-5 existing lowwall batter regraded to 20°. Critical FOS = 1.55 (GWL = 190.8 mAHD).

6.2.6 IP-S2-6 Endwall

Cross-section IP-S2-6 is located in a softwalled endwall.

There is an 8 m thick highly weathered horizon at the top of the endwall which has been excavated at a batter angle of about 80°. This horizon has a FOS = 1.36 (Figure 16) and it is likely that in the long term it will erode back to an angle of around 27°, at which point the FOS will exceed 1.50. To achieve this, the crest would retreat by about 13 m. Alternatively, the highly weathered horizon could be battered back to 27° as part of mine site rehabilitation (Figure 17).

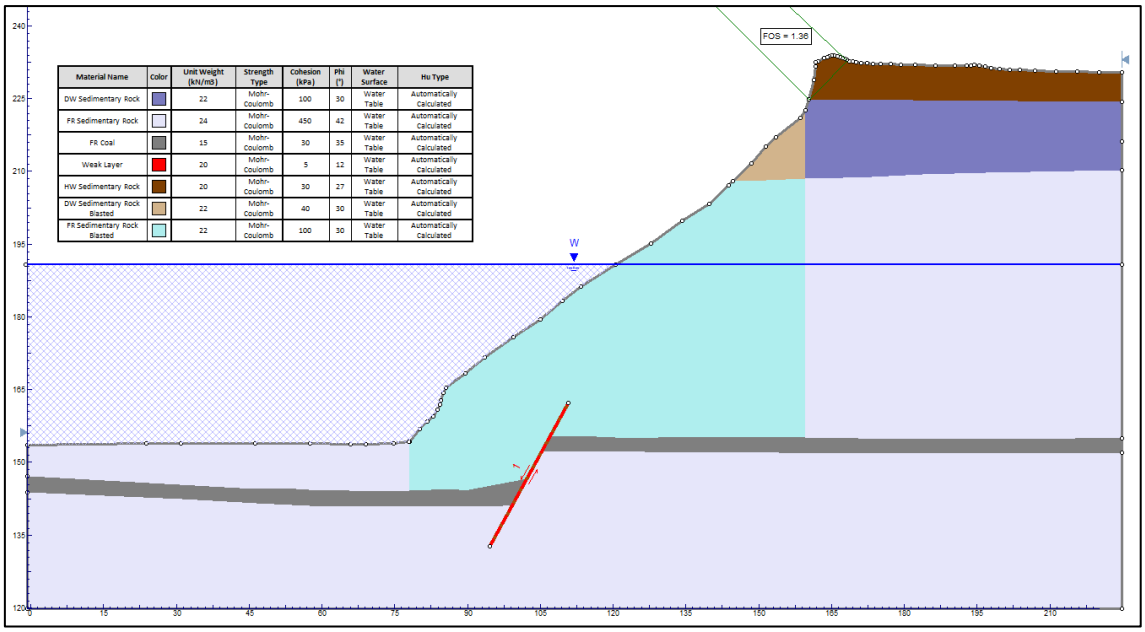


Figure 16. IP-S2-6 existing softwalled endwall critical FOS = 1.36 (GWL = 190.8 mAHD).

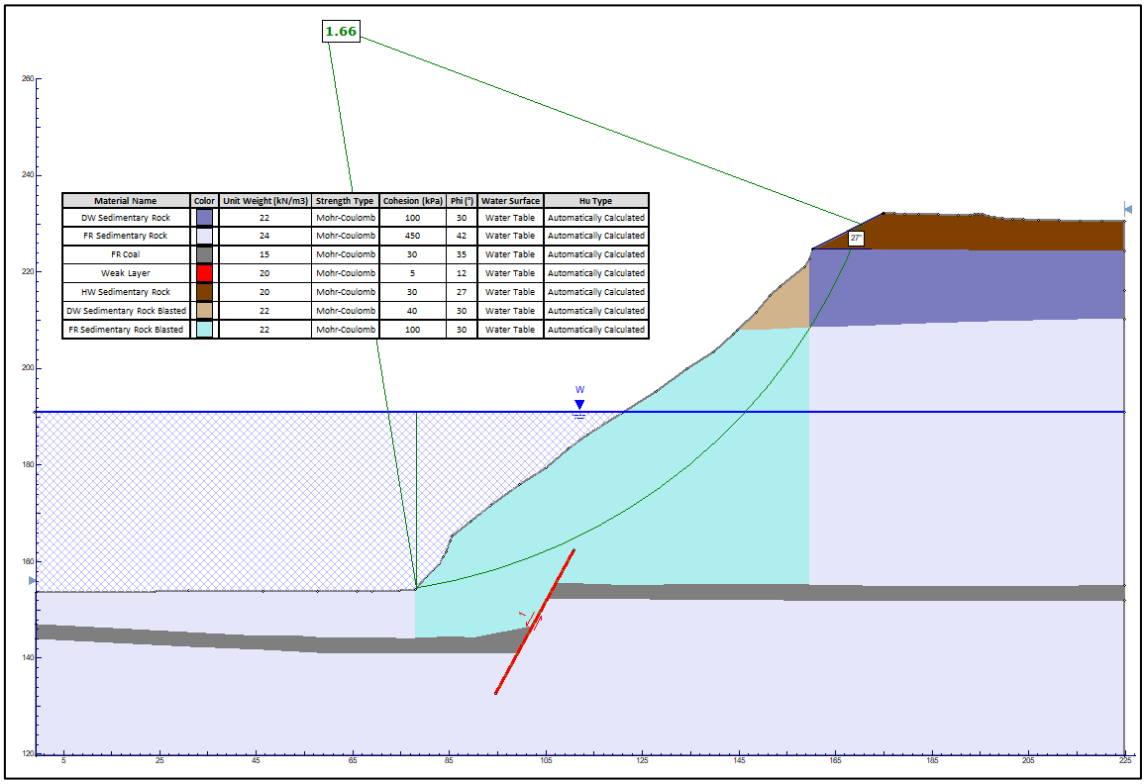


Figure 17. IP-S2-6 existing softwalled endwall highly weathered horizon battered back to 27°. Critical FOS = 1.66 (GWL = 190.8 mAHD).

6.3 IP S3 Pit

6.3.1 IP-S3-1 Highwall & Lowwall

IP-S3 will be rehabilitated by backfilling the existing partially backfilled void with additional Cat 2.5 spoil thereby raising the level of the floor to 200 mAHD, i.e., approximately 10 m above the predicted final void lake level.

The spoil slope will be reprofiled to approximately 15% (8°) on the lowwall side, resulting in a critical FOS = 3.88, as shown in Figure 18.

The spoil slope will be reprofiled to approximately 25% (14°) on the highwall side, resulting in a critical FOS = 3.04, as shown in Figure 19.

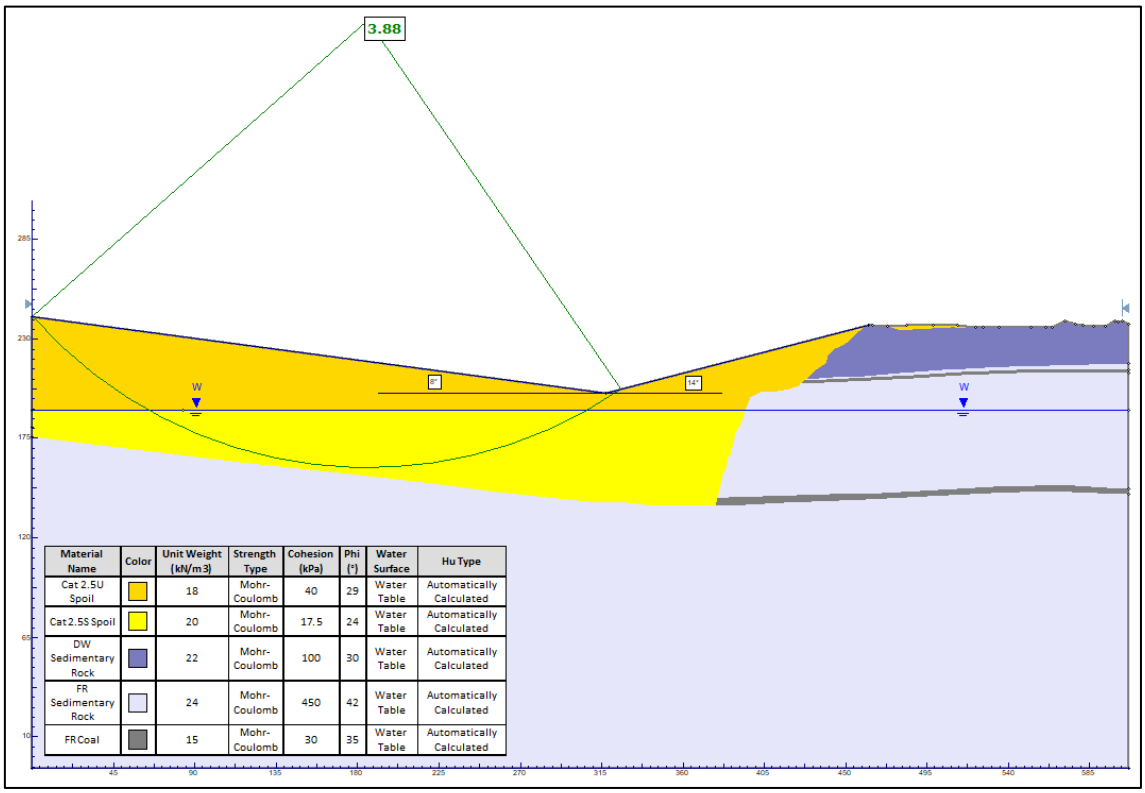


Figure 18. IP-S3-1 lowwall side – pit floor level raised to 200 mAHD and slope regraded to 15%. Critical FOS = 3.88 (GWL = 190.8 mAHD).

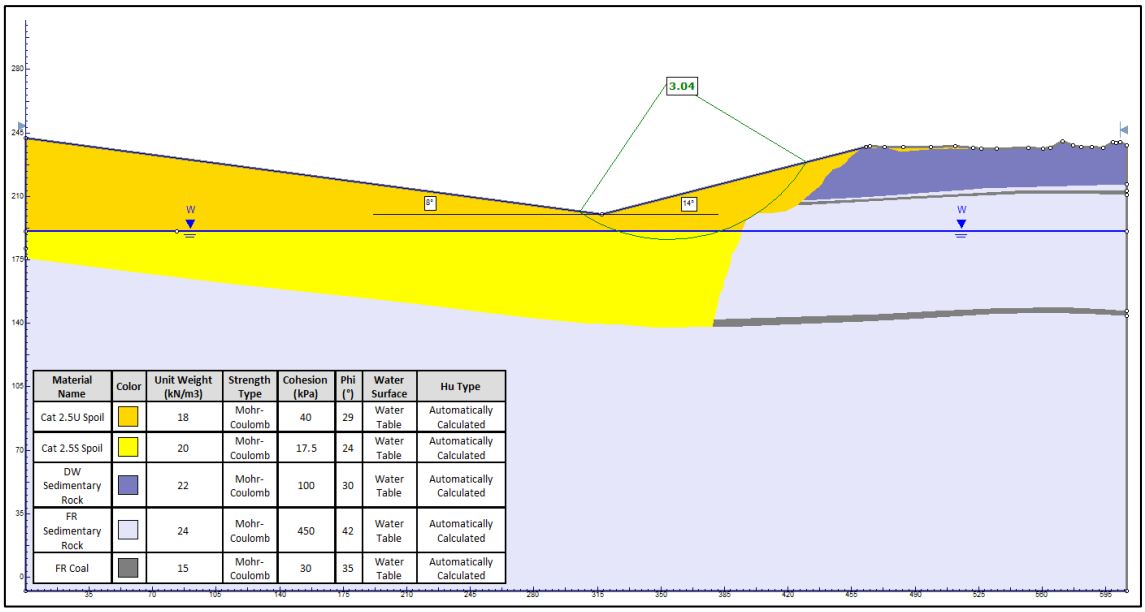


Figure 19. IP-S3-1 highwall side – pit floor level raised to 200 mAHD and slope regraded to 25%. Critical FOS = 3.04 (GWL = 190.8 mAHD).

6.4 IPE Pit 1

6.4.1 IPE-1-1 Endwall

The IPE-1-1 proposed backfilled final endwall cross-section shown in Figure 20 results in a critical FOS = 2.89. The circular failure surface is located through the Tertiary horizon.

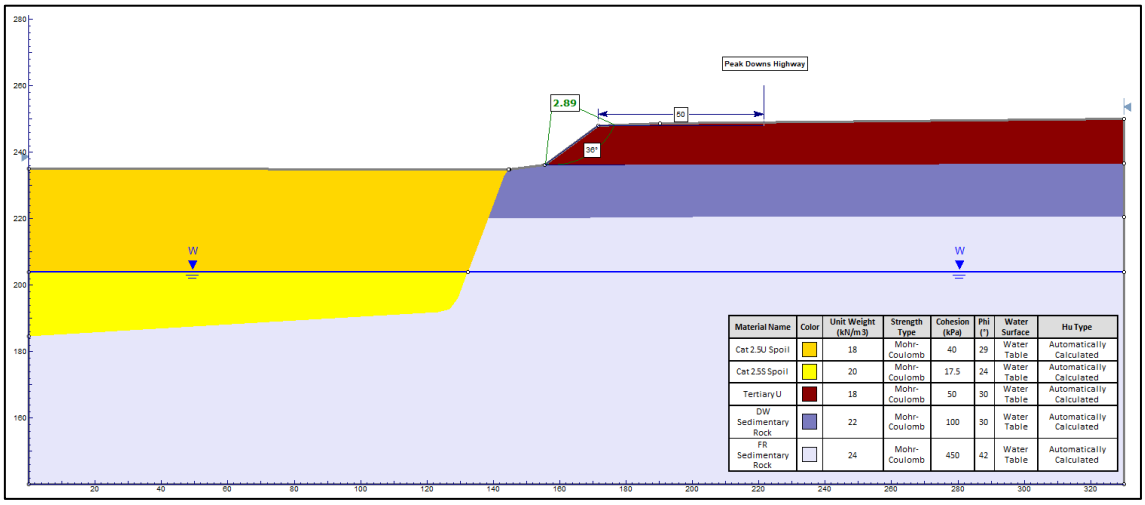


Figure 20. IPE-1-1 proposed final endwall backfilled. Critical FOS = 2.89 (GWL = 203.8 mAHD).

6.4.2 IPE-1-2 Highwall

The IPE-1-2 proposed final highwall cross-section shown in Figure 21 results in a critical FOS = 2.47 which exceeds the minimum FOS required. The circular critical surface is located through the fresh rock mass.

