Progressive Rehabilitation and Closure Plan

Jubilee Metals Limited
Croydon Gold Mine
ML5248
BAA220037.01
21 March 2023

CROYDON GOLD MINE PRC PLAN COVER PAGE

A Progressive Rehabilitation and Closure Plan (PRC Plan) must contain a cover page and include the following information:

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1 REHABILITATION PLANNING PART

1.1 Introduction

Jubilee Metals Limited (Jubilee), formerly known as Wilson Minerals Pty Ltd, own and manage the non-operational Croydon Gold Mine Project (the Project), located on Mining Lease (ML) 5248, which they acquired in 2016.

The Project was formerly a large low-grade gold mine which has since been closed, decommissioned, and rehabilitated. Gold mining took place from the late 1880s for approximately three decades, before mining was recommenced in 1987. Mining then ceased in 1990 and the mine was decommissioned in 1993. Significant rehabilitation works were undertaken between 1993 and 1996, and upon auditing were continued to 1997. Since this time ongoing monitoring, evaluation, and maintenance activities have taken place.

Mining related landforms that remain on ML5248 are comprised of open pits which now contain approved pit lakes, rehabilitated waste rock dumps and infrastructure areas such as roads and tracks, abandonment bunds, water management structures and rehabilitated hardstand areas.

This Progressive Rehabilitation and Closure Plan (PRC Plan) has been developed as part of the transitional provisions whereby the holder of Environmental Authority (EA) EPML00950913 must submit a proposed PRC Plan that meets the requirements of Sections 126C and 126D of the *Environmental Protection Act 1994* (EP Act), pursuant to Section 754 of the EP Act. Furthermore, this PRC Plan has been prepared in accordance with the *Mining and Energy Resources (Financial Provisioning) Act 2018* (MERFP Act) and to meet the requirements of the PRC Plan Guideline (ESR/2019/4964) and Schedule 8A of the *Environmental Protection Regulation 2019*.

Ultimately, the PRC Plan seeks to demonstrate Jubilee's ongoing commitment to sound environmental practice and responsibility. The PRC Plan ensures the Project has an agreed post mining land use and describes how rehabilitation of the site has been carried out historically. The PRC Plan further describes project planning, community consultation, risk assessment, monitoring and maintenance, and includes a PRC Plan Schedule (**Appendix A**).

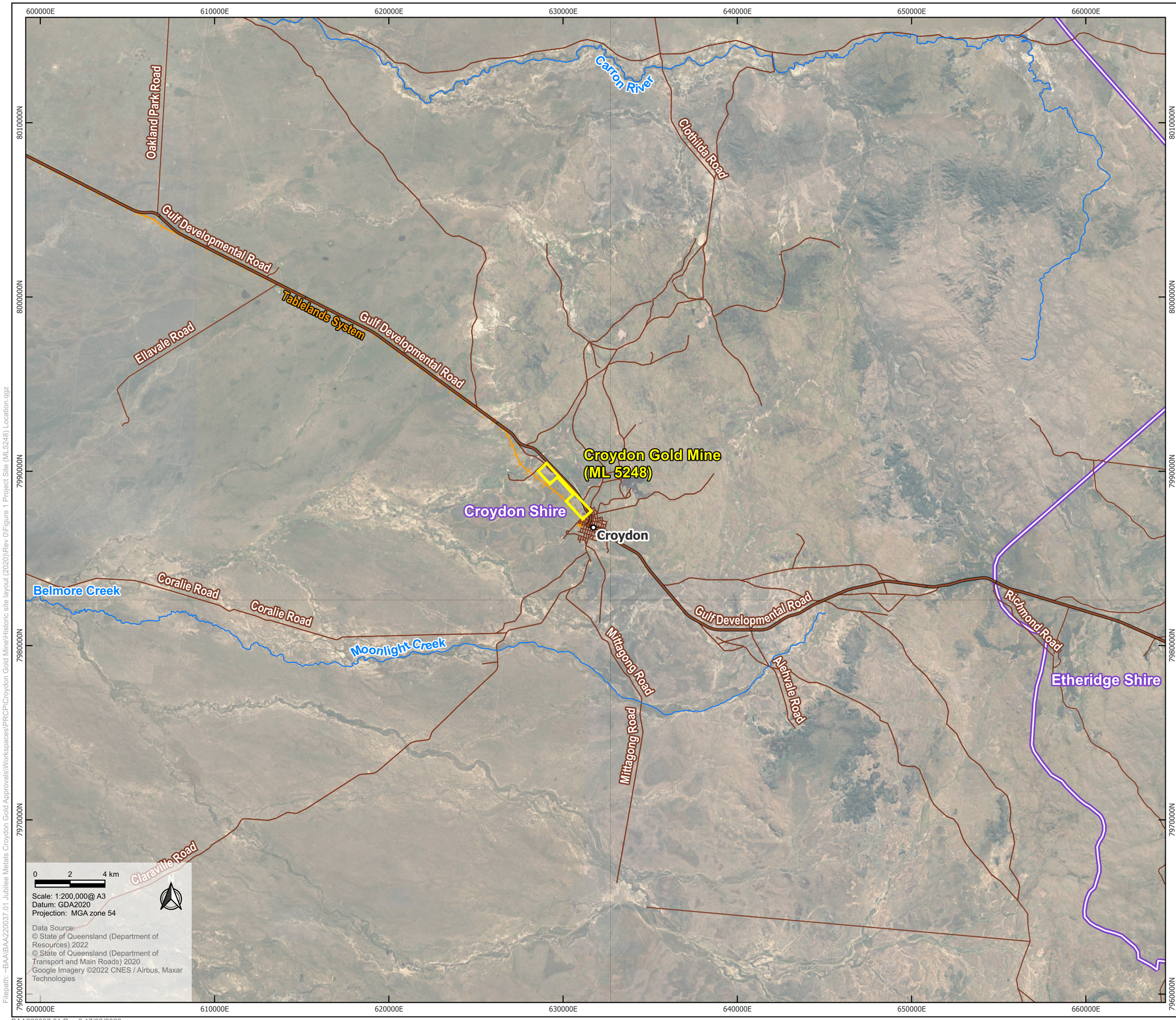
1.2 Site Location Overview

The Project is located wholly within ML5248, an area of 174.4 hectares (ha). The ML is located within the Shire of Croydon Local Government Area, with ML5248 located immediately west of the Croydon township and approximately 560 kilometres (km) west of Cairns, Queensland (refer **Figure 1**).

1.3 Purpose of Plan

Following historic closure of the Project, the Project has remained in care and maintenance. The purpose of this PRC Plan is to outline the progressive rehabilitation and closure requirements that:

- Meet landholder expectations for final land use
- Achieves a decommissioned site that is safe, fit for purpose, and non-polluting
- Eliminates residual impact or liability for community and future land holders following rehabilitation
- Restores agreed areas of the mine footprint to an agreed condition



Legend

- Site boundary
- Local Government Areas
- Railways
- Roads and tracks
- State controlled roads
- Major watercourses

Jubilee Metals
Progressive Rehabilitation and Closure Plan
Croydon Gold Mine

Figure 1
Project Site (ML5248) Location

Filepath: -BAA\BAA220037.01 Jubilee Metals Croydon Gold Approvals\Workspaces\PRCP\Croydon Gold Mine\Historic site layout (2020)\Rev 0\Figure 1 Project Site (ML5248) Location.qgz

2 PROJECT PLANNING

This section of the PRC Plan provides baseline information, site location details, a description of the Project and information on rehabilitation/improvement planning.

2.1 Baseline Information

2.1.1 Site Topography

Regionally, the Croydon area's topography is relatively consistent, with elevations of 100-110 m Australian Height Datum (AHD) to the north and west of ML5248 and 130-140 m AHD to the north-east (refer **Figure 2**). Changes in regional topography are seen to the south-east of ML5248 and north-east of Croydon township itself where elevation ranges from 140-180 m AHD.

Topography within the Project area ranges from 105 m AHD elevation in the north to 130 m AHD in the south of the ML. There is a slight topographical rise located immediately west of ML5248, however the shape of the ML skirts this area of elevation and does not intersect it (**Figure 2**).