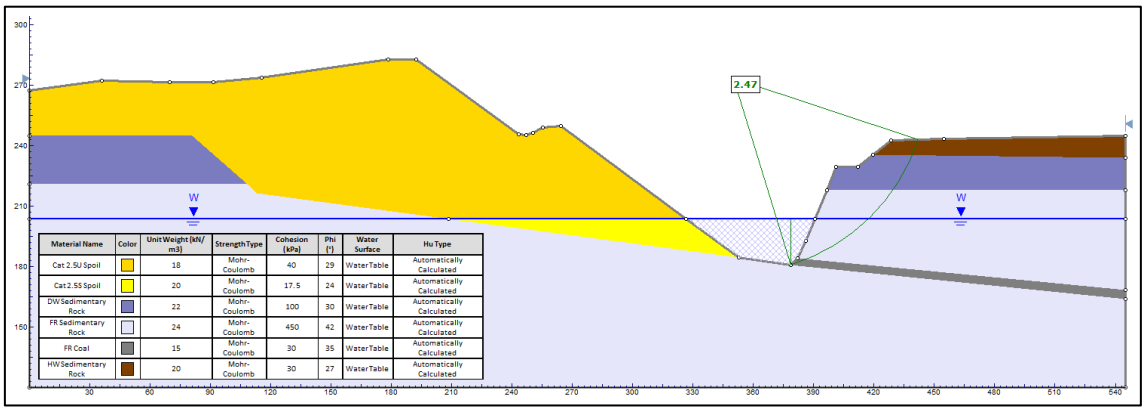


Figure 21. IPE-1-2 proposed final highwall. Critical FOS = 2.47 (GWL = 203.8 mAHD).

6.4.3 IPE-1-3 Lowwall

The IPE-1-3 proposed lowwall cross-section shown in Figure 22 results in a critical FOS = 0.99. The circular failure surface emerges through the saturated spoil toe.

Dozer pushing the spoil to 23° results in critical FOS = 1.51 for the circular failure mode, as shown in Figure 23.

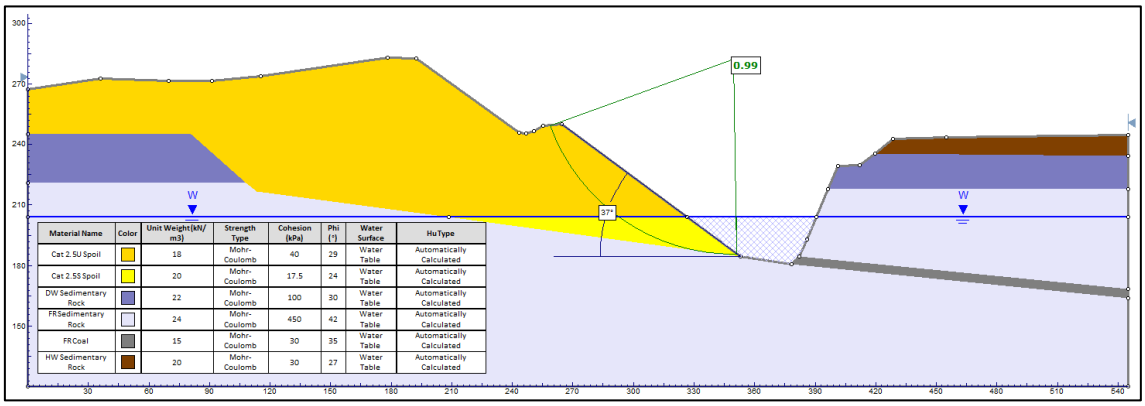


Figure 22. IPE-1-3 proposed lowwall batter at 37°. Critical FOS = 0.99 (GWL = 203.8 mAHD).

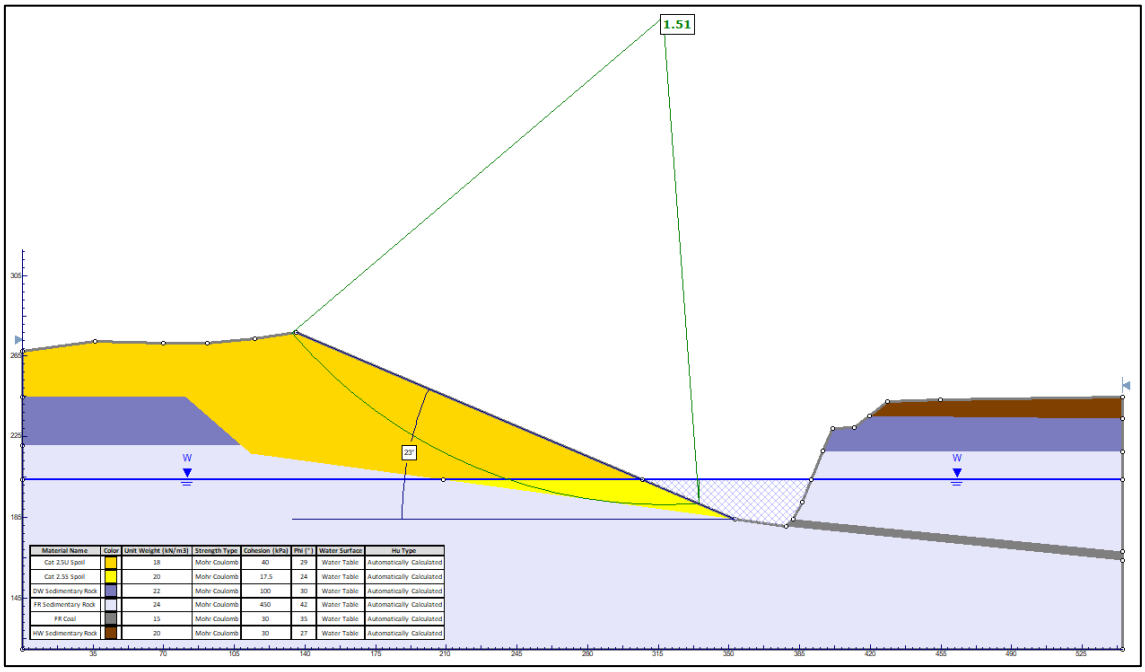


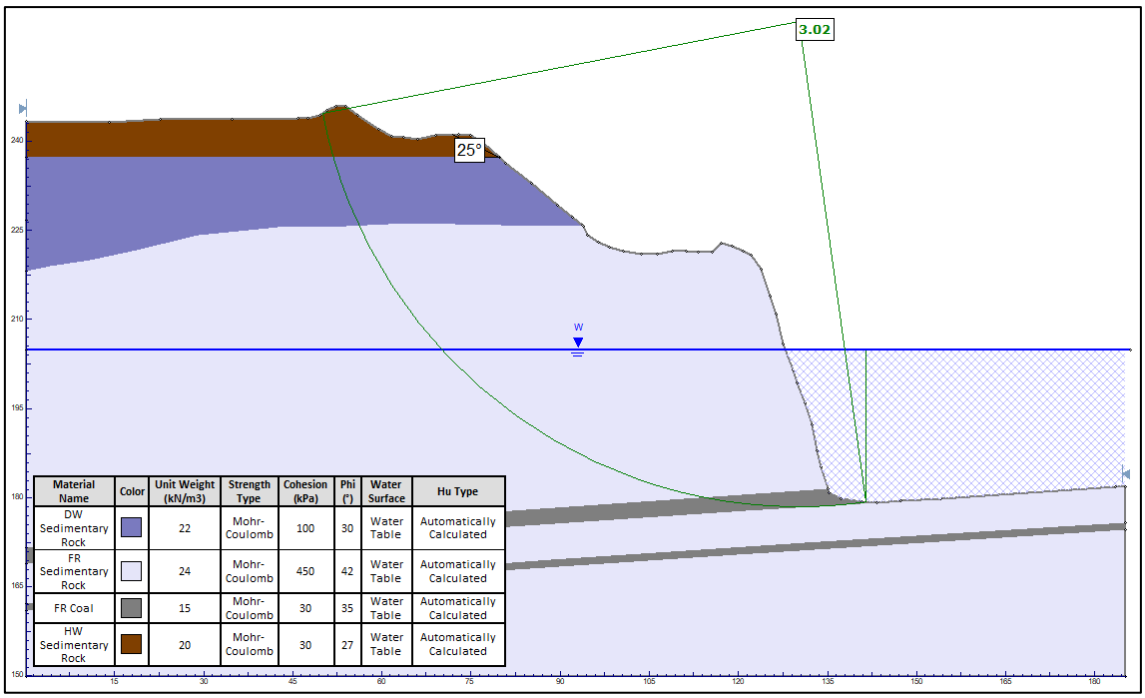
Figure 23. IPE-1-3 proposed lowwall battered back to 23°. Critical FOS = 1.51 (GWL = 203.8 mAHD).

6.5 IPE Pit 2

6.5.1 IPE-2-1 Highwall

The existing highwall has an overall FOS = 3.02.

There is an approximately 4 m thick, highly weathered horizon at the top of the wall. In time, it is likely that this layer will erode back to about 27° i.e., the crest would retreat by about 8 m. It is considered that this inconsequential since it would not encroach on the existing bund that is shown in Figure 24.



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Water Surface	Hu Type
DW Sedimentary Rock		22	Mohr-Coulomb	100	30	Water Table	Automatically Calculated
FR Sedimentary Rock		24	Mohr-Coulomb	450	42	Water Table	Automatically Calculated
FR Coal		15	Mohr-Coulomb	30	35	Water Table	Automatically Calculated
HW Sedimentary Rock		20	Mohr-Coulomb	30	27	Water Table	Automatically Calculated

Figure 24. IPE-2-1 existing highwall and final void lake. Critical FOS = 3.02 (GWL = 204.9 mAHD).

6.5.2 IPE-2-2 Lowwall

Cross-section IPE-2-2 cuts through a lowwall spoil dump as shown in Figure 25. The existing profile, plus the effect of the final void lake, results in a critical FOS = 1.19.

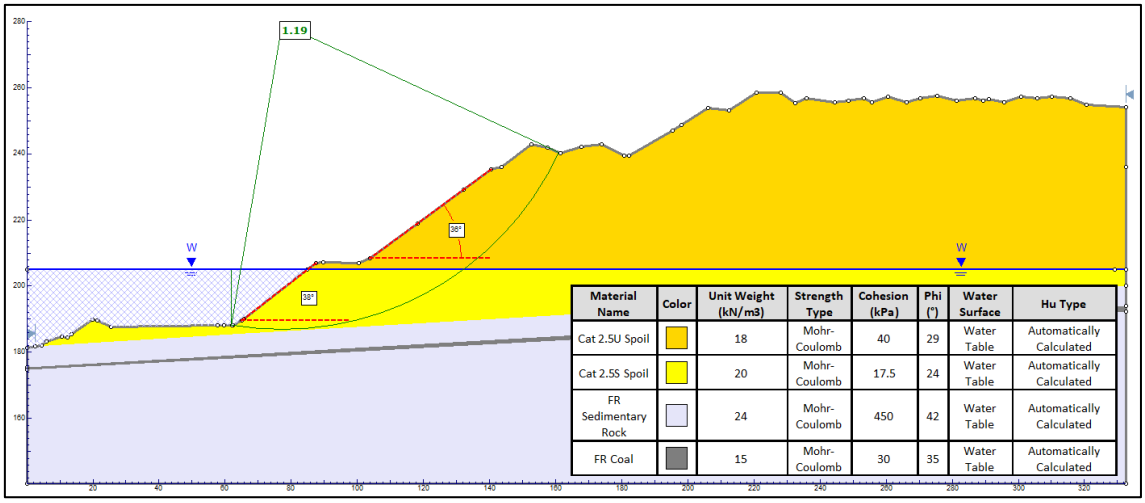


Figure 25. IPE-2-2 existing lowwall. Critical FOS = 1.19 (GWL = 204.9 mAHD).

Dozing down the spoil to an overall batter angle of 22° results in a critical FOS= 1.50, as shown in Figure 26.

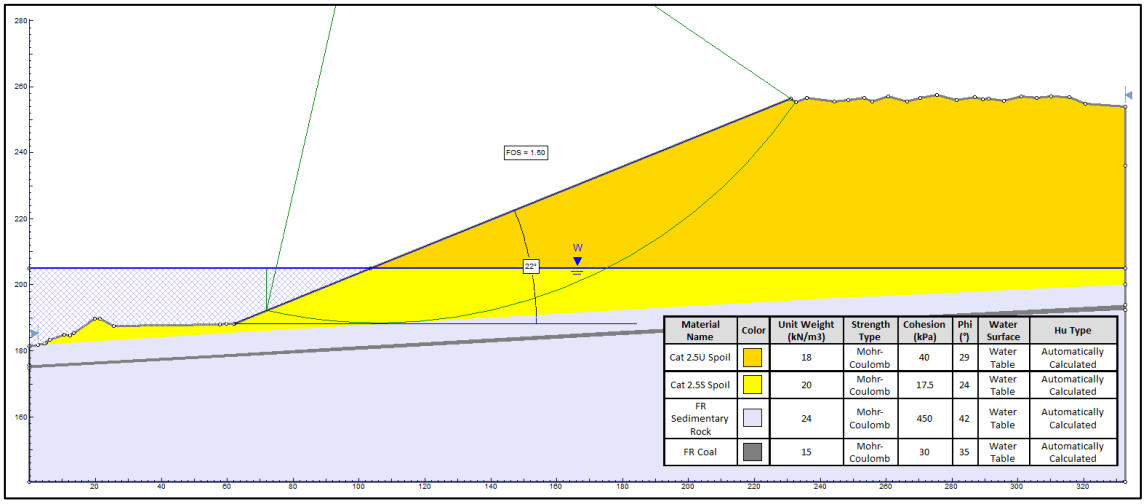


Figure 26. IPE-2-2 existing lowwall battered back to 20°. Critical FOS = 1.50 (GWL = 204.9 mAHD).

6.5.3 IPE-2-3 Endwall

The IPE-2-3 endwall cross-section in Figure 27 shows an overall FOS = 2.47.

The critical FOS = 2.47 surface is located in the highly weathered horizon. While this value is more than adequate, it is considered likely that the highly weathered horizon will eventually erode back to a 27° slope. This would represent a crest retreat of approximately 6 m. Alternatively, the highly weathered horizon could be battered back to 27°.