628000E 629000E 630000E 631000E 632000E

7990000N 7989000N 7988000N 7987000N

Content Pit

Lady Isabella Pit

Gulf Developmental Road

Croydon Gold Mine
(ML 5248)

Tablelands System

Golden Butterfly
North Pit

Golden Butterfly
Pit

Croydon

0 250 500 m

Scale: 1:15,000@ A3
Datum: GDA2020
Projection: MGA zone 54

Data Source:
© State of Queensland (Department of Resources) 2022
© State of Queensland (Department of Transport and Main Roads) 2020
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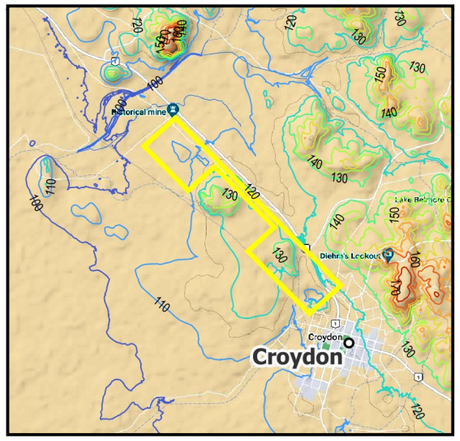

Legend

Site boundary

Historical site infrastructure

Pit

Railways

Roads and tracks

State controlled roads

Elevation contour - mAHD (2018-05-18)

90 - 100

100 - 110

110 - 120

120 - 130

130 - 140

140 - 150

150 - 160

160 - 170

170 - 180

180 - 190

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Figure 2
Topography

2.1.2 Climate

The Project area experiences a hot semi-arid steppe climate according to the Köppen-Geiger classification system (Australian Bureau of Meteorology (BoM) 2022). Hot semi-arid climates are a dry climate subtype characterised by hot summers and warm to cool winters with minimal levels of precipitation.

The closest long term synoptic weather station to the Project (operating 1889 to present) is located directly south of the ML, at Croydon Township (Station 029012). Temperature and rainfall data have been obtained from the Croydon Township weather station using available data (BoM 2022). This data has been analysed to determine indicative temporal fluctuations in weather patterns, refer **Table 1**.

The data indicates that:

- Mean annual rainfall is 745.2 mm
- December to March have the highest mean monthly rainfall. The highest mean monthly rainfall occurs in January with 221.0 mm
- Mean maximum temperatures range from 29.2°C in June to 37.3°C, in December, with an annual mean temperature of 33.8°C
- Mean minimum temperatures range from 14.0°C in July and August to 24.6°C in December
- Mean monthly wind speeds are greatest in the winter months

Table 1. Long Term Climate Data from Croydon Township Weather Station

Month	Temperature (°C)[1]		Relative humidity (%)[2]		Wind speed (km/h)[2]		Rainfall (mm)[1]		
	Mean Max	Mean Min	9am	3pm	9am	3pm	Mean Monthly	Highest Daily	Highest Monthly
Jan	35.5	24.2	70	50	7.1	6.3	221.0	381.0	860.5
Feb	34.5	24.0	75	54	6.9	6.2	179.4	367.8	601.4
Mar	34.3	23.4	67	47	8.2	6.9	118.8	245.9	591.4
Apr	33.9	21.0	57	36	10.0	7.6	24.5	155.2	279.8
May	31.6	17.9	54	34	11.1	8.0	9.0	118.0	150.0
Jun	29.2	14.7	53	32	11.0	8.2	7.9	91.0	139.2
Jul	29.2	14.0	51	29	11.6	8.7	4.2	48.0	83.4
Aug	31.2	15.7	45	25	12.9	9.1	2.5	39.6	44.2
Sep	34.3	19.2	44	23	13.9	9.3	5.3	77.5	92.7
Oct	36.9	22.4	44	25	12.3	8.5	14.2	63.5	145.0
Nov	38.0	24.4	51	30	10.5	7.5	44.2	151.1	384.7
Dec	37.3	24.6	60	37	8.3	7.2	113.8	153.0	312.0
Mean	**33.8**	**20.5**	**56**	**35**	**10.3**	**7.8**	**62.0**	**157.6**	**307.0**

2.1.2.1 Rainfall

Climate data shows there is a distinct wet season, however rainfall averages are comparatively low to tropical regions of Queensland, with the highest rainfall intensities occurring from December through to March, averaging 158.25 mm, when monsoonal activity is prevalent.

2.1.2.2 Wind

A wind rose of measured wind data from 1962 to 2014 at Croydon is presented in **Plate 1**. The wind rose indicates that the region is dominated by south-easterly winds.

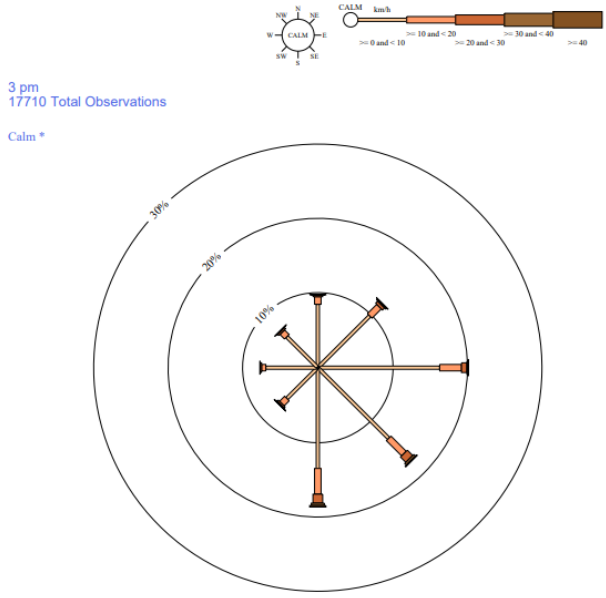

Plate 1. Wind Rose at Croydon (1966 to 2014); Source: Commonwealth of Australia (2022)

2.1.2.3 Drought

Drought is defined as an acute water shortage brought about by a serious or severe rainfall deficiency. To classify the severity of a drought, rainfall periods of three months or greater are examined. A drought is classified as serious if rainfall falls above five percent of the recorded rainfall but below ten percent for the period in question, and as severe if rainfall is among the lowest five per cent for the period in question (BoM 2022).

Croydon Shire has been subject to many severe droughts in the past. Recent droughts which have affected the region include both the Millennium Drought (1997-2003) and the 2017-2019 drought.

Drought frequency, intensity, and duration can vary markedly, and are influenced by the El Niño-Southern Oscillation (ENSO) cycle. El Niño events are characterised by reduced rainfall, warmer than average temperatures, later monsoon onset, reduced tropical cyclone numbers, and a shift in temperature extremes (BoM 2022). Currently, Australia is in its third back-to-back La Niña event, with La Niña conditions of higher than average rainfall expected to carry through until early 2023, when an ENSO-neutral condition is projected (BoM 2022).

2.1.2.4 Cyclones

Tropical cyclones are low pressure systems that form over warm tropical waters and have well defined wind circulations of at least gale force strength (sustained wind of 63 kilometres per hour (km/h) or greater with gusts in excess of 90 km/h) (BoM 2022). There is no recorded history of cyclones posing a threat to the ML with the closest tropical cyclone, Tropical Cyclone Steve (27 February – 9 March 2000) recorded tracking inland from Cairns as a tropical low to the north of Croydon township.

Cyclone frequency and intensity can vary markedly from year to year, influenced by several factors especially variations in the ENSO cycle and the Indian Ocean Dipole (IOD). Cyclone frequency during La Niña is twice that of El Niño. Long-range forecasts of the Southern Oscillation Index are not currently possible.

2.1.3 Geological Setting

2.1.3.1 Regional Geology

The Croydon District lies along the western boundary of the Georgetown Inlier, which is composed of Precambrian metamorphics; granites intruded into volcanics predominately composed of rhyodacitic welded tuffs of the 'Croydon Cauldron Subsidence Area' (collapsed caldera). It covers an area of approximately 300 by 200 km. The Georgetown Inlier is overlain to the north by the Carpentaria Basin, to the east by the Tasman Geosyncline and the south and west by the Northern Great Artesian Basin (Wave 2022).

2.1.3.2 Croydon Project Geology

The Croydon sub-province of the Georgetown inlier is dominated by a sequence of mid-Proterozoic felsic pyroclastic and lavas of the Croydon Volcanic Group, intruded by co-genetic granites (Esmeralda Granite). These rocks predate Proterozoic metamorphism. The Croydon Volcanics are dominated by ignimbrite and rhyolitic lavas, but minor basalt and intercalated sediments also occur. An Rb-Sr age of 1429 ± 75 m.y. is given for the volcanics, similar to the Esmeralda Granite (Wave 2022). These rocks are unconformably overlain by Mesozoic and Cainozoic sediments. East of Croydon the lorunie Group overlies the volcanics and is intruded by Upper Palaeozoic rocks. There are major NNW-SSE trending faults of probable normal displacement. The volcanic rocks are folded about NW-trending axes.

Volcanic and intrusive rocks of Permian age (aged by K-Ar and Rb-Sr) have been identified within 50 km of Croydon township, but these rocks have not been identified in the vicinity of the deposits. Carboniferous felsic ignimbrites, related to sag-type cauldron structures also occur in the region, but not close to any ore deposit (Wave 2022).

A feature of the Esmeralda granite and its co-genetic volcanic rocks is the abundance of graphite. Ignimbrites (formerly described as 'felsites') frequently contain abundant graphite as rounded, lustrous particles up to 1 cm in diameter (Wave 2022).

The contact between the granite and volcanics is shallow dipping and is marked in the Croydon township area by a belt of graphitic granite 3 km long and 500 m wide. This belt represents the presence of abundant xenoliths many of which are graphitic but also include gneisses and schists (Wave 2022).

2.1.4 Site Hydrology and Fluvial Networks

2.1.4.1 Waterways and Watercourses

There is one minor, ephemeral first order stream originating in the north-western portion of the Project area, while a second originates in the south-eastern portion of the Project area (Engeny 2023). Both streams are unmapped under the *Water Act 2000* (Water Act), refer **Figure 3**. The northern stream flows into Belmore Creek, located approximately 550 m north-west of the Project area. The southern stream flows into Corktree Creek, located approximately 5 km south-west of the Project area. Corktree Creek converges with Belmore Creek, and Belmore Creek converges with the Norman River before discharging to the Gulf of Carpentaria (Engeny 2023).

Belmore Creek is the closest stream to be mapped as a watercourse under the Water Act in the vicinity of the Project area.

625000E
630000E
635000E
7995000N
7990000N
7985000N

Gulf Developmental Road
Golden Gate Creek
Golden Gate Creek
Golden Gate Creek
Golden Gate Creek
Mine Access Road Golden Gate
Welcome Creek
Clothilda Road
Chalmers Cpk
Tablelands System
Belmore Creek
Belmore Road
Content Pit
Lady Isabella Pit
Croydon Gold Mine
(ML 5248)
Dam Wall Road
Water Main Access
Dam Road
McArthur Street
Belmore Creek
Golden Butterfly
North Pit
Golden Butterfly
Pit
Elizabeth Street
Croydon
The Lakes Road
Alldridge Street
Airport Road
Gulf Developmental Road
Corktree Creek
Corktree Creek
Claraville Road
Claraville Road
Corktree Creek
Corge Reef
Mittagong Road

0 500 1,000 m

Scale: 1:50,000@ A3
Datum: GDA2020
Projection: MGA zone 54

N

Data Source:
© State of Queensland (Department of Resources) 2022
© State of Queensland (Department of Transport and Main Roads) 2020
Google Imagery ©2022 CNES / Airbus, Maxar Technologies

Filepath: ...GIS\Projects\2022\BAA\BAA220037.01 Jubilee Metals Croydon Gold Approvals\Workspaces\PRCP\Croydon Gold Mine\Historic site layout (2020)\Rev 0\Figure 3 Waterways and Watercourses.qpz

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Legend

- Site boundary
- Railways
- Roads and tracks
- State controlled roads

Historical site infrastructure

- Pit

QLD waterways for waterway barrier works

- Low
- Moderate
- High
- Major

Vegetation management watercourses v6.0

- Major
- Minor

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Figure 3
Waterways and Watercourses

2.1.4.2 Catchment Overview (Regional and Local)

The Project area is located within the Norman River Catchment, a sub-basin of the Norman Catchment. The Norman Catchment and the Norman River sub-catchment appear to share the same boundary, with both catchments having a total area of 50,677 km^2 (Engeny 2023).

The major river systems within the Norman Catchment are the Norman, Clara, Yappar, and Carron Rivers. The rivers all converge into the Norman River which discharges into the Gulf of Carpentaria, adjacent the township of Karumba (Engeny 2023).

2.1.4.3 Flooding

Review of Queensland Globe (Queensland Government 2023) and FloodCheck Queensland (DoR 2022) has indicated that the Project area has not undergone historical flooding and is not likely to experience a one percent Annual Exceedance Probability (AEP) flood event (Engeny 2023).

The Queensland Floodplain Assessment Overlay (Queensland Government 2023) represents an estimate of areas potentially at threat of inundation by flooding. This overlay has not yet been refined by local governments and is considered to be an initial estimate only. For the Project, it is estimated that in the event of a flood, the north-western portion of the Project area could be inundated (Engeny 2023).

2.1.4.4 Wetlands

There are no high ecological significance (HES) wetlands mapped within or downstream of the Project area (Engeny 2023). The closest identified wetland is associated with the riparian zones of Belmore Creek and is located approximately 2.2 km downstream of the Project area. A number of artificial lacustrine wetlands also exist within and around the Project area.

2.1.4.5 Existing Water Uses

Assessment of potential surface water users surrounding the Project (Engeny 2023) found:

- No water extraction licences exist within a 50 km radius of the Project area
- A number of mapped surface water features, such as dams, waterholes, and rockpools are present downstream of the Project area
- A total of 22 licences to take water have been identified within a 50 km radius of the Project area, five of which are located directly downstream of the Project area. Of the five closest licences, three have an authorised purpose for stock, one is for domestic supply/stock, and one is for urban

It is noted the Golden Butterfly North Pit and Content Pit are used for water supply purposes by Croydon Shire Council and an adjacent landholder respectively. The Council scheme was opened in May 2017 and water extraction volumes are not available. Croydon Shire Council previously supplied water to the Croydon township from a borefield located along Slaughteryard Creek, approximately 1 km south-west of Golden Butterfly Pit, however the borefield was decommissioned around the year 2000 (Barrick 2016).

2.1.4.6 Other Nearby Mines

A number of non-operational mining leases exist upstream and adjacent to the Project area; however, these leases have either expired, or were abandoned or surrendered (Engeny 2023). Mines in this area previously focussed on activities pertaining to copper, molybdenum, uranium, lead, zinc, silver, and gold.

The Croydon King Mine (ML5108) is the closest active mine to the Project area and is located approximately 8.1 km to the south-east, followed by the Werewolf of London (ML100028), and the City of London (ML30234). There are also four active mining leases located 11.4 km to the north-east of the Project site, including La Perouse (ML30255), La Perouse No.2 (ML100025), La Perouse No.3 (ML100026), and Bobby Dazzler (ML100031). All mines in proximity to the Project focus on gold and silver (Engeny 2023).

2.1.5 Groundwater Levels and Properties

Groundwater flow directions have been assessed on a local and regional scale through the preparation of a potentiometric surface (RDM Hydro 2023). On the scale of ML5248, water levels were measured during the October 2020 groundwater monitoring event and more recent pit water levels. During the October 2020 monitoring event, except for the Content Pit, the water levels were observed to be below the Barrick pit level sensors (now decommissioned), thus were at their lowest during the monitoring record (RDM Hydro 2023). The local scale potentiometric surface shows:

- The water levels in the Golden Butterfly and Golden Butterfly North pits are at lower elevation than their surrounds and are therefore a groundwater sink where evaporation exceeds inflows
- Based on the potentiometric surface prepared, the Lady Isabella pit appears to be a discharge feature (groundwater sink)
- The water level in the Content Pit is at a similar elevation to bore BH11 and the pit may therefore represent the water table and a throughflow feature. There is potential for transfer of water from the pit to the surrounding aquifer after significant rainfall events when water levels in the pit rise
- Groundwater flowing from ML5248 would ultimately discharge to Belmore Creek, at an estimated distance of more than 10 km to the west of the ML5248 boundary

Because the pits mostly act as groundwater sinks, there is limited potential for contaminants to enter the groundwater system via the pits. Transfer from the pits to surrounding aquifers may occur after high rainfall events when there may be surface water ingress of pit water to the formation (RDM Hydro 2023).

A regional east to west groundwater flow direction is consistent with the ground surface elevation, suggesting that the regional potentiometric surface is a subdued reflection of topography (RDM Hydro 2023). The regional groundwater flow direction was assessed using water level data available from the Queensland groundwater bore database. It is recognised that this data is from different times, however the age of data related uncertainty is unlikely to alter the outcome of the interpretation at a regional scale, which is currently consistent with that described by CSIRO (2012).

2.1.5.1 Existing Groundwater Use

Potentially active water supply bores in the vicinity of ML5248 were identified via the groundwater bore database and include all those registered bores that are not identified as ‘Abandoned and Destroyed’ or that can be readily identified as monitoring or investigation bores via their original names or construction details (RDM Hydro 2023). The authorised use of the bores was determined via the Queensland Government water entitlements database. The hydrostratigraphic unit that the bore is assumed to access was determined in the following order:

- The authorised formation identified in the water entitlements database
- If the bore was spatially located within the Croydon province, the bore was assumed to access basement
- The formation identified in the groundwater bore database ‘aquifer’ table
- By intersecting the maximum bore depth from the groundwater bore database with the hydrostratigraphic surface depths from CSIRO (2012)

Twenty-one active supply bores were identified within a 15 km radius of the Mining Lease (RDM Hydro 2023). Most of the bores are clustered around Slaughteryard Creek, within approximately 1.5 km of the ML5248 boundary, and are likely to be the former Croydon water supply borefield. There are two bores located within the Croydon township, and the remainder are distributed further afield (RDM Hydro 2023).