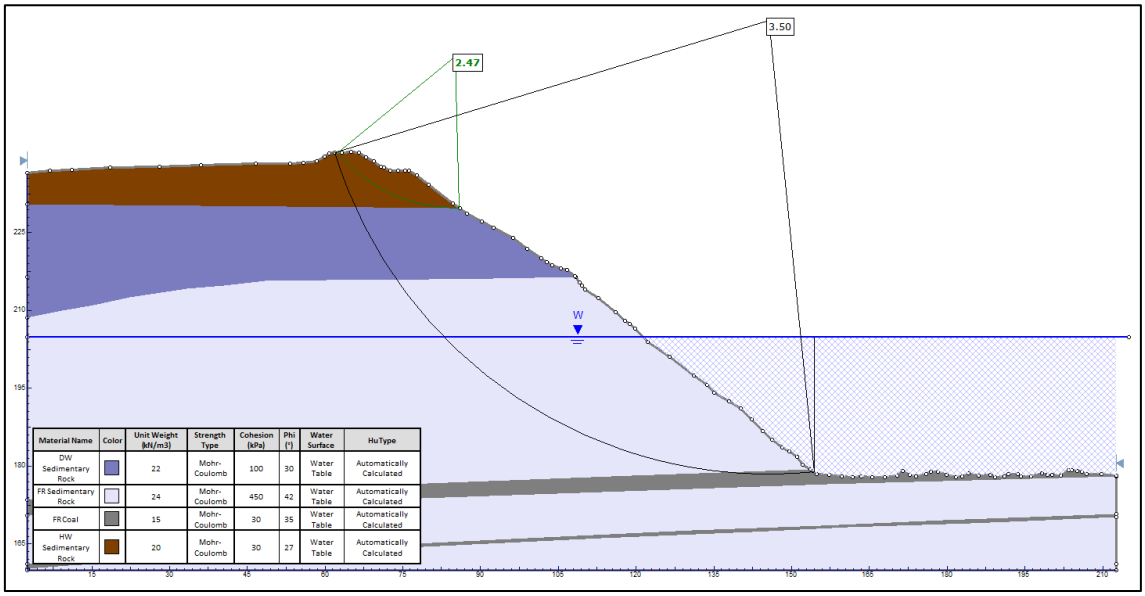


Figure 27. IPE-2-3 existing endwall final void lake. Overall FOS = 3.50; Critical FOS = 2.47 (GWL = 204.9 mAHD).

6.6 IPE Pit 3

6.6.1 IPE-3-1 Highwall

The IPE-3-1 highwall cross-section shown in Figure 28 results in an overall FOS = 2.87.

The critical FOS = 2.27 and is located in the distinctly weathered horizon. It is likely that the highly weathered horizon, which currently has a batter angle of 45°, will eventually erode back to a 27° slope. This would represent a crest retreat of approximately 5 m. Alternatively, the highly weathered horizon could be battered back to 27°.

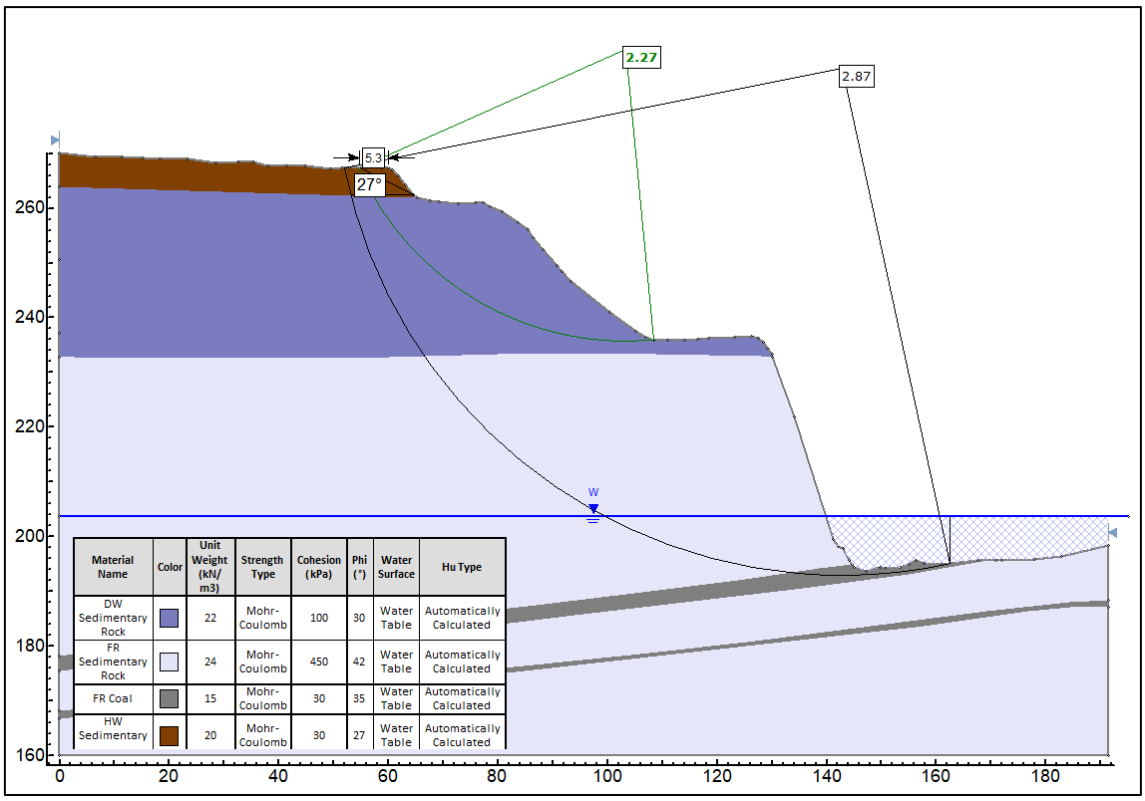


Figure 28. IPE-3-1 existing highwall final void lake. Overall FOS = 2.87. Critical FOS = 2.27 (GWL = 203.7 mAHD).

6.6.2 IPE-3-2 Highwall

The IPE-3-2 highwall cross-section shown in Figure 29 results in an overall FOS = 2.64.

The critical FOS = 2.00 and is located in the highly weathered horizon. It is likely that the highly weathered horizon, which currently has a batter angle of 45°, will eventually erode back to a 27° slope. This would represent a crest retreat of approximately 9 m. Alternatively, the highly weathered horizon could be battered back to 27° as part of the rehabilitation.

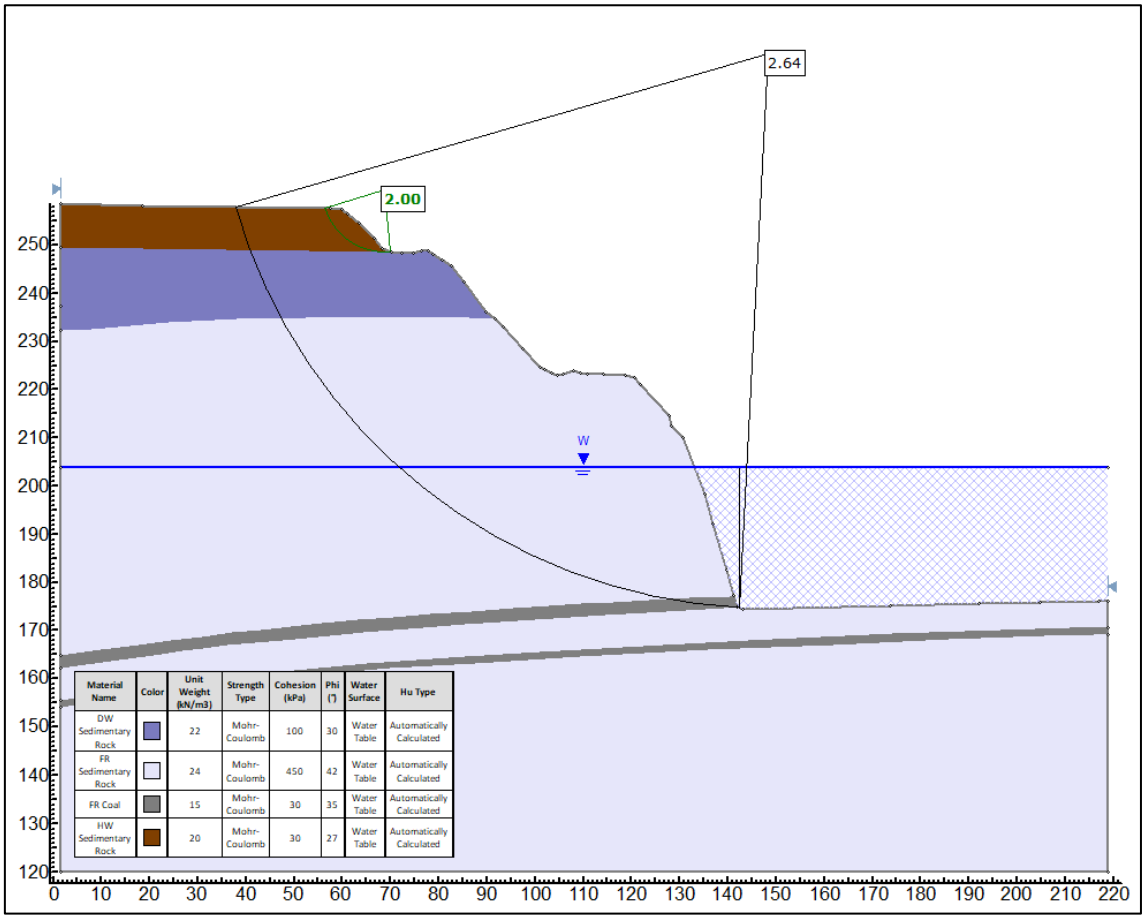


Figure 29. IPE-3-2 existing highwall final void lake. Overall FOS = 2.64. Critical FOS = 2.00 (GWL = 203.7 mAHD).

6.6.3 IPE-3-3 Lowwall

The IPE-3-3 lowwall spoil toe is below the level of the final void lake. For this reason, both circular and non-circular modes of failure were modelled. The basal plane was constrained within a saturated spoil horizon. The resultant critical FOS = 1.33 for the circular failure mode and critical FOS = 1.57 for the non-circular failure mode.

To achieve FOS ≥ 1.50 for both failure modes, dozer pushing the existing spoil to 25° results in critical FOS = 1.51 for the circular failure mode, as shown in Figure 30 and FOS = 1.79 for the non-circular failure mode, as shown in Figure 31.

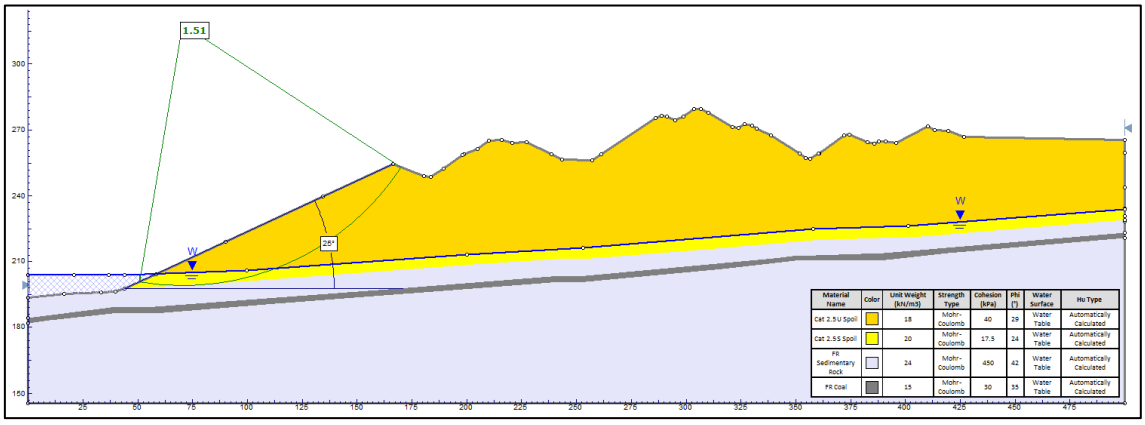


Figure 30. IPE-3-3 existing lowwall battered back to 25°. Circular failure critical FOS = 1.51 (GWL = 203.7 mAHD).

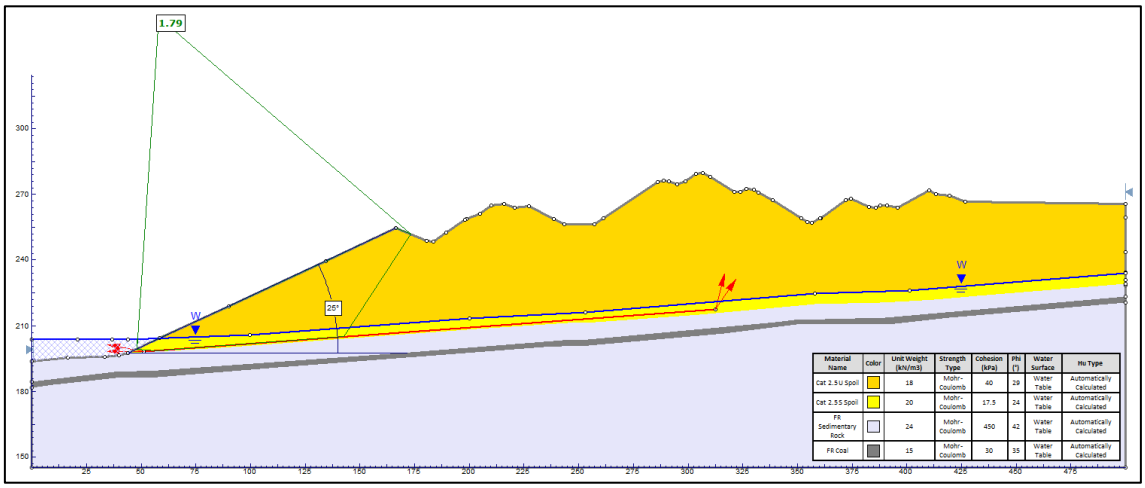


Figure 31. IPE-3-3 existing lowwall battered back to 25°. Non-circular failure critical FOS = 1.79 (GWL = 203.7 mAHD).

6.7 IPE Pit 4

6.7.1 IPE-4-1 Lowwall

The IPE-4-1 lowwall spoil cross-section is substantially above the level of the final void lake. For this reason, a non-circular mode of failure was modelled with the basal plane constrained within the saturated spoil horizon. Analyses were carried out for the ramp level at about 196 mAHD and the upper spoil level with the crest at about 247 mAHD. The results are shown in Figure 32 and Figure 33.

For the lower batter, FOS = 2.11.
For the upper batter, FOS = 1.68.