2.1.5.2 Springs and Other Groundwater Dependent Ecosystems

Doody et al. (2019) defines groundwater dependent ecosystems (GDEs) 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 GDEs are (Eamus et al. 2006):

- Ecosystems dependent of surface expression of groundwater – springs, groundwater fed wetlands or baseflow fed streams or rivers
- Ecosystems dependent on sub-surface expression of groundwater – terrestrial GDEs
- Subterranean ecosystems – stygofauna

WetlandInfo was interrogated to identify potential GDEs in the vicinity of the Project area. No GDEs are located within ML5248 or in the vicinity of Croydon (WetlandInfo 2020). There are no potential GDE aquifers mapped in the vicinity of Croydon, confirming a low potential for the presence of GDEs (RDM Hydro 2023).

The closest mapped springs are located more than 17 km from the nearest boundary to the tenement and are associated with the Flinders River supergroup of the Great Artesian Basin (CSIRO 2012). These springs are not EPBC listed (CSIRO 2012). The closest mapped terrestrial GDEs and potential baseflow reaches are associated with the Flinders River, over 100 km from the site (RDM Hydro 2023).

2.1.6 Soils and Land Stability

The landform of the site is described as gently undulating plains mostly comprised of poorly consolidated sediments and granitoids with a section of mudrock. Soils across the Project site are characterised as earthy sands (AC22) on gently undulating lands.

With regards to potential acid sulfate soils, it is noted that acid sulfate soils typically occur in areas of elevation below 20 m AHD, particularly in coastal areas. Queensland Globe mapping shows that acid sulfate soils are not applicable to the Project area, and elevation is above 100 m AHD.

General erosion control works have previously been completed on the waste rock dumps and general mining disturbance areas to address the formation of small gullies. Backfill material was used to fill these depressions, and to reduce an infiltration through the waste rock dump. No excavation took place on top of any capped areas to avoid any potential impacts to the capping layer integrity. Subsequent rainfall and surface runoff have not caused further erosion. Ongoing monitoring and review is undertaken to ascertain if potential problems are developing in order to schedule any remedial erosion control action.

2.1.7 Vegetation Communities and Ecological Data

An Ecological Assessment Report was undertaken in December 2022 for the purpose of potential future works, it is noted that whilst this report is based on a possible future scenario, the baseline ecological assessment remains relevant and has been drawn upon for the purpose of this PRC Plan. The report assessed the ecological values of the site and assessed the significance of potential Project impacts to Matters of National Environmental Significance (MNES) and Matters of State Environmental Significance (MSES) based on field assessments completed by Epic Environmental ecologists in 2020 and 2022. All information in this section has been derived from this report which has also been provided in **Appendix B**.

The Project site is located within the Gilberton Plateau biogeographic subregion of the Gulf Plains Bioregion (GPB). The GPB encompasses over 219,000 km^2 extending across a substantial area of north-west Queensland stretching from the south-east edge of Cape York Peninsula west to the border of the Northern Territory and stretching as far south as the McKinlay area. Away from the coastal areas of the Gulf of Carpentaria the vegetation features a mixture of monsoonal woodlands and predominantly treeless plains which are similar to the grasslands associated with the adjacent Mitchell Grass Downs bioregion. The site features a monsoonal climate with the majority of rainfall occurring from December to March.

Based on field survey, a total of 52 flora species were identified within the site across the two site surveys, including three non-native species. The flora assemblage is largely comprised of eucalypt canopy species, softwood scrub understorey trees, acacia shrubs and perennial tussock grasses.

2.1.7.1 Ground-truthed Regional Ecosystems

A total of 10 secondary Regional Ecosystem (RE) assessments and two quaternary RE assessments were completed across the site (**Figure 4**).Ground-truthing of current RE mapping of the site confirmed the presence of three vegetation communities analogous to three RE types, water bodies, and non-remnant areas impacted by historical mining activities and vegetation clearing. The description, status and area of each RE is provided

in **Table 2**, and the extent illustrated in **Figure 4**. Further detail regarding vegetation community floristic, structure and representative photographs are provided in **Appendix B**.

Table 2. Ground-truthed REs

Vegetation Community	RE	Regulated Vegetation Category	EP Act (biodiversity) Status	Extent within Site (ha)
Remnant woodland on Mesozoic sandstone plateaus	2.5.19a	B	No concern at present	23.6
	2.5.9			48.5
Remnant low open-woodland on granite hills	9.12.33c			3.4
Regrowth woodland on Mesozoic sandstone plateaus	2.5.19a	C		13.3
	2.5.9			11.3
Water	-	X	-	6.9
Non-remnant				67.4

628000E 628500E 629000E 629500E 630000E 630500E 631000E 631500E 632000E 632500E

7990500N 7990000N 7989500N 7989000N 7988500N 7988000N 7987500N 7987000N

Croy S1
Croy S4
Croy Q1
Croy S2
Croy S3
Croy S5
Croy Q2
Croy S6
Croy S10
Croy S9
Croy S8
Croy S7

Croydon Gold Mine
(ML 5248)

Tablelands System

Croydon

0 200 400 m

Scale: 1:15,000@ A3
Datum: GDA2020
Projection: MGA zone 54

Data Source:
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© State of Queensland (Department of Transport and Main Roads) 2020
Google Imagery ©2022 CNES / Airbus, Maxar Technologies

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Legend

- Site boundary
- Railways
- Roads and tracks
- State controlled roads
- Field tracks

Ground-truthed Regional Ecosystems

- 2.5.19a
- 2.5.9
- 9.12.33c
- Water
- Non-remnant

Biodiversity status

- Regrowth
- Remnant

Survey site

- Secondary RE
- Quaternary RE

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Croydon Gold Mine

Figure 4
Regional Ecosystem Survey Sites GTRE

2.1.7.2 Threatened Ecological Communities

No Threatened Ecological Communities (TECs) were recorded during the field assessment. None of the ground-truthed RE types are considered a component of any TEC.

2.1.7.3 Conservation Significant Flora Species

No conservation significant flora species were identified during the field assessment. A single near-threatened (*Nature Conservation Act 1992*) flora species, *Leptospermum pallidum*, is considered a potential occurrence within the site.

Near-threatened species are not MSES and threatened flora species are considered unlikely to occur within the site and were therefore not considered further (**Appendix B**).

2.1.7.4 Weed Species

A total of three non-native flora species were identified within the site, namely:

- Neem Tree (*Azadirachta indica*)
- Purple Pigeon Grass (*Setaria surgens*)
- Hyptis (*Hyptis suaveolens*)

These species are not listed as restricted matters under the Queensland *Biosecurity Act 2014*.

2.1.7.5 MNES and MSES

The Project area does not support any threatened plant species (MNES) or TECs.

2.1.8 Fauna Presence and Populations

An Ecological Assessment Report was developed for the Project site in December 2022. As mentioned in **Section 2.1.7**, the Ecological Assessment Report was undertaken for the purpose of potential future works, whilst this report is based on a possible future scenario, the baseline ecological assessment remains relevant and has been drawn upon for the purpose of this PRC Plan. The report assessed the ecological values of the site and assessed the significance of potential Project impacts to MNES and MSES based on site assessments completed by Epic Environmental ecologists in 2020 and 2022. All information in this section has been derived from this report which has also been provided in **Appendix B**.

The fauna surveys across the 2020 and 2022 site visits recorded a total of 55 native fauna species. The native fauna assemblage comprised two amphibians, one reptiles, 50 bird and two mammal species. Fauna habitat assessments were completed across the site to ascertain the quality and availability of habitat, particularly for the potential presence of Gouldian Finch (*Chloebia gouldiae*), listed as Endangered under both the NC Act and EPBC Act and Painted Honeyeater (*Grantiella picta*), listed as Vulnerable under both the NC Act and EPBC Act.

2.1.8.1 Conservation Significant Fauna Species

No conservation significant fauna species were identified within the site during the surveys. The surveys were both conducted in late spring, whilst the Painted Honeyeater is only likely to occur during the winter months as non-breeding migrant. The species may still occur at the site.