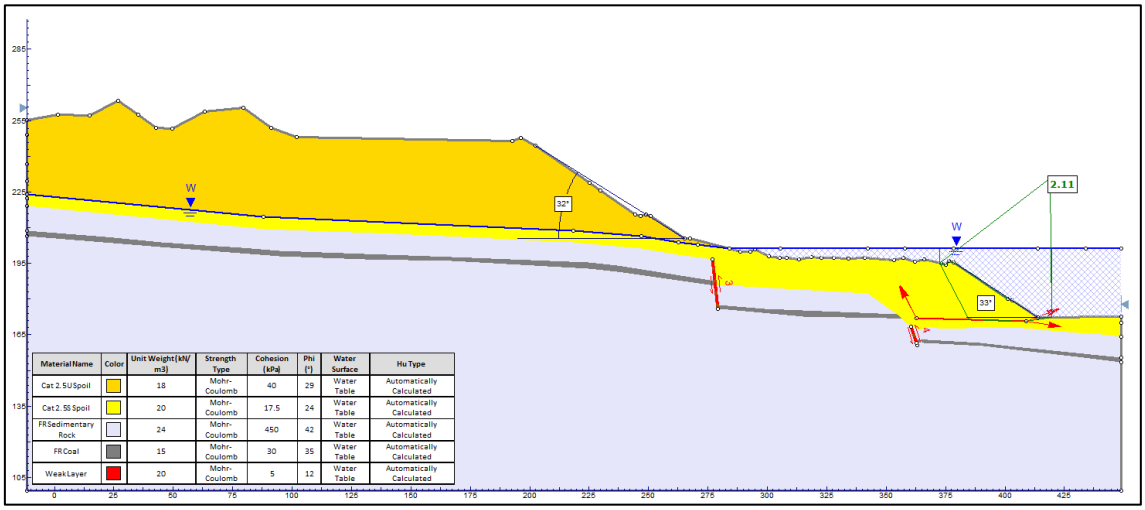


Figure 32. IPE-4-1 existing lowwall lower batter. Non-circular failure critical FOS = 2.11 (GWL = 201.1 mAHD).

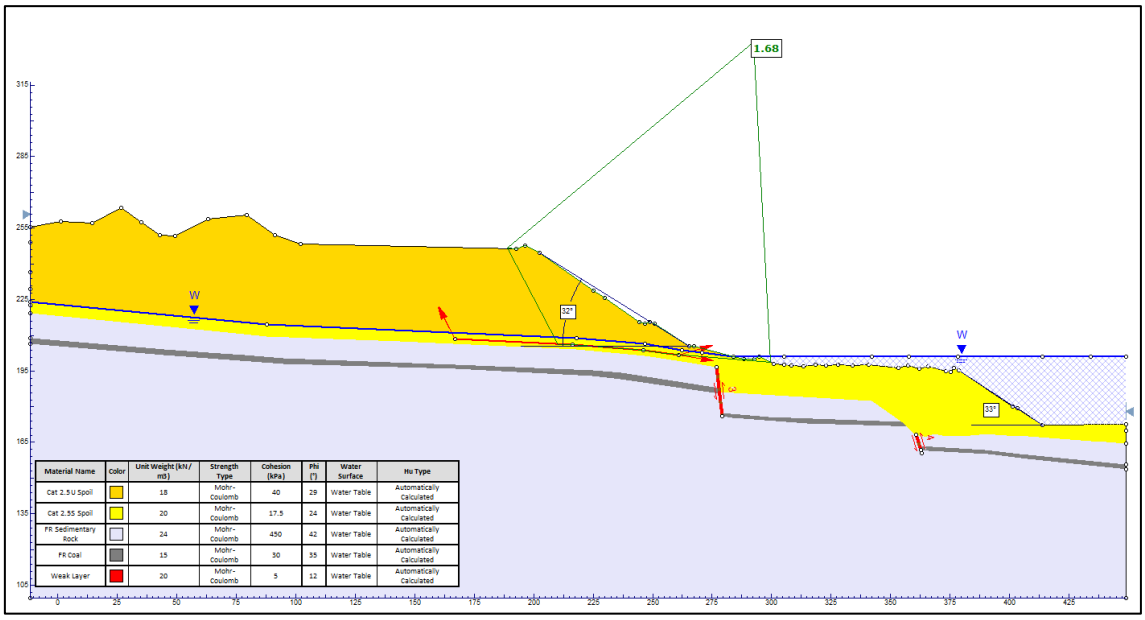


Figure 33. IPE-4-1 existing lowwall upper batter. Non-circular critical FOS = 1.68 (GWL = 201.1 mAHD).

6.7.2 IPE-4-2 Endwall

The IPE-4-2 endwall cross-section shown in Figure 34 results in an overall FOS = 3.99.

The critical FOS = 2.20 and the surface is located in the highly weathered and distinctly weathered horizons. It is likely that the highly weathered horizon which currently has a batter angle of 45° will eventually erode back to a 27° slope. This would represent a crest retreat of approximately 6 m. Alternatively the highly weathered horizon could be battered back to 27° as part of the final voids reshaping.

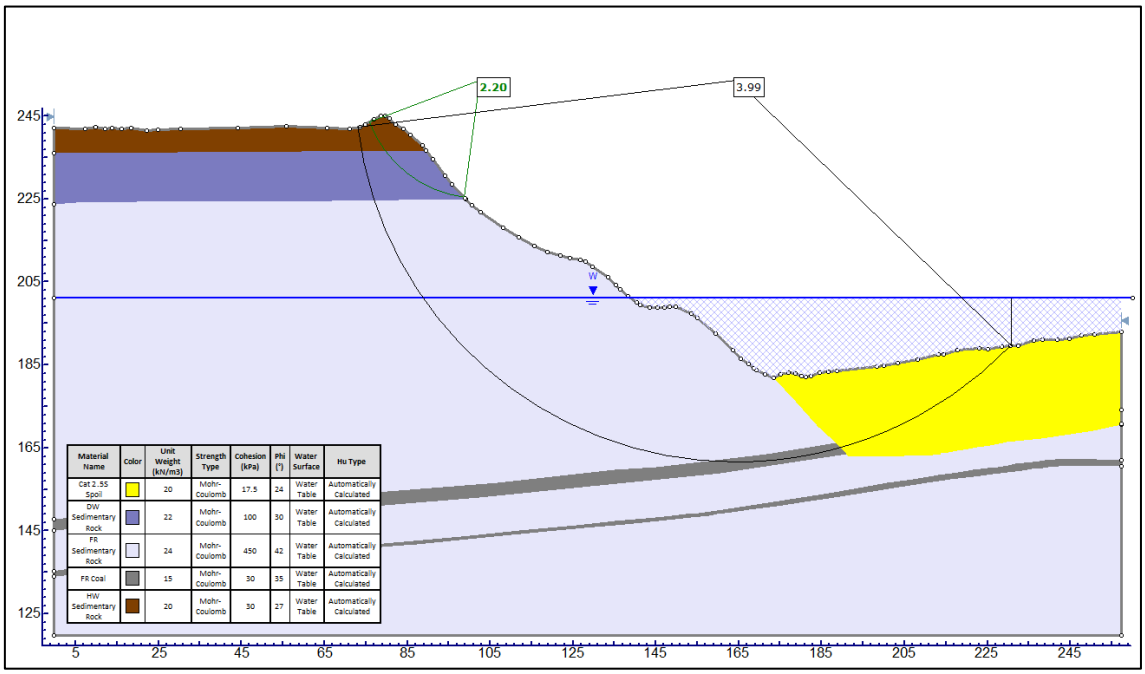


Figure 34. IPE-4-2 existing endwall partially backfilled with final void lake. Overall FOS = 3.99. Critical FOS = 2.20 (GWL = 201.1 mAHD).

6.7.3 IPE-4-3 Highwall

The IPE-4-3 highwall cross-section shown in Figure 35 results in an overall FOS = 3.29.

The critical FOS = 2.59 and the surface is in the highly and distinctly weathered horizons. It is likely that the highly weathered horizon, which currently has a batter angle of 45°, will eventually erode back to a 27° slope. This would represent a crest retreat of approximately 6 m. Alternatively, the highly weathered horizon could be battered back to 27° as part of the final voids reshaping.

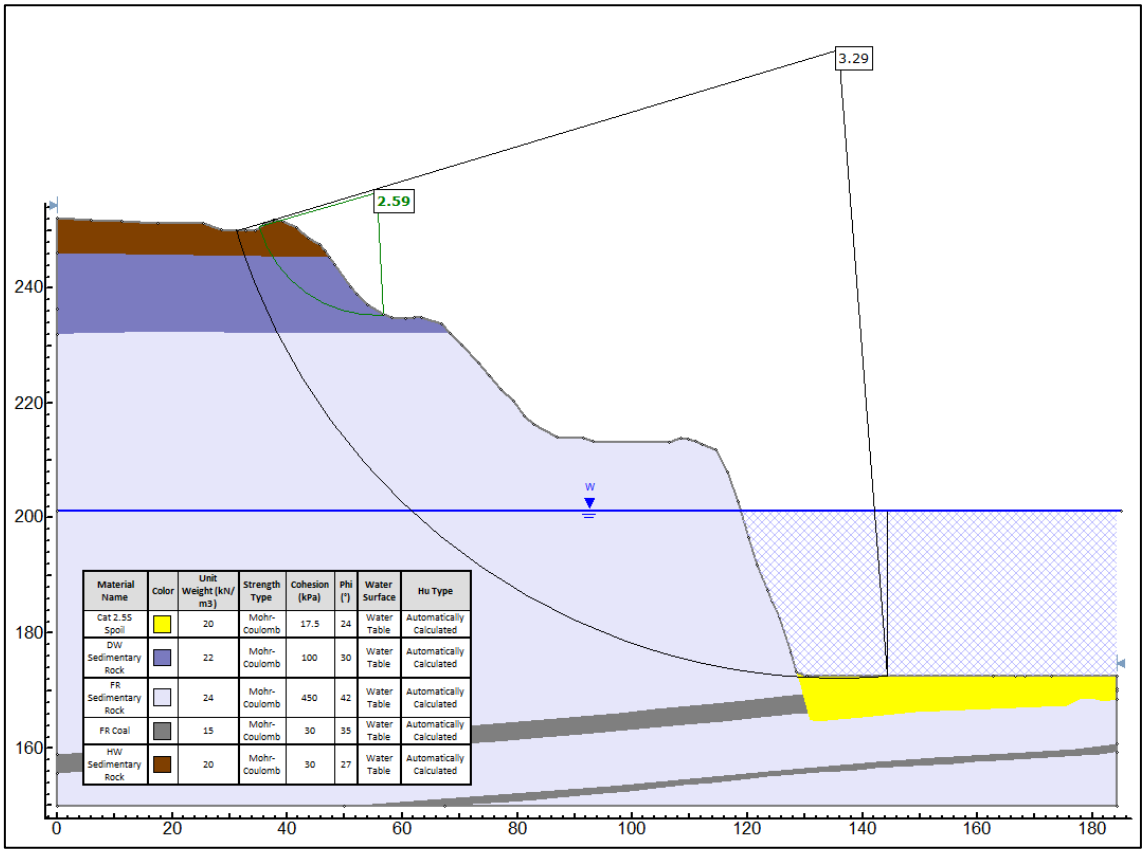


Figure 35. IPE-4-3 existing highwall final void lake. Overall FOS = 3.29. Critical FOS = 2.59 (GWL = 201.1 mAHD).

6.7.4 IPE-4-4 Lowwall

A cross section of the existing IPE-4-4 lowwall spoil, which is likely to be the final void geometry, is shown in Figure 36. The spoil is all located above the level of the predicted final void lake. Consequently, a non-circular style failure on a basal plane within the saturated base of the spoil has been assumed for the eastward facing spoils and a circular analysis for the westward facing spoil, where a failure through the saturated layer is unlikely.

The easternmost spoil batter has a calculated FOS = 1.39, as shown in Figure 37. Without a buttress, it would need to be dozed down to an overall batter angle of 31° in order to achieve a FOS ≥ 1.50, as shown in Figure 38.

In all other cases, the calculated critical FOS ≥ 1.50, as shown in the plots in Figure 39 and Figure 40.

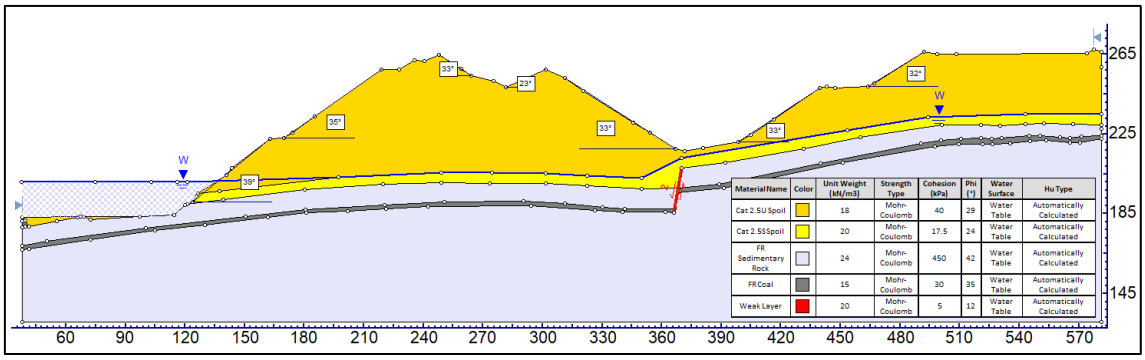


Figure 36. IPE-4-4 final void geometry East -LHS, West RHS, (GWL = 201.1 mAHD).

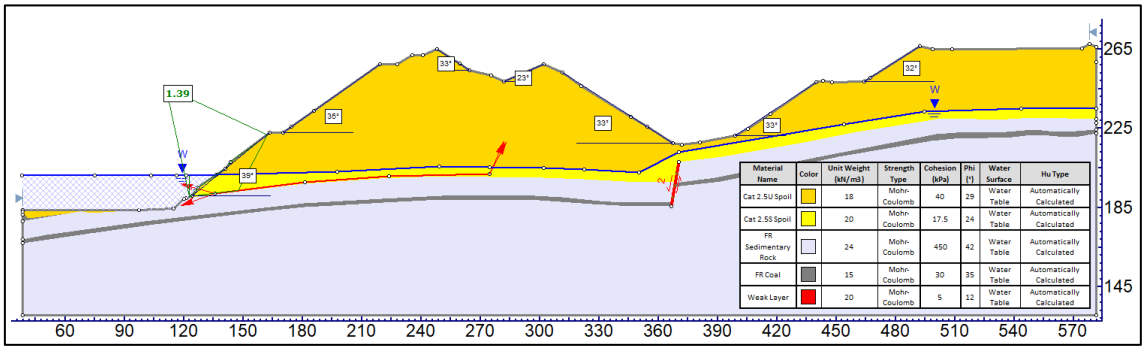


Figure 37. IPE-4-4 existing lowwall easternmost lowwall external batter. Critical FOS = 1.39 (GWL = 201.1 mAHD).

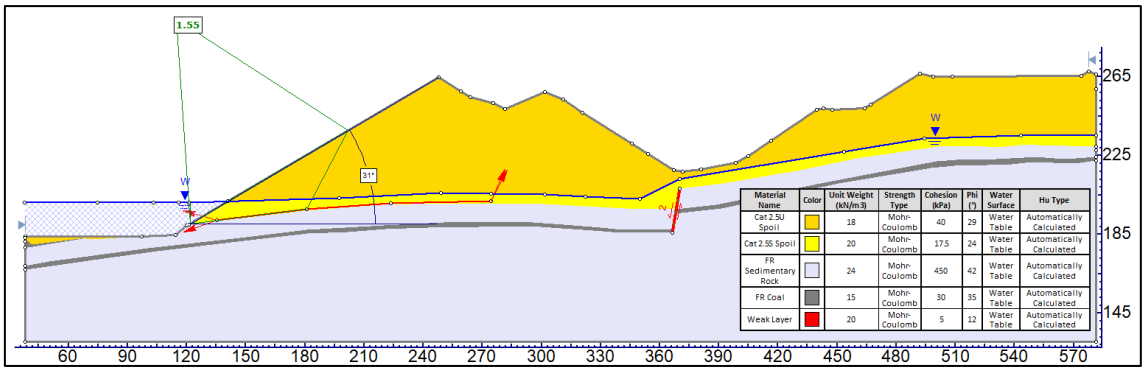


Figure 38. IPE-4-4 existing lowwall easternmost external batter regraded to 31°. Critical FOS = 1.55 (GWL = 201.1 mAHD).

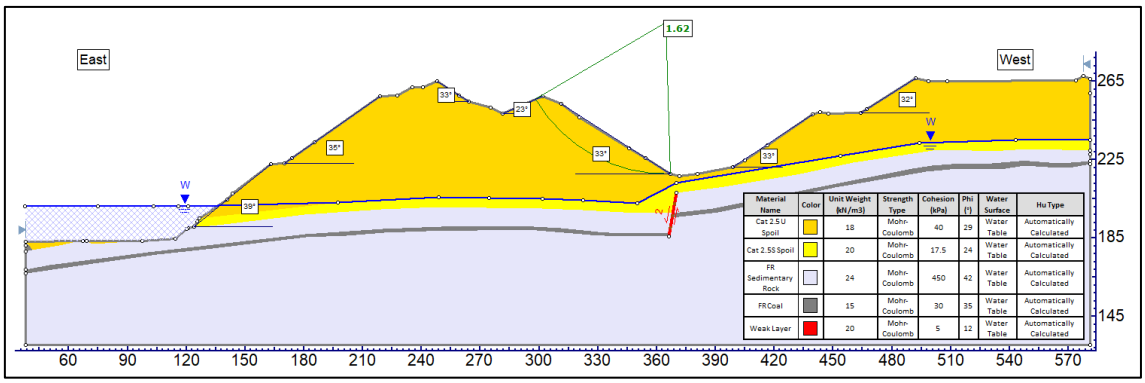


Figure 39. IPE-4-4 existing lowwall eastern internal batter. Critical FOS = 1.62 (GWL = 201.1 mAHD).

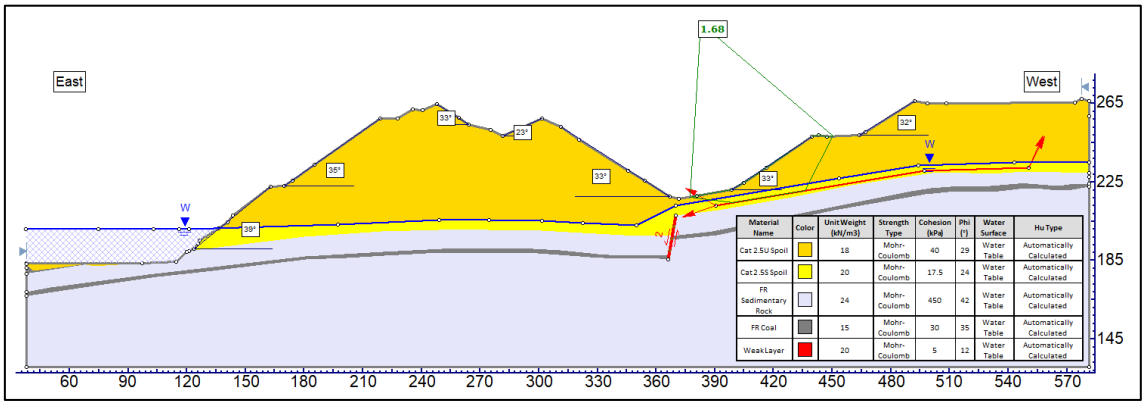


Figure 40. IPE-4-4 existing lowwall western internal batter. Critical FOS = 1.68 (GWL = 201.1 mAHD).

6.7.5 IPE-4-5 Highwall

The IPE-4-5 highwall cross-section shown in Figure 41 results in an overall FOS = 2.85.

The critical FOS = 2.28 and the surface is in the highly and distinctly weathered horizons. The highly weathered horizon has been battered back to 27° and is unlikely to erode much more provide there is not concentrated discharge towards the pit.

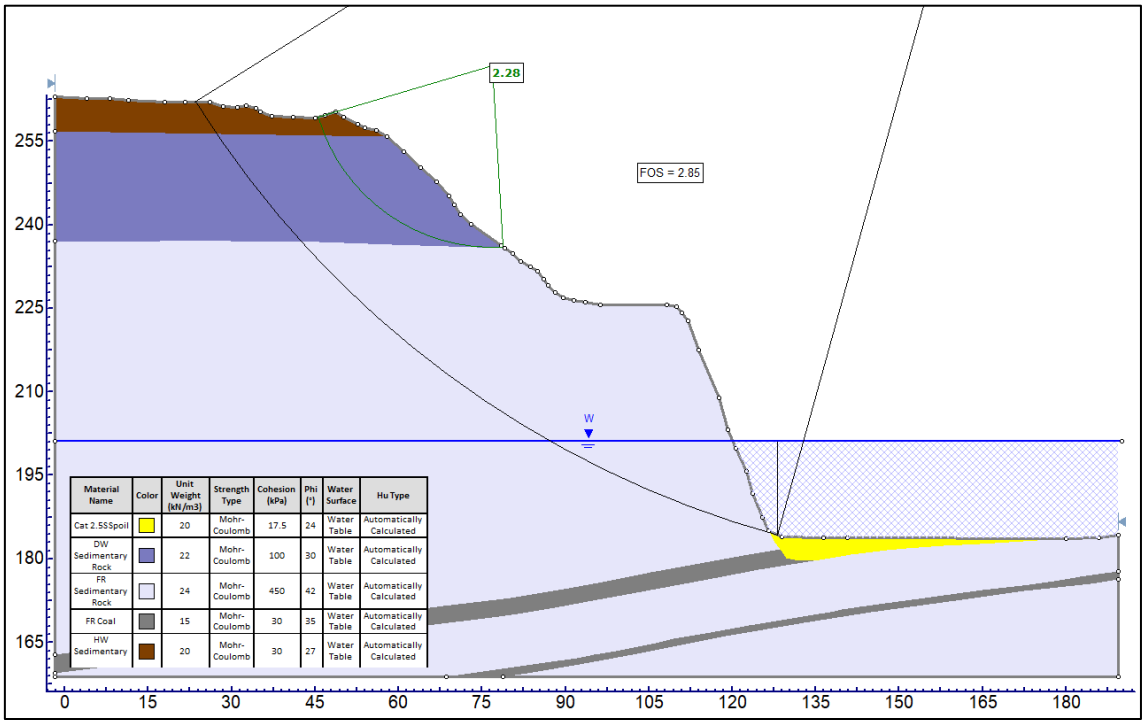


Figure 41. IPE-4-5 existing highwall final void lake. Overall FOS = 2.85. Critical FOS = 2.28 (GWL = 201.1 mAHD).

6.8 IPE Pit 5

6.8.1 IPE-5-1 Northern Wall

The IPE-5-1 proposed northern wall final void lake shown in Figure 42 results in a critical FOS = 3.20. The non-circular failure surface follows the LHD Seam layer.

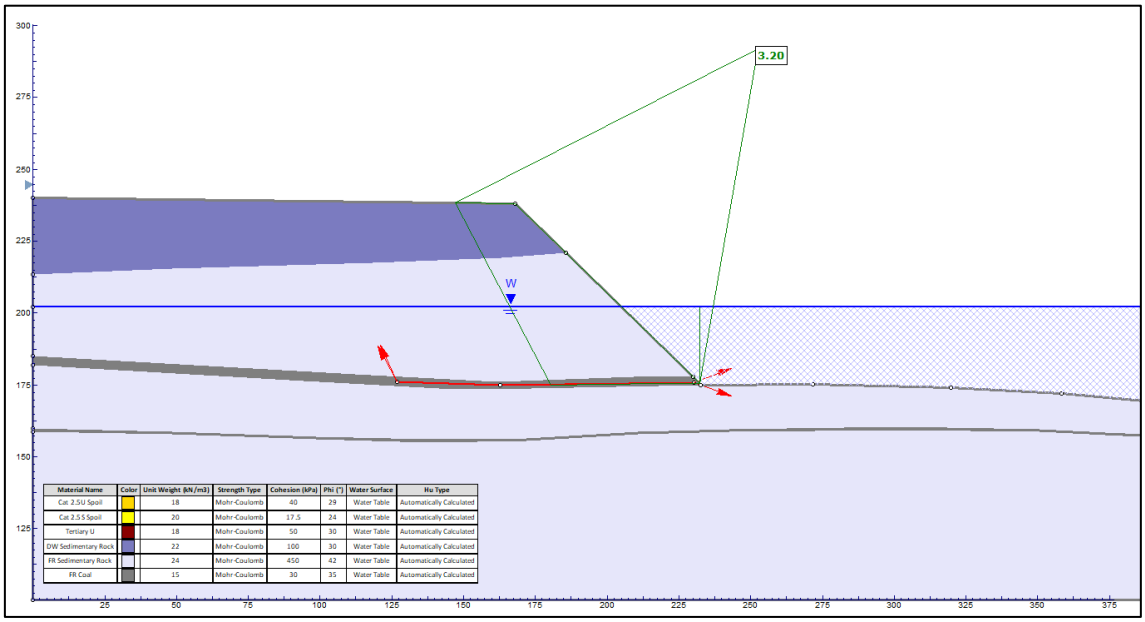


Figure 42. IPE-5-1 proposed northern wall final void lake. Critical FOS = 3.20 (GWL = 202.1 mAHD).

6.8.2 IPE-5-2 Eastern Wall

The IPE-5-2 eastern wall final void lake shown in Figure 43 results in a critical FOS = 2.49. The circular failure surface is in the distinctly weathered horizon.

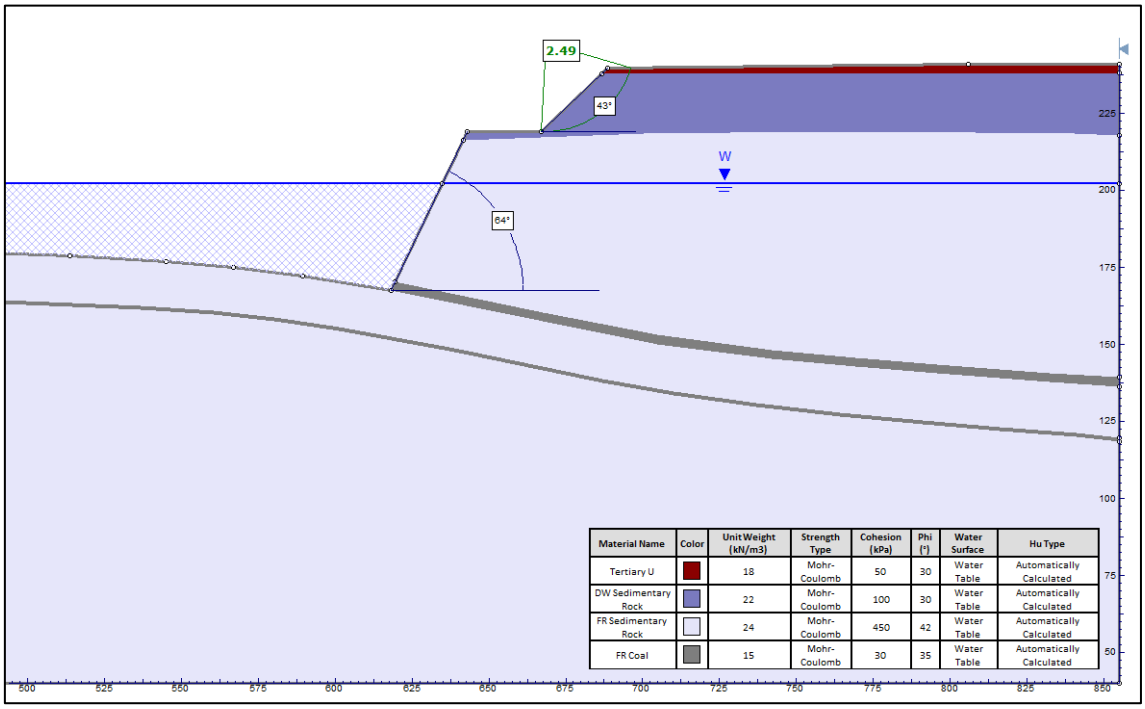


Figure 43. IPE-5-2 proposed eastern wall final void lake. Critical FOS = 2.49 (GWL = 202.1 mAHD).

6.8.3 IPE-5-3 Southern Wall

The IPE-5-3 proposed southern wall backfilled void shown in Figure 44 results in a critical FOS = 2.65. The circular failure surface is in the distinctly weathered horizon.