2.1.8.2 Pest Fauna

The field surveys recorded three non-native fauna species as restricted under the *Biosecurity Act 2014*:

- Domestic Dog (*Canis familiaris*)
- Pig (*Sus scrofa*)
- Cane Toad (*Rhinella marina*)

2.1.8.3 Fauna Habitat Values

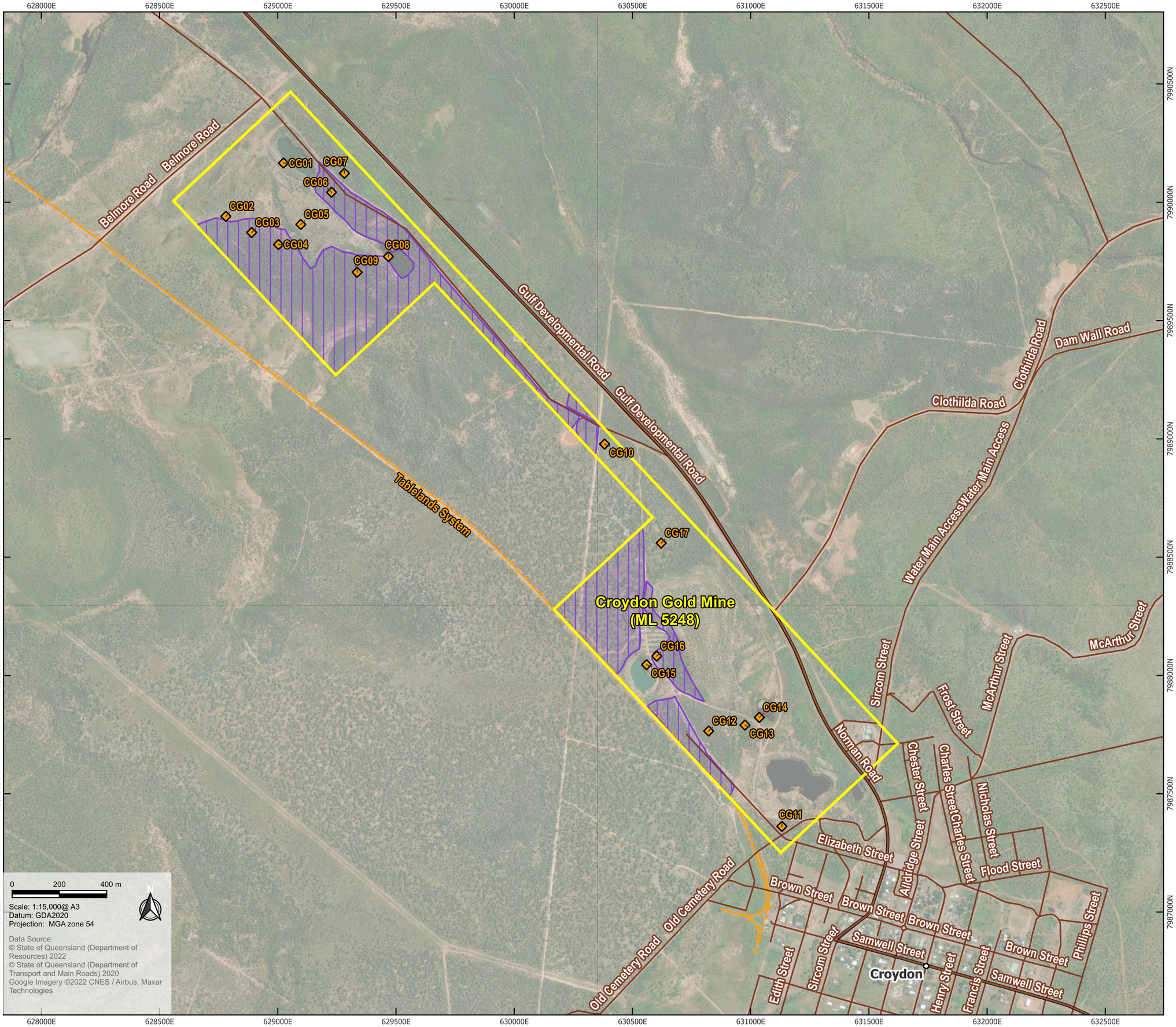
A total of 17 habitat assessments were completed across the site, refer **Figure 5**. Habitat assessment was primarily focussed on the two potential species: Gouldian Finch and Painted Honeyeater.

Gouldian Finch

At the time of the survey water was pooling in several areas of the Project area and the pits from historical mining activities were partially full. Cattle disturbance was mostly low except for two survey sites where the disturbance was considered moderate. Small and medium sized hollows were recorded exclusively in stags and deadwood with one large hollow recorded. These hollows were all deemed to be unsuitable for Gouldian Finch breeding based on the known habitat/breeding hollow requirements for the species (i.e. small horizontal hollows in live timber). In addition, no grass species known to be preferred forage species for Gouldian Finch were observed within the site at the time of the survey and grass cover in general was relatively poor.

Painted Honeyeater

The presence of Flat-leaved Mistletoe (*Lysiana spathulata* subsp. *spathulata*) was recorded at two habitat assessment locations within the site. Mistletoe was recorded within regrowth RE 2.5.19a and remnant RE 2.5.9. Mistletoes are known and preferred foraging habitat for Painted Honeyeater. The species may utilise the habitat to forage during the non-breeding winter months. Ground-truthed RE polygons with mistletoe records were categorised as suitable habitat for the Painted Honeyeater. Ground-truthed RE polygons of the same RE type with no habitat assessment sites were also categorised as suitable habitat for Painted Honeyeater. The estimated extent of potential habitat for Painted Honeyeater within the site is 57.16 ha and illustrated in **Figure 5**. This is likely to be an overestimation of the actual extent of potential habitat present as mistletoes are unlikely to be present through the entirety of the mapped area.



epic ENVIRONMENTAL

Legend

- Site boundary
- Railways
- State controlled roads
- Roads and tracks

Survey site

- Painted Honeyeater habitat
- Habitat assessment

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Croydon Gold Mine

Figure 5
Habitat Assessment Sites and Painted Honeyeater Suitable Habitat

Filepath: ...GIS\Projects\2022\BAA\BAA220037.01 Jubilee Metals Croydon Gold Approvals\Workspaces\PRCP\Croydon Gold Mine\Historic site layout (2020)\Rev 0\Figure 5 Habitat Assessment Sites and Painted Honeyeater Suitable Habitat.qgz

2.1.8.4 Conservation Significant Fauna Species Likelihood of Occurrence Assessment

The likelihood of occurrence of threatened fauna (**Appendix B**) determined that a single species could possibly occur within the site, namely; Painted Honeyeater. The remaining threatened fauna species are considered unlikely to occur within the site and were not considered further. The likelihood of occurrence assessment of migratory fauna determined that no migratory species could occur within the site (**Appendix B**). All migratory fauna species are considered unlikely to occur within the site and were not considered further.

2.1.8.5 MNES and MSES

The only MNES considered a possible occurrence within the site is the Painted Honeyeater. An assessment of the potential for significant impacts (SI) resulting from the Project activities was carried out on MNES considered as known, likely or possible occurrence within the Project area. The SI assessment was carried out in accordance with the *MNES Significant Impact Guidelines 1.1* (MNES Guidelines) (DE 2013).

Refer **Section 7.1.1** in **Appendix B** for the SI assessment on Painted Honeyeater. The assessment outcome was that the Project is unlikely to result in a significant impact on Painted Honeyeater. Significant impacts are unlikely due to the relatively small extent of habitat loss and the lack of any evidence to suggest that the site provides critical habitat for Painted Honeyeater or supports an important population of the species. No other MNES values are present. Referral under the EPBC Act was not deemed necessary.

With regards to MSES, the only matter identified was protected wildlife habitat for a vulnerable or endangered species: Gouldian Finch. The MSES Guideline provides significant residual impact criteria for assessing the potential impacts of a development on threatened species (as listed under the NC Act) where the species is present, or where the species habitat is predicted to occur (including the presence of protected wildlife habitat mapping). Habitat assessments carried out on the site targeted habitat features suitable for the species presence (small tree hollows and favoured grass species for foraging). The results of the habitat assessment and the likelihood of occurrence assessment for threatened species (refer **Appendix B**) indicate the species is unlikely to occur on or near the site. As such, an assessment for significant residual impacts regarding Gouldian Finch is not considered warranted. No significant residual impacts on MSES values were identified as occurring.

2.1.9 Pre-Mining Land Use

Prior to the commencement of mining in the 1880s, it can only be assumed that the site was previously pastoral land.

Today, the Project area is zoned as rural under the *Croydon Shire Planning Scheme 2019*. The *Croydon Shire Planning Scheme 2019* states that the purpose of the rural zone is to:

a) Provide for rural uses and activities

b) Provide for other uses and activities that are compatible with–

   i. Existing and future rural uses and activities

   ii. The character and environmental features of the zone

c) Maintain the capacity of land for rural uses and activities by protecting and managing significant natural resources and processes

Croydon Shire Council's purpose of the rural zone is to also:

a) Ensure the productive capacity of agricultural and associated rural industries is maximised and maintained, while protecting biodiversity values and allowing for farm diversification and value adding industries to occur in the rural area

b) Maintain the character and amenity of the rural and natural environment

c) Encourage tourism development where it can value-add to the viability of rural enterprises, does not diminish biodiversity values and avoids impacts of flooding and bushfire

d) Ensure that the functional connectivity of the stock route network is maintained and any development within or adjacent to stock routes or reserves provides for their continued function

e) Ensure development protects extractive industry or potential resource sites for future development, and also protects existing rural uses from impacts of proposed extractive industry and associated activities.