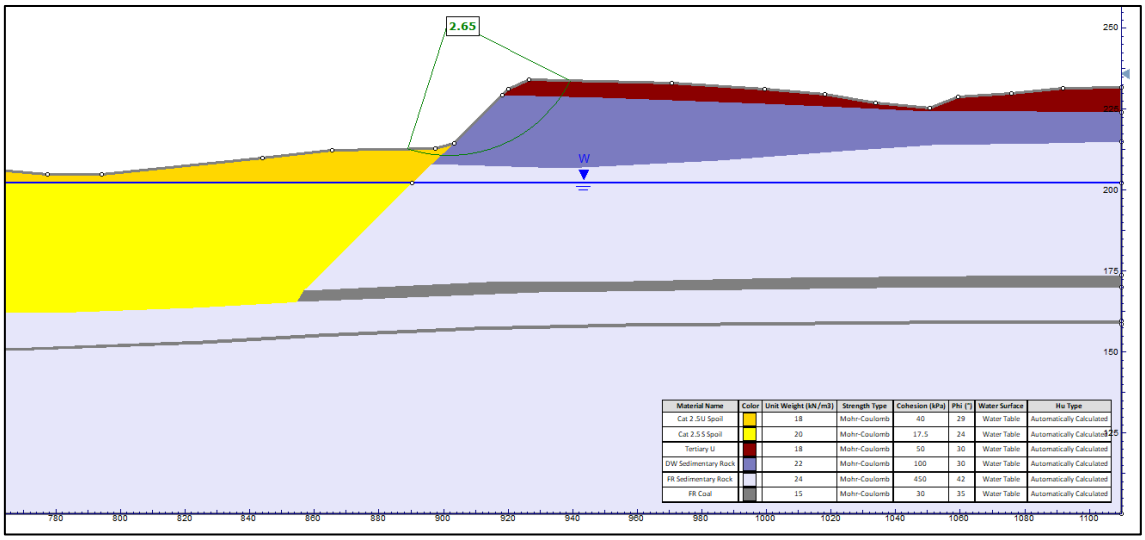


Figure 44. IPE-5-3 proposed southern wall backfilled. Critical FOS = 2.65 (GWL = 202.1 mAHD).

6.8.4 IPE-5-4 Western Lowwall

The IPE-5-4 proposed western lowwall final void lake cross-section shown in Figure 45 results in a critical FOS = 2.14. The circular failure surface is located in the distinctly weathered horizon.

The backfilled cross-section shown in Figure 46 results in a critical FOS = 1.90 owing to the presence of the final void lake and saturation of the spoil.

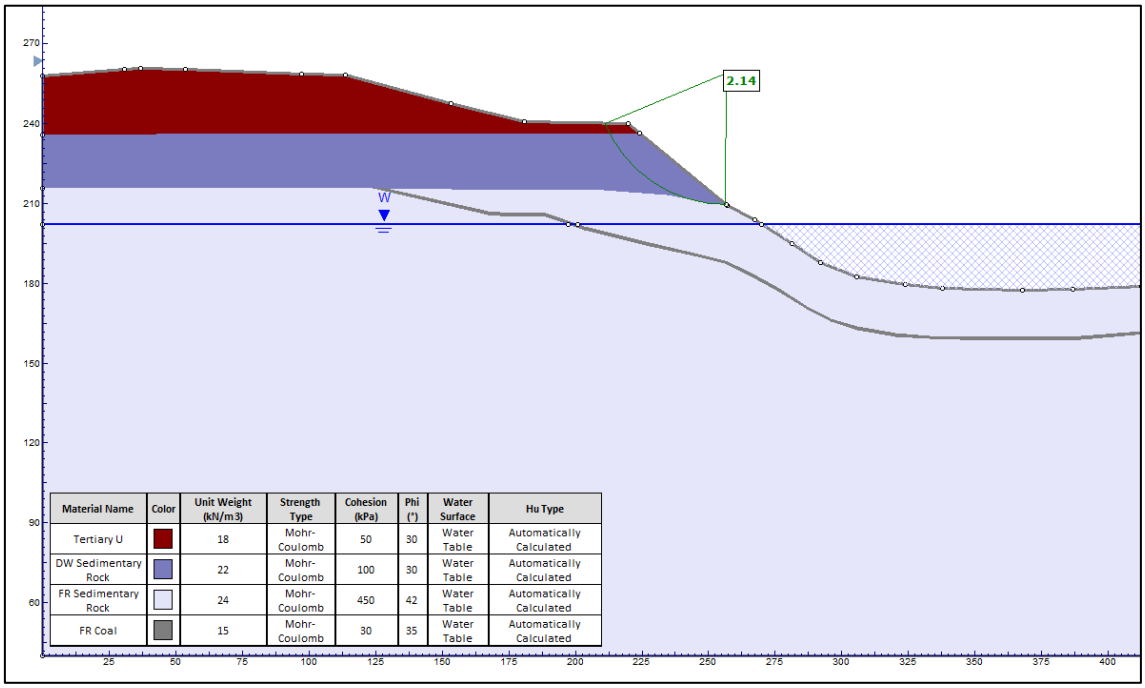


Figure 45. IPE-5-4 proposed western lowwall final void lake. Critical FOS = 2.14 (GWL = 202.1 mAHD).

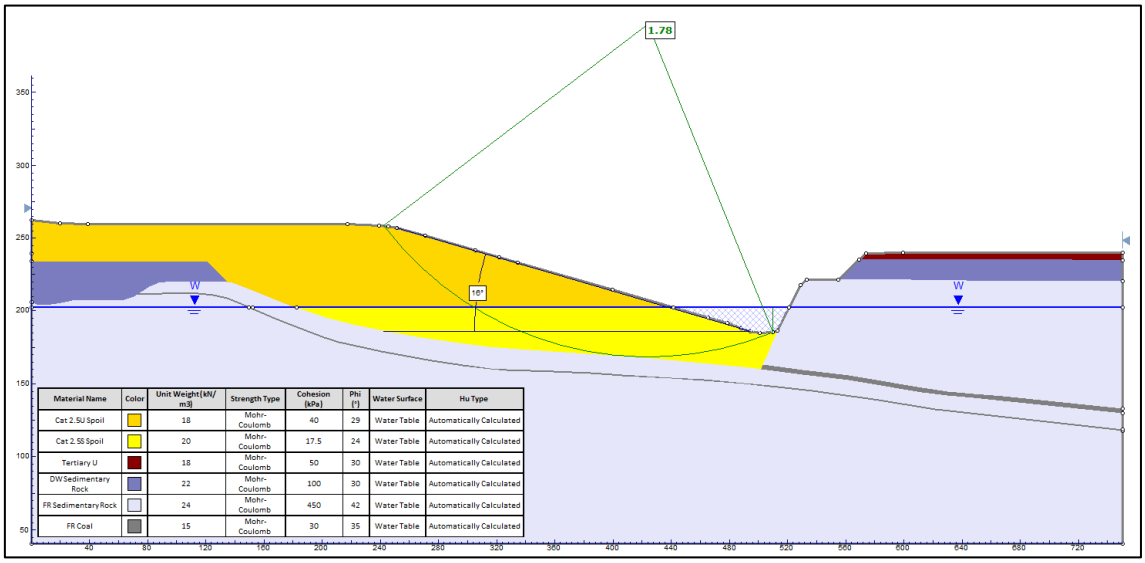


Figure 46. IPE-5-4 proposed western lowwall backfilled. Critical FOS = 1.78 (GWL = 202.1 mAHD).

7 RELEVANCE OF SINGLE DESIGN FOS ≥ 1.50

Guidelines for factors of safety and probability of failure have been published in "*Acceptance Criteria in Guidelines for Open Pit Slope Design*" by Read & Stacey (2009). This publication is widely accepted both in Australia and internationally.

Table 9.9 from Read & Stacey (2009) indicates that a FOS of 1.50 is appropriate where there is a high consequence of failure and that the FOS would apply to the overall slope. In civil engineering, a FOS of 1.50 would be appropriate to permanent works where there is a high level of public exposure, such as a road or rail cutting.

For final voids, where there is virtually no public exposure, and particularly where any failures are fully contained within existing pits, a FOS of 1.20 or 1.30 is considered appropriate.

Theoretically, slopes with a FOS of 1.20 should not fail but because of the uncertainties associated with the materials, groundwater conditions, and methods of analysis, it is acknowledged that there is a small chance of failure. The calculated probability of that failure depends on the variability of the input parameter values. In the case of the final voids, such failures would probably take the form of slumps through the saturated spoil.

If, nevertheless, a FOS ≥ 1.50 is required, then previous work has established that the most economical way to achieve this is likely to be dozer pushing the spoil down at angles in the range of 18° to 27°.

Table 4. Typical FOS and POF acceptance Criteria (Table 9.9 in Read & Stacey, 2009).

Slope Scale	**Consequences of Failure[2]**	**Acceptance Criteria[1]**		
		Min FOS (Static)	**Min FOS (Dynamic)**	**Max POF P[FOS≤1]**
Bench	Low-high	1.10	NA	25-50%
Inter-ramp	Low	1.15 - 1.20	1.00	25%
	Medium	1.20	1.00	20%
	High	1.20 -1.30	1.10	10%
Overall	Low	1.20 - 1.30	1.00	15-20%
	Medium	1.30	1.05	5-10%
	High	1.30 - 1.50	1.10	≤5%

1. Needs to meet all acceptance criteria
2. Semi-quantitatively evaluated.

8 TAILINGS CAPPING

Tailings have been and will continue to be disposed in parts of IP N1. Eventually, these tailings storage facilities (TSFs) will be capped and rehabilitated. Typically, tailings are allowed to dry out for a period of time until a crust has formed. The strength and thickness of the crust is evaluated, and a design is generated for capping the tailings. Usual practice is initially to cover the tailings with a thin layer of spoil using lightweight equipment such as “swamp dozers” and then, having created a platform of sufficient strength, place additional spoil using heavier equipment. Geotechnically, the overburden spoil that has been generated at Isaac Plains is considered suitable as a capping material.

9 DISCUSSIONS AND CONCLUSIONS

The nominated target geotechnical factor of safety (FOS) for the final voids landforms is 1.50. This is an historical value and a 2024 ACARP report by Simmons, Henderson and Kennedy indicates that a FOS in the range of 1.20 to 1.50 is appropriate. Nevertheless, for this report a target FOS of 1.50 has been maintained.

The current ground surface, including the existing voids, approximates the landform proposed for relinquishment. A series of stability analyses was undertaken to check the factors of safety of the existing voids and, where the calculated FOS was less than 1.50, alternative scenarios were tested to achieve the target FOS.

All of the highwalls in fresh rock achieved a FOS ≥ 1.50.

Over steepened, highly weathered rock and soil horizons at the top of highwalls typically have FOS values < 1.50. However, these horizons are usually less than 20 m thick. They have been excavated to batter angles of around 45° and could be reshaped or be allowed to erode back to a geotechnically stable slope of around 27° (1V in 2H).

All the overburden dumps in which the base of the spoil is not inundated by a final void lake have critical FOS values ≥ 1.50.

All the overburden dumps in which the base of the spoil is inundated have a critical FOS < 1.50. Alternative geometries have been analysed that would achieve a critical FOS ≥ 1.50. Any of the solutions would require extensive movement of spoil. If a FOS ≥ 1.50 is required, the most practical solution, rather than building buttresses out of imported Cat 3 spoil, would be to simply doze the existing spoil down to angles that would range between 18° to 27°, with the angle depending on specific pit geometries.

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APPENDIX Q FINAL VOID PMF FLOODING ASSESSMENT REPORT

Isaac Plains Complex PRCP

Final Void PMF Flooding Assessment Report

Stanmore Limited

Doc. Ref.: IPM-003-B1

Date: 18 June 2025

Rev. No.	Doc Ref.	Report Date	Report Author	Reviewer
1	IPM-003-B	18 June 2025	AMH	MGB

For and on behalf of **HydroBalance**
Environmental and Mine Water Management Solutions

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1 Introduction

The Isaac Plains Complex (IPC) is an operating open cut coal mine located approximately 7 km north-east of Moranbah township in Central Queensland and comprises Isaac Plains Mine (IPM) and Isaac Plains East (IPE). Production at IPM commenced in 2006 (under a previous owner) as a truck and shovel operation, and dragline operations commenced in 2011/12. The operation was placed under care and maintenance by the previous owner in late 2014 and was acquired by the proponent in November 2016. Mining operations at IPM recommenced in January 2016. Expanded operations at IPE were approved in March 2018, with mining operations commencing in July 2018.

HydroBalance was engaged by Stanmore IP Coal Pty Ltd (Stanmore) to undertake a final void flooding assessment. This assessment is to support the Progressive Rehabilitation and Closure (PRC) Plan for the Isaac Plains Mine (IPM) and responds to the Information Request provided by the Department of Environment, Tourism, Science and Innovation (DETSI).

2 Flood assessment

2.1 Overview

The existing Isaac River TUFLOW flood model was used to assess the PMF water levels was used to assess the potential interaction between regional and local floodwaters and the proposed final landform. Isaac River, Smoky Creek and Five Mile Gully streamflows have been included in this assessment. The drainage in the vicinity of the final landform is shown in Figure 2.1.

Development of the Isaac River TUFLOW flood model is documented in the *Isaac Downs Extension – Surface Water Assessment,* prepared by HydroBalance in 2025.