2.1.10 Identification of Underlying Landholders

Tenure associated with the Project area (ML5248) is detailed in **Table 3** and shown on **Figure 6**. It is noted that a stock route traverses through the ML area along parts of its north-eastern boundary line.

Table 3. ML5248 Tenure

Lot/Plan	Tenure	Area (ha)
Main Areas of ML (Lot/Plan Area >1 ha)		
1SP269692	Reserve	71.28
952SP178689	Reserve	81.25
3CP895985	Freehold	1.08
1MPH34864	Freehold	1.07
231SP109395	Lands Lease	3.15
Lot/Plan Area <1 ha		
12MPH15912	Freehold	0.03
13MPH15912	Freehold	0.09
16USL656	State Land	0.40
1MPH124	Reserve	0.10
1MPH15912	Freehold	0.07
1SP206978	Freehold	0.07
232SP109395	Reserve	0.05
23MPH15912	Freehold	0.10
24MPH15912	Freehold	0.10
25MPH15912	Freehold	0.10
26MPH15912	Freehold	0.10
2MPH124	Reserve	0.10
2MPH15912	Freehold	0.07
2MPH22368	Reserve	0.08
2SP116187	Lands Lease	0.23
2SP206978	Freehold	0.10
35MPH15912	Freehold	0.10
36MPH15912	Freehold	0.08
37B144220	State Land	0.20
3MPH124	Reserve	0.10
3MPH15912	Freehold	0.01
3MPH22368	Reserve	0.07
3SP116187	Reserve	0.73
41MPH15912	Freehold	0.06
42MPH15912	Freehold	0.02
4MPH124	Reserve	0.09
59USL656	State Land	0.01
5MPH124	Reserve	0.08
65USL656	State Land	0.06
73USL656	State Land	0.01
843SY28	Reserve	0.11
844SY28	Reserve	0.10
845SY28	Reserve	0.10
846SY28	Reserve	0.10
91USL656	State Land	0.01
938SY28	Reserve	0.08
949C3591	Reserve	0.04
ASP284230	Easement	0.37

2.1.10.1 Native Title

As shown on **Figure 6**, the Project area is located within the traditional homelands and native title area of the Tagalaka People. The Tagalaka People have an active interest in land management/development issues in areas they consider as their traditional homelands.

629000E
630000E
631000E
632000E
7990000N
7989000N
7988000N

Belmore Road
Belmore Road
1SP269692
1SP269692
Gulf Developmental Road
Gulf Developmental Road
37B144220
952SP178689
231SP109395
8SY21
952SP178689
949C3591
952SP178689
3CP895985
3CP895985
952SP178689
952SP178689
952SP178689
952SP178689
952SP178689
Water Main Access
McArthur Street
Refer to inset A
Refer to inset B
Old Cemetery Road
Elizabeth Street
Elizabeth Street
Sircom Street
Frost Street
Frost Street
Chester Street
Charles Street
Nicholas Street
Kelman Street
Aldridge Street

Inset A

Tagalaka People
Gulf Developmental Road
952SP178689
5MPH124
4MPH124
3MPH124
2MPH124
1MPH124
42MPH15912
41MPH15912
952SP178689
Frost Street
1MPH34864
3MPH15912
2MPH15912
1MPH15912
Frost Street Frost Street
Sircom Street
16USL656
846SY28
845SY28
844SY28
843SY28
952SP178689
Norman Road
Norman Road
35MPH15912
36MPH15912
59USL656
65USL656
26MPH15912
25MPH15912
24MPH15912
23MPH15912
2SP206978
1SP206978
73USL656
Sircom Street
13MPH15912
12MPH15912
91USL656
Chester Street
Chester Street
Tagalaka People #2

Inset B

Tagalaka People
Tagalaka People #2
952SP178689
3MPH22368
2MPH22368
938SY28
3SP116187
2SP116187
Elizabeth Street
Helen Street

0 200 400 m
Scale: 1:12,500@ A3
Datum: GDA2020
Projection: MGA zone 54

Data Source:
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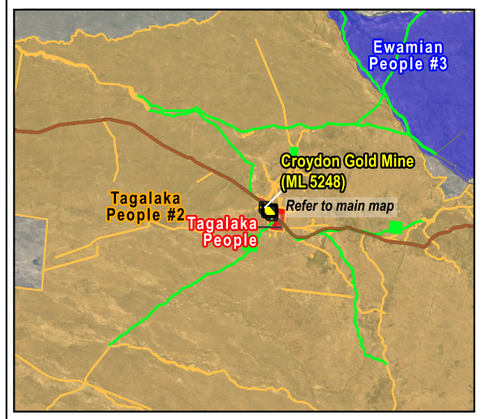
© State of Queensland (Department of Transport and Main Roads) 2020
Google Imagery ©2022 CNES / Airbus, Maxar Technologies



Legend

- Site boundary
- Stock routes
- Cadastre (DCDB)
- Roads and tracks
- State controlled roads

Native title determination

- Tagalaka People
- Tagalaka People #2
- Others

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Croydon Gold Mine

Figure 6
Tenure and Native Title

2.2 Project Description

Croydon Gold Mine is currently not operational. As such, activities presently taking place focus primarily on maintenance, monitoring and environmental investigations.

It is noted there are some external non-mining related activities that appear around the edges of ML5248, such as off-lease borrow pits, and the landowner in the south-eastern portion of the lease has infrastructure, buildings, and scrap material within and surrounding the lease. These items and activities are not part of the mining activity and have been excluded from this PRC Plan. Only the items listed within this PRC Plan are relevant to the historical mining operation and rehabilitation activities.

2.2.1.1 Mining Tenements

The Project is wholly located within ML5248, an area of 174.4 ha.

2.2.1.2 Primary Mine Features/Infrastructure Onsite

Overview

Mining related landforms that remain on ML5248 are comprised of four open pits which now contain approved pit lakes, rehabilitated waste rock dumps and infrastructure areas such as roads and tracks, abandonment bunds, water management structures and rehabilitated hardstand areas, these are as follows:

Open Pits/Approved Pit Lakes:

- Golden Butterfly Pit
- Golden Butterfly North Pit
- Content Pit
- Lady Isabella Pit

Rehabilitated Waste Rock Dumps:

- Rehabilitated Golden Butterfly waste rock dump
- Rehabilitated Content waste rock dump

Other:

- Abandonment bunds across the four pit's access ramps
- Water diversion bunds and rehabilitated sediment dam adjacent to the Content and Golden Butterfly waste rock dumps
- Rehabilitated hardstand areas adjacent to Content and Golden Butterfly waste rock dumps
- Roads and tracks

Historical Mining Operations

ML5248 historically contained four operational mine pits. Content Pit lies to the most northern aspect of the site, with Lady Isabella situated to its south-east. Content Pit waste rock dump lies between the Content and Lady Isabella pits. Golden Butterfly Pit is located within the south-west corner of ML5248, and Golden Butterfly North lies to its north-west. The larger Golden Butterfly waste rock dump is located immediately north-east of Golden Butterfly North Pit (refer **Figure 7**). In terms of historical disturbance areas, a schedule of disturbance has been provided in **Table 4**.

It is noted that all rehabilitation works required to meet Condition C1-2 and C1-3 of the EA for the Content waste rock dump and Golden Butterfly waste dump have been completed. The surface of the Content waste rock dump has been drained to Content Pit, low-lying areas were filled, and the site has been revegetated (refer **Figure 8**). Golden Butterfly waste rock dump has also been revegetated. No further rehabilitation works at either waste rock dump are anticipated to be required.

Table 4. Schedule of Disturbance

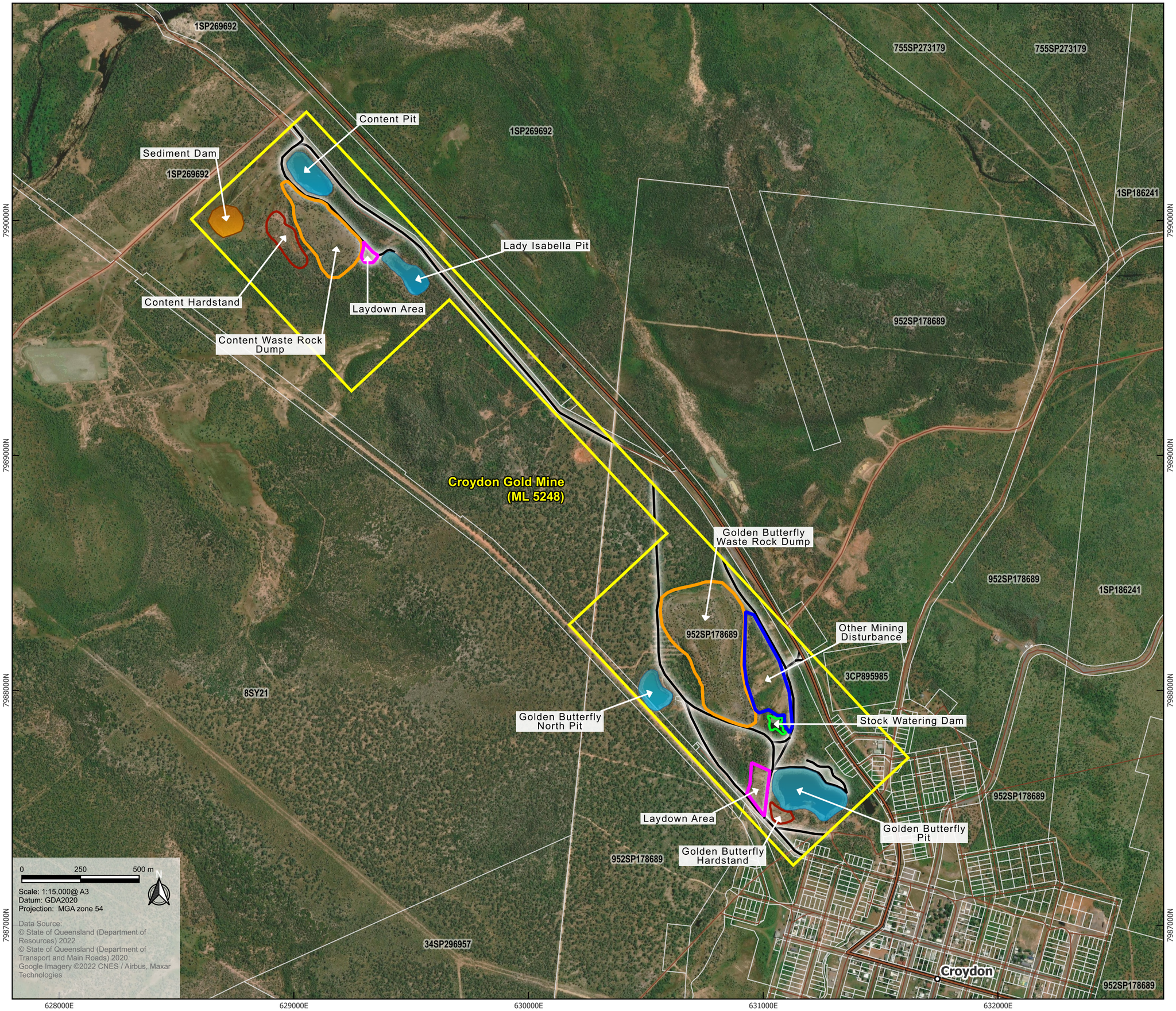
Disturbance Type	Post-Mine Land Description (per the EA)	Disturbance Area (ha)	Current Water Volume (Megalitres (ML))[1]
Open Pits/Approved Pit Lakes			
Golden Butterfly Pit	Non-beneficial land use	5.1	99.7
Golden Butterfly North Pit	Non-beneficial land use	1.6	104.6
Content Pit	Non-beneficial land use	2.1	95.9
Lady Isabella Pit	Non-beneficial land use	1.7	100.7
Rehabilitated Waste Rock Dumps			
Golden Butterfly waste rock dump	Low intensity grazing/ disturbed native habitat	15.2	N/A
Content waste rock dump	Low intensity grazing/ disturbed native habitat	6.3	N/A
Other			
Content hardstand	Low intensity grazing/ disturbed native habitat	2.0	N/A
Golden Butterfly hardstand	Low intensity grazing/ disturbed native habitat	0.5	N/A
Sediment dams	Low intensity grazing/ disturbed native habitat	1.5	N/A
Roads/tracks	Low intensity grazing/ disturbed native habitat	3.5	N/A
Total Surface Disturbance Area		**39.5**	-

[1] Latest water volume as of October 2022.

Additional Disturbance

Additional disturbance areas due to mining were identified in 2020 as part of the Estimated Rehabilitation Cost (ERC) review process. These areas include:

- Laydown Area North – approximately 0.3 ha
- Laydown Area South – approximately 1.3 ha
- Other mining disturbance immediately east of Golden Butterfly waste rock dump – approximately 5.6 ha



epic ENVIRONMENTAL

Legend

- Site boundary
- Cadastre (DCDB)
- Roads and tracks
- State controlled roads

Historical site infrastructure

- Hardstand
- Pit
- Rock dump
- Laydown area
- Other mining disturbance
- Sediment dam
- Stock watering dam
- Access track

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Croydon Gold Mine

Figure 7
Historical Disturbance Areas

628000E 629000E 630000E 631000E 632000E

7990000N 7989000N 7988000N 7987000N

1SP269692 755SP273179 755SP273179 1SP269692 1SP186241 952SP178689 952SP178689 952SP178689 952SP178689 952SP178689 3CP895985 8SY21 34SP296957

Content Pit
Sediment Dam
Lady Isabella Pit
Content Hardstand
Laydown Area
Content Waste Rock Dump
Croydon Gold Mine (ML 5248)
Golden Butterfly Waste Rock Dump
Other Mining Disturbance
Golden Butterfly North Pit
Stock Watering Dam
Laydown Area
Golden Butterfly Pit
Golden Butterfly Hardstand
Croydon

0 250 500 m

N

Scale: 1:15,000@ A3
Datum: GDA2020
Projection: MGA zone 54

Data Source:
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© State of Queensland (Department of Transport and Main Roads) 2020
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epic ENVIRONMENTAL

Legend

- Site boundary
- Cadastre (DCDB)
- Roads and tracks
- State controlled roads

Historical site infrastructure

- Hardstand
- Pit
- Rock dump
- Laydown area
- Other mining disturbance
- Sediment dam
- Stock watering dam
- Access track

Historical site rehabilitation

- Existing rehabilitation area
- Site rehabilitation

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Croydon Gold Mine

Figure 8
Historic Rehabilitation Areas

2.2.1.3 Type of Mining Operation

As the site is currently not operational, there are no ongoing mining operations taking place within ML5248 and hence no type/s of mining operation to be defined in this section.

2.2.1.4 Proposed Duration of Operation

The proposed duration of operations (as they are) is anticipated to be until approximately December 2048.

2.3 Design for Closure

This section of a PRC Plan is typically designed to outline how progressive rehabilitation and closure has been considered in the design of the Project site. However, in this instance, as the site has evolved since the 1880s and is now non-operational, design for closure cannot be detailed in this sense. Further, it is noted that transitional PRC Plans are not required to demonstrate how aspects of the mine site have been designed for closure for existing or approved disturbance.

2.3.1 Location of Mine Features / Infrastructure

Locations of historic mine features/infrastructure are shown in **Figure 7**. Whilst these locations are already pre-set, it is acknowledged that if mining related activities were ever to re-commence onsite, that locations of mine features would be designed with closure in mind, in terms of:

- Protection of environmental values of the site and receiving environment, including Matters of National Environmental Significance, Matters of State Environmental Significance, and Matters of Local Environmental Significance
- Surrounding land uses and proximity to sensitive receptors
- Proximity to any open-pit exits
- The gradient of the footprint area, both for the direction of drainage from the landform and for the dumping costs
- Local and regional topography
- Surface and groundwater features (quality, quantity, seasonal variation)
- Geotechnical conditions (i.e., soil/rock characteristics) and suitability for the structure type (i.e., presence of structural features that could transmit seepage)
- Competing water and land uses
- Visual impact

2.3.2 Size, Shape and Design of Mine Features / Infrastructure

As stated above, the mine features and infrastructure were designed and constructed as long ago as the 1880s. The sizes, shapes, and designs of these mines features and infrastructure are detailed in **Table 4** and shown on **Figure 7**.

2.3.3 Mining Methods

Prior to decommissioning, the mining methods employed onsite could be defined as extraction via open cut pits. As mentioned however, mining has since ceased at the site.

2.4 Rehabilitation / Improvement Planning

The areas for rehabilitation and improvement planning are located within the bounds of ML5248.

2.4.1 Objectives

The objectives of rehabilitation for ML5248 remain the same as that previously approved under the existing EA (EPML00950913, refer **Appendix C**). Schedule C – Land of the EA sets out the approved mining activities and rehabilitation objectives, as well as the requirements for the Post Mine Land Use Plan, Rehabilitation Monitoring Program, infrastructure, residual voids, chemicals or flammable or combustible liquids, and contaminated land.

Broadly speaking, the objectives of mine rehabilitation in relation to the Project are to:

- Create a landscape safe for humans and wildlife into the foreseeable future
- Create a stable landscape with natural rates of erosion
- Establish native vegetation communities, which blend visually with the surrounding landscape and vegetation
- Establish functional, self-sustaining vegetation communities
- Establish ecosystems that resemble neighbouring unmined areas in their ability to respond to fire and drought
- Ensure minimal post-mining impacts on surface catchments

2.4.2 Overview of Rehabilitation and Improvement Areas

A total of six (6) Rehabilitation Areas (RAs) and four (4) Improvement Areas (IAs) have been established for the Project. These areas are outlined in **Table 5** and further detailed in the PRC Plan Schedule, refer **Appendix A**.