2.2 Existing conditions flood behaviour

2.2.1 Modelled flood depths and extent

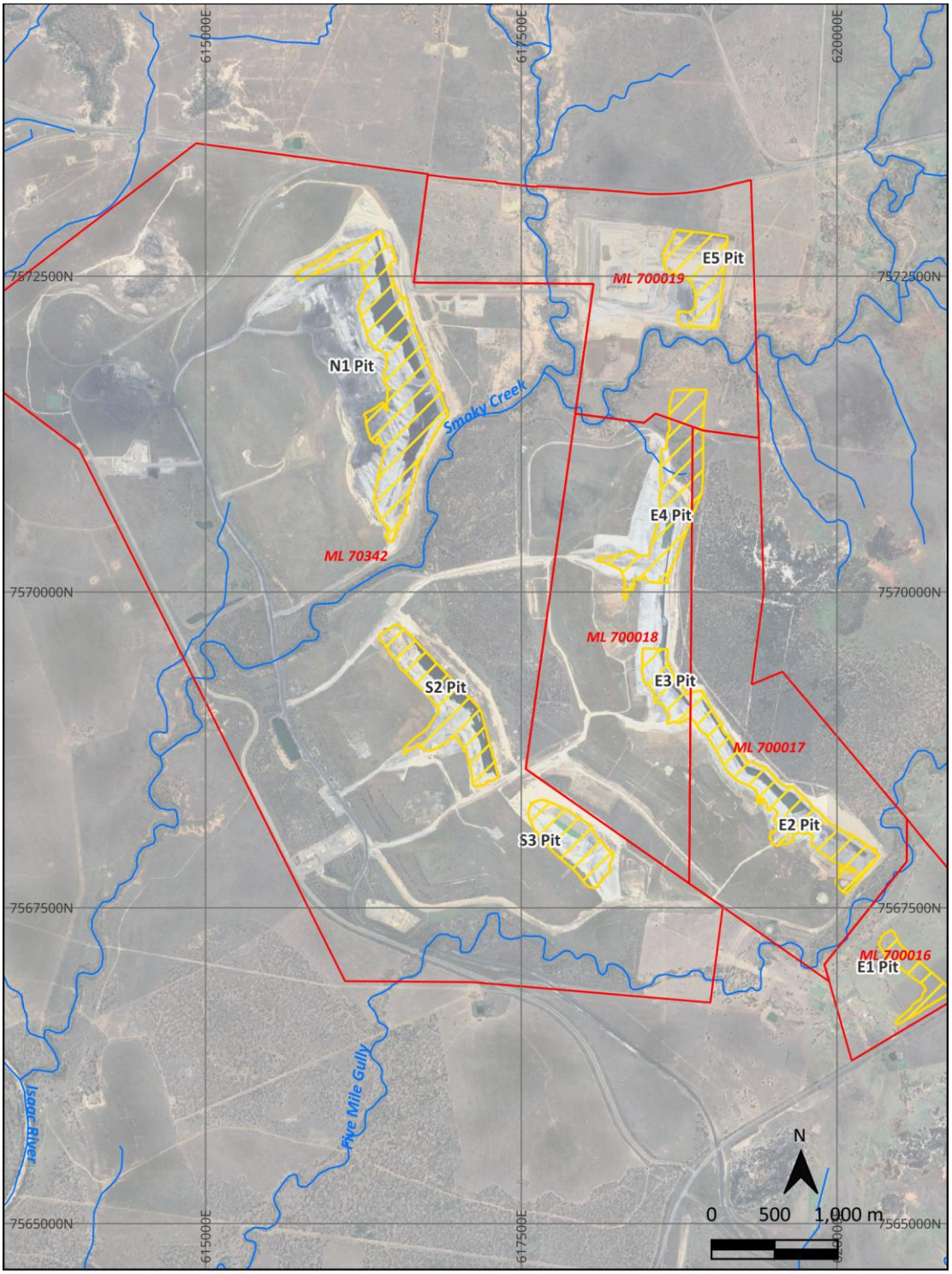
The Probable Maximum Flood (PMF) flood depths and extent in the vicinity of the existing site are shown in Figure 2.2. This figure shows that the existing mining pits are not located within the PMF event extent. Elevated depths were observed in a number of locations in Smokey Creek, particularly near N1 Pit and E5 Pit.

The IPC site is a significant distance from the Isaac River floodplain, hence there is no modelled interaction between the Isaac River PMF floodplain and the IPC final landform.

2.2.2 Modelled flood velocity

The PMF flood velocities in the vicinity of the existing site are shown in Figure 2.3.

The PMF flood velocities are generally between 2.0-4.0 m/s in Smoky Creek and 1.0-3.0 m/s in Five Mile Creek, in the vicinity of the site. Velocities are highest through a confined section between the N1 Pit and S2 Pit spoil dumps, reaching up to 5.0 m/s.



Title: Isaac Plains Complex current and proposed final void layout

Project: Isaac Plains Mine PRC Plan Surface Water

HydroBalance

Legend

- Mining leases
- Final void footprint
- Watercourse

Figure 2.1 – Local hydrology and proposed final void layout

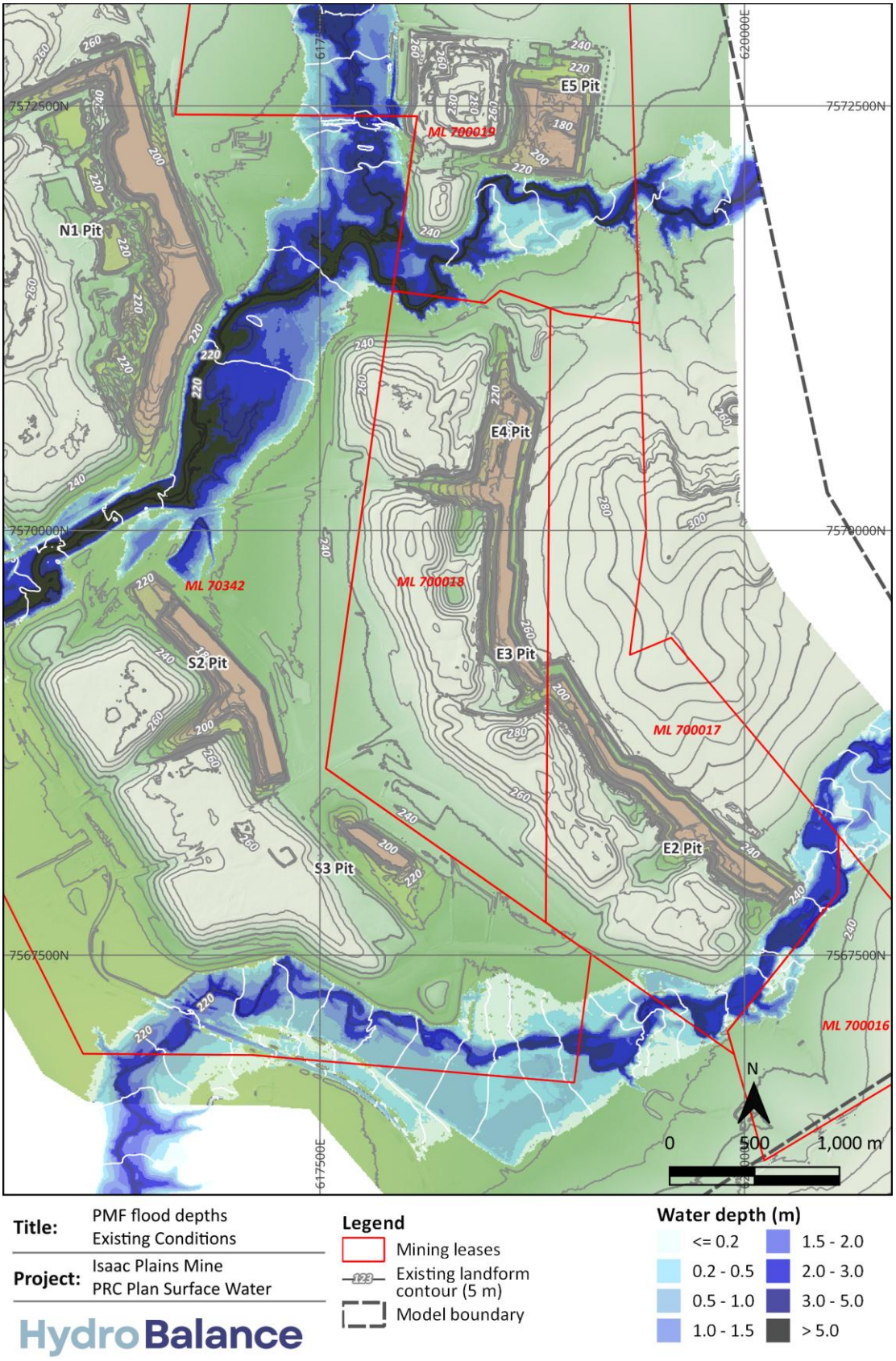


Figure 2.2 – Existing modelled flood depths and extent – PMF event

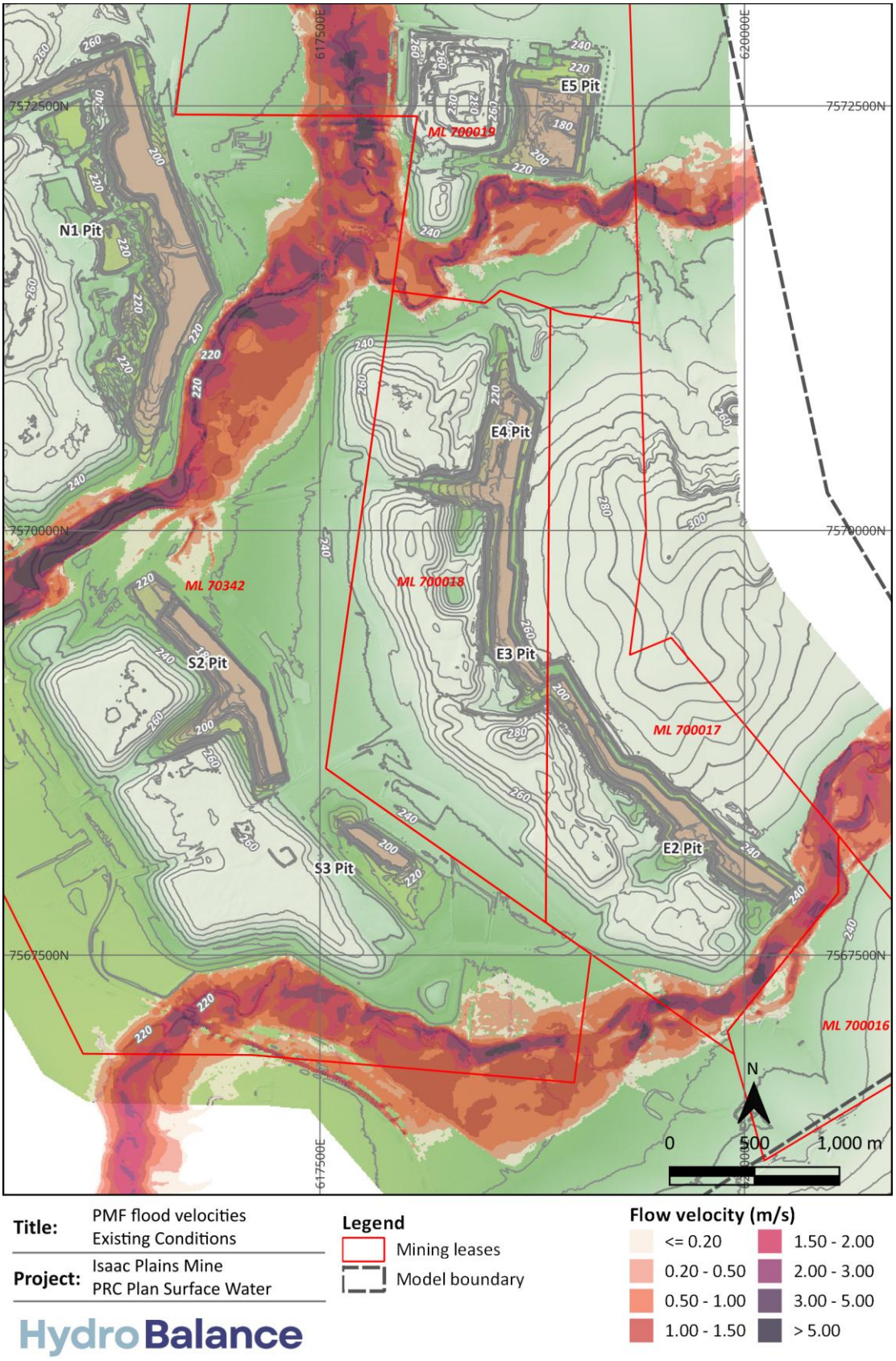


Figure 2.3 – Existing modelled flood velocities – PMF event

2.3 Post-closure flood behaviour

The post-closure flood behaviour has been modelled based on the proposed final landform surface developed by Stanmore.

2.3.1 Modelled flood depths and extent

The Probable Maximum Flood (PMF) flood depths and extent in the vicinity of the final landform are shown in Figure 2.4. This figure shows that the final voids are not located within the PMF event extent, hence it is highly unlikely that the final void would be located within the local creek floodplain for any conceivable flood event.

The impact of the final landform on the existing PMF water level is shown in Figure 2.5. This figure shows that the water level impacts would generally be confined within the Mine Leases, with the exception of some minor impacts in Five Mile Gully extending up to 750 m downstream of the Mine Lease. Flood level impacts generally manifest in lower water levels, aside from several localised increases, particularly near E4 Pit and E1 Pit.

2.3.2 Modelled flood velocity

The PMF flood velocities in the vicinity of the final landform are shown in Figure 2.6. The maximum PMF velocities adjacent to each final void pit are as follows:

- N1 Pit: 4.0 m/s, separated by 10 m high, 60 m wide haul road.
- S2 Pit: 0.1 m/s Smoky Creek backwater, approximately 75-100 m from the void crest.
- S3 Pit: no PMF floodwaters in the vicinity of the void.
- E1 Pit: 0.1 m/s Five Mile Creek overbank flows, approximately 20 m from the void crest.
- E2 Pit: 1.8 m/s, separated by final landform.
- E3 Pit: no PMF floodwaters in the vicinity of the void.
- E4 Pit: 0.3 m/s, separated by final landform.
- E5 Pit: 3.0 m/s, separated by final landform.

The impact of the final landform on the existing PMF velocities is shown in Figure 2.7. The velocity impacts vary across site, ranging between decreases of 1.0 m/s and increases of 2.0 m/s. The velocity impacts do not extend more than 750 m downstream of the Mine Leases.