Table 5. Rehabilitation and Improvement Areas

Area No.	Area Description	Area (ha)
Rehabilitation Areas		
RA1	Waste Rock Dumps (Content and Golden Butterfly)	21.5
RA2	Hardstand Areas (Content and Golden Butterfly)	2.5
RA3	Sediment Dam	1.5
RA4	Roads/Tracks	3.5
RA5	Laydown Areas	1.6
RA6	Other Mining Disturbance	5.6
Improvement Areas		
IA1	Open Pit/Pit Lake – Golden Butterfly Pit	5.1
IA2	Open Pit/Pit Lake – Golden Butterfly North Pit	1.6
IA3	Open Pit/Pit Lake – Content Pit	2.1
IA4	Open Pit/Pit Lake – Lady Isabella Pit	1.7

It is noted that undisturbed areas are not included as ‘rehabilitation areas’ and hence are not shown here.

2.4.3 Rehabilitation by Year

As the site is currently non-operational, and largely rehabilitated, it is not appropriate to produce year by year rehabilitation mapping. Refer **Appendix A** for PRC Plan Schedule and final site design figure.

2.4.4 Identification of Relevant Activities on Mine Site

Per EA EPML00950913, the relevant mining activities and rehabilitation objectives on ML5248 are outlined in Schedule C – Table 1 (reproduced here, refer **Table 6**).

Essentially, the EA requires ML5248 (except for the four open pits) to be rehabilitated to a post mine land use of low intensity grazing/disturbed native habitat. The four open pits are required to be rehabilitated to a post mine land use of 'non-beneficial land use' which can be translated into a modern-day Non-Use Management Area (NUMA).

Table 6. Mining Activities and Rehabilitation Objectives

Landform (refer EA, Schedule H – Map 1)	Surface area (ha)	Rehabilitation Objectives		
		Post-mine land description	Land classification[1]	Analogue site identification
Golden Butterfly North Pit	1.6	Non-beneficial land use	Class VIII	Sites to be rehabilitated to a standard nominated in the rehabilitation program developed in accordance with Condition C2-1 based on analogue sites
Golden Butterfly Pit	5.1	Non-beneficial land use	Class VIII	
Lady Isabella Pit	1.7	Non-beneficial land use	Class VIII	
Content Pit	2.1	Non-beneficial land use	Class VIII	
Content Dump	6.3	L.I.G.[2] / disturbed native habitat	Class VI or better	
Golden Butterfly Dump	15.2	L.I.G.[2] / disturbed native habitat	Class VI or better	
Content Hardstand	2.0	L.I.G.[2] / disturbed native habitat	Class VI or better	
Golden Butterfly Hardstand	0.5	L.I.G.[2] / disturbed native habitat	Class VI or better	
Sediment Dams	1.5	L.I.G.[2] / disturbed native habitat	Class VI or better	
Roads/Tracks	3.5	L.I.G.[2] / disturbed native habitat	Class VI or better	

[1] Technical guidelines for the Environmental Management of Exploration and Mining in Queensland (DME) 1995. [2] L.I.G. (Low Intensity Grazing) defined by criteria listed in Land Use Acceptance criteria.

2.4.5 Duration of Relevant Activities

Relevant activities at the site have ceased. Historically, rehabilitation took place onsite between 1993 and 1996, and upon auditing was then continued to 1997 (HLA-Envirosciences 2001 – **Appendix D**). Since this time, the site has been in care and maintenance.

2.4.6 Size / Extent of Relevant Activities

Refer **Table 6** and **Figure 7** for the surface areas and extents of each landform (historic relevant activities) within ML5248.

2.4.7 Ability for Progressive Rehabilitation per Relevant Activity

As the rehabilitation has already been mostly completed, the ability to plan for progressive rehabilitation is largely not applicable in this case. Where applicable, remaining rehabilitation activities have been identified/ scheduled in the PRC Plan Schedule, refer **Appendix A**.

2.4.8 Existing Rehabilitation Already Completed (Pre-PRC Plan)

A Post Mine Land Use Plan (PMLP) (Barrick 2011a, **Appendix E**) was prepared in accordance with EA Condition C2-1. General rehabilitation activities undertaken previously included the maintenance of boundary fencing and gates, maintenance of pit perimeter fencing, gates and signage to limit unauthorised human entry. Following preparation and implementation of engineered cover systems, all areas were sown with a seed mix of native tree and shrub species broadly representative of those found in surrounding, undisturbed areas (Barrick 2011b, refer **Appendix F**).

All final landforms were constructed when the Project was decommissioned/closed in 1993 and when additional rehabilitation works were substantially completed in 1996/1997. The final landforms on ML5248 are dominated by low hills over the waste rock dumps, which are considered stable and compatible with existing topography in the area. The slope and cover design of the waste rock dumps were developed to provide low permeability encapsulation to contain any potential acid mine drainage (Barrick 2011b). **Table 7** details rehabilitation and land use activities at the site.

Table 7. Rehabilitation and Land Use Activities

Domain	Summary Rehabilitation Methodology	Rehabilitation Works Already Undertaken	Post Mine Land Description	Land Classification[1]
Golden Butterfly North Pit	N/A as per EA Condition C5-1	N/A as per EA Condition C5-1	Non-beneficial land use	Class VIII
Golden Butterfly Pit	N/A as per EA Condition C5-1	N/A as per EA Condition C5-1	Non-beneficial land use	Class VIII
Lady Isabella Pit	N/A as per EA Condition C5-1	N/A as per EA Condition C5-1	Non-beneficial land use	Class VIII
Content Pit	N/A as per EA Condition C5-1	N/A as per EA Condition C5-1	Non-beneficial land use	Class VIII
Content Waste Rock Dump	Clay capping, rock backfill and revegetation	Completed in 1996 and 1997	Low intensity grazing[2] / disturbed native habitat	Class VI or better
Golden Butterfly Waste Rock Dump	Clay capping, rock backfill and revegetation	Completed in 1996 and 1997	Low intensity grazing[2] / disturbed native habitat	Class VI or better
Content Hardstand	Sand, clay capping, rock, mulch, soil, and revegetation	Completed in 1996 and 1997	Low intensity grazing[2] / disturbed native habitat	Class VI or better

Domain	Summary Rehabilitation Methodology	Rehabilitation Works Already Undertaken	Post Mine Land Description	Land Classification[1]
Golden Butterfly Hardstand	Rehabilitated in accordance with off-lease analogue sites as per EA Condition C2-1	Completed in 1996 and 1997	Low intensity grazing[2] / disturbed native habitat	Class VI or better
Sediment Dams	Rehabilitated in accordance with off-lease analogue sites as per EA Condition C2-1	Completed in 1996 and 1997	Low intensity grazing[2] / disturbed native habitat	Class VI or better
Roads/Tracks	Rehabilitated in accordance with off-lease analogue sites as per EA Condition C2-1	Completed in 1996 and 1997	Low intensity grazing[2] / disturbed native habitat	Class VI or better

[1] Technical guidelines for the Environmental Management of Exploration and Mining in Queensland (DME) 1995. [2] Low Intensity Grazing defined by criteria listed in Land Use Acceptance criteria.

Further details on rehabilitation activities undertaken are outlined below.

2.4.8.1 Mining Pits

As per condition C5-1 of EA EPML0095091 – Residual Voids, or the contents of residual voids, must not cause any environmental harm other than the environmental harm caused within the footprint of the residual void itself, voids do not need to be backfilled or rehabilitated beyond their current state.

Site Drainage

ML5248 is located within the Slaughteryard Creek catchment. The lease drains to a number of small tributaries including Belmore Creek and Town Creek as well as Slaughteryard Creek, and an area of higher relief between the eastern and western portions of the lease acts as a drainage divide between these areas. The site drainage hierarchy is summarised as follows:

- Western portion – westward via minor drainage to Belmore Creek, then to Slaughteryard Creek to Croydon's south-west
- Eastern portion – directly southward, via Town Creek and Slaughteryard Creek

Pit Void Water Balance

The four historical mine pits currently contain pit lakes of varying volumes (refer **Table 4**). In 2020, RGS Environmental (RGS) undertook a water balance assessment of the pit lakes (**Appendix G**). This report generated an independent model incorporating pit geometries, inflows and outflows over a five-year period.

The results identified that during this period all pits were unlikely to have a spill event (RGS 2020). Hence, the potential for any uncontrolled releases is considered highly unlikely. The model was developed conservatively using worst-case rainfall data from 2008 - 2012 and also assumed there was no anthropogenic extraction during this time. This resulted in a chance of Content Pit overtopping based on these assumptions and conditions.

RGS (2020) outlined a risk mitigation plan