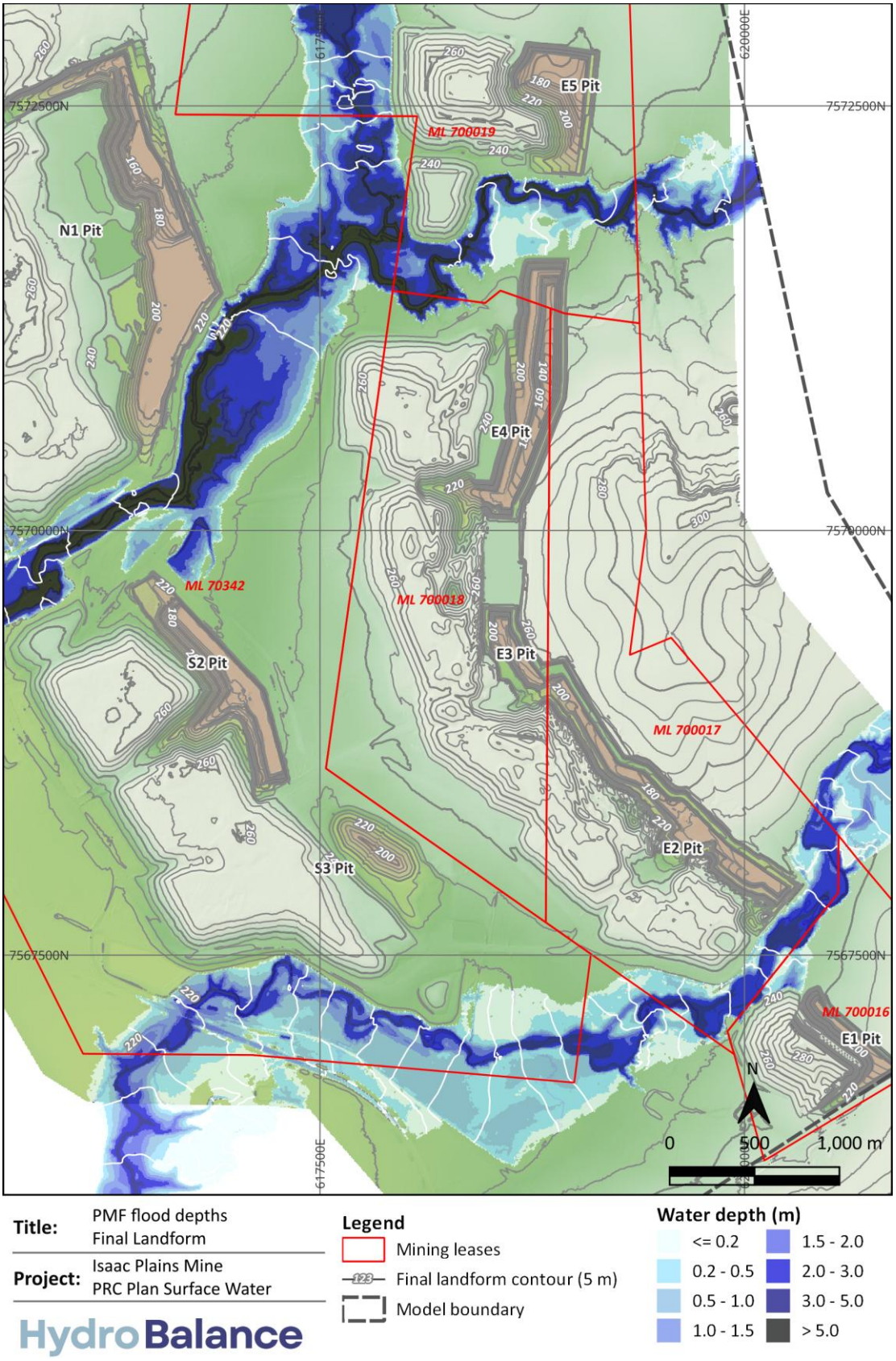
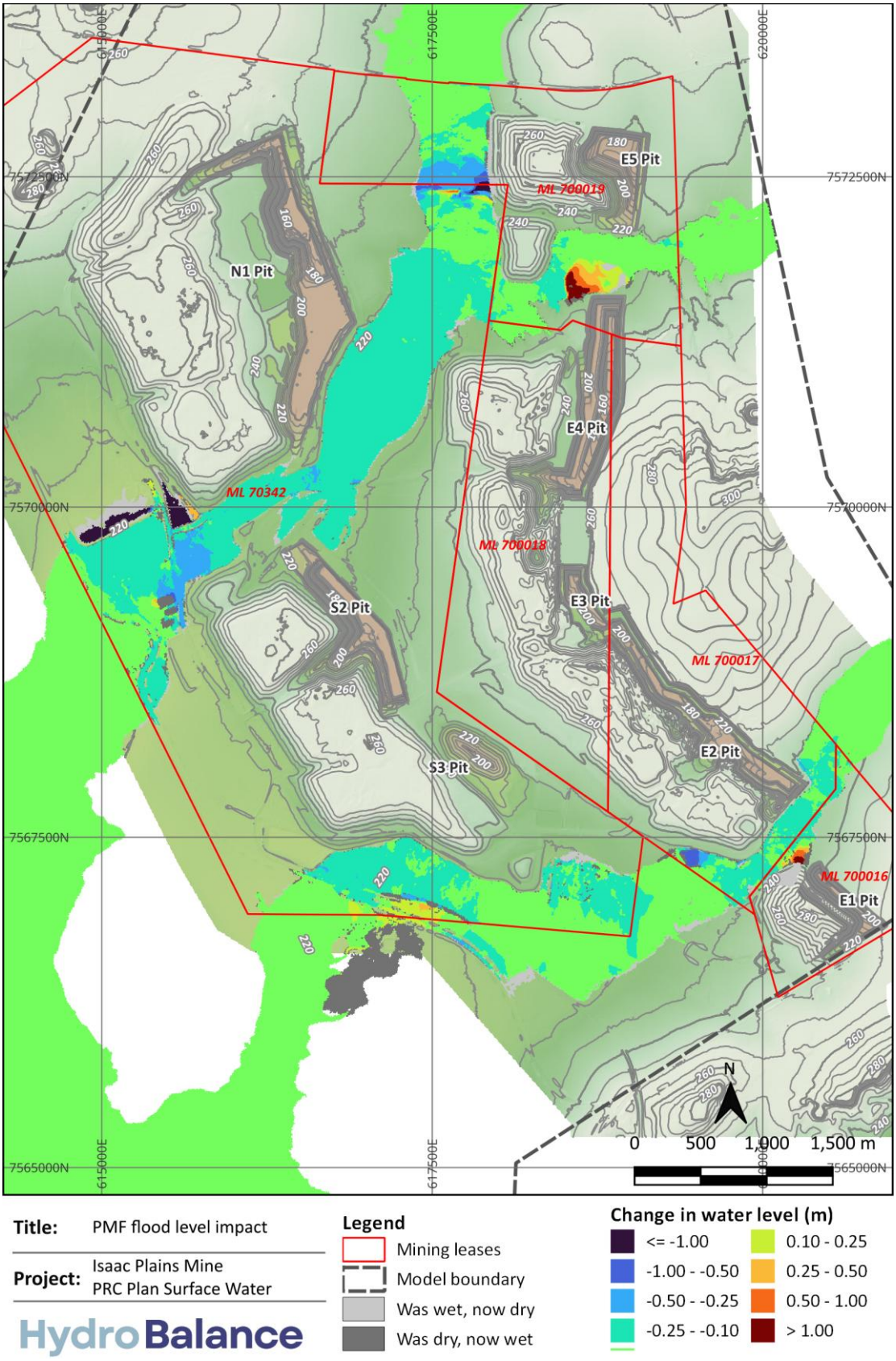


Figure 2.4 – Proposed final landform modelled flood depths and extent – PMF event



Title: PMF flood level impact

Project: Isaac Plains Mine
PRC Plan Surface Water

HydroBalance

Legend

- Mining leases
- Model boundary
- Was wet, now dry
- Was dry, now wet

Change in water level (m)

- <= -1.00
- -1.00 - -0.50
- -0.50 - -0.25
- -0.25 - -0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- > 1.00

Figure 2.5 – Proposed final landform modelled flood level impact – PMF event

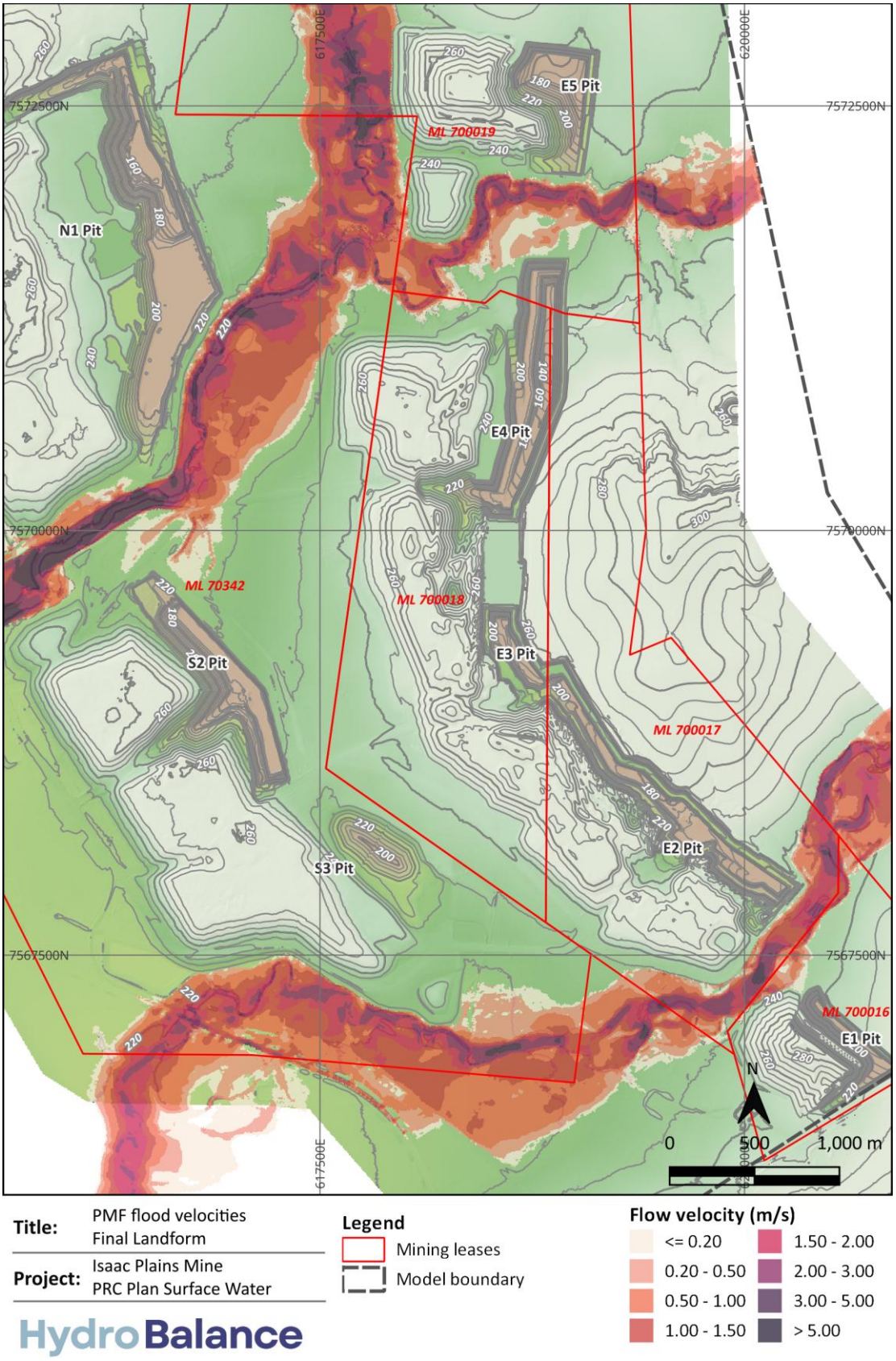


Figure 2.6 – Proposed final landform modelled flood velocities – PMF event

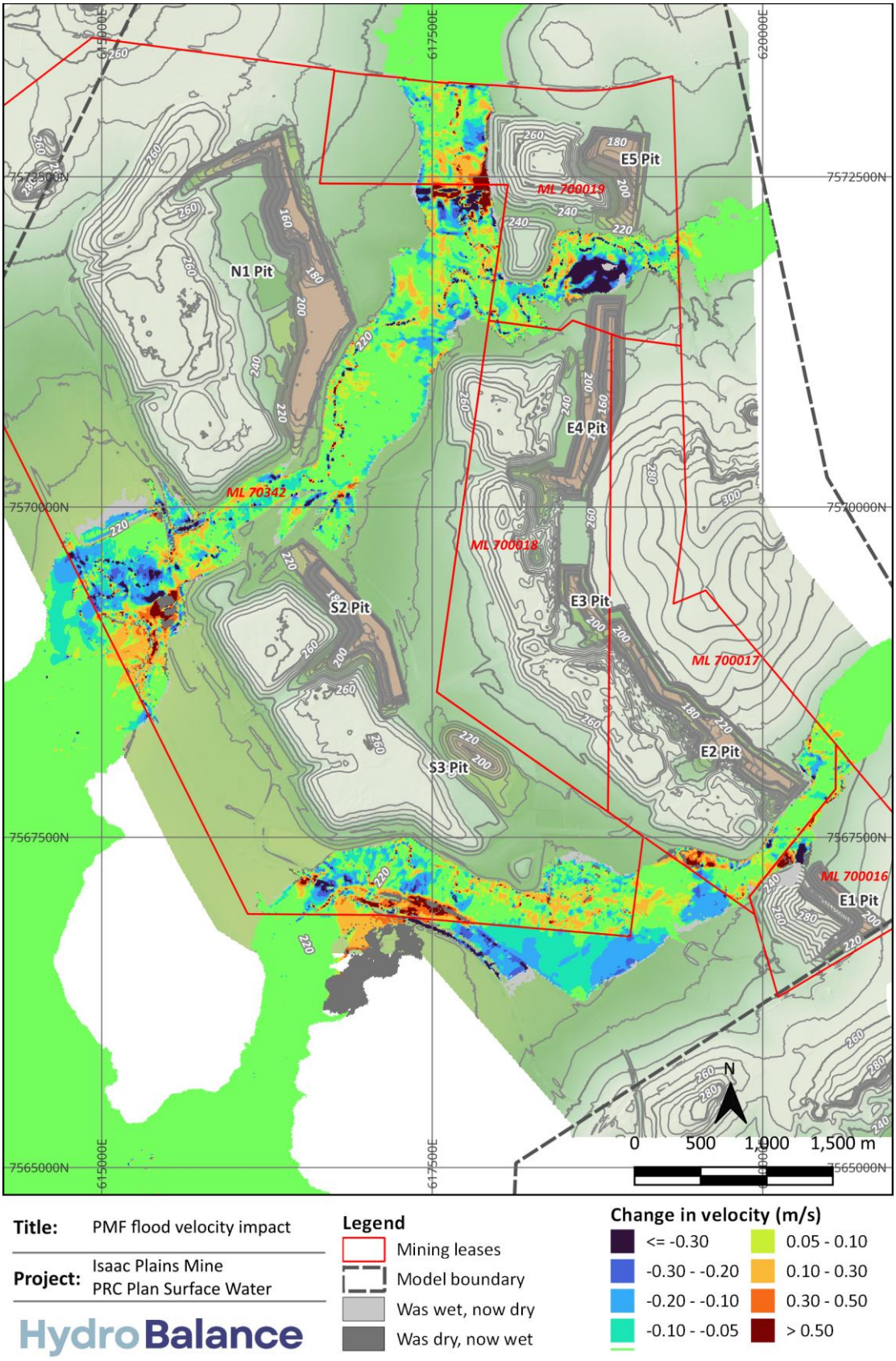


Figure 2.7 – Proposed final landform modelled flood velocity impact – PMF event

3 Summary and conclusions

A TUFLOW hydraulic model was developed to assess the expected flood behaviour of the local and regional waterways in the vicinity of the IPC final landform.

The final landform flood assessment demonstrates that the Isaac River and local creek flooding would not interact with or flow into the IPC final voids for the PMF event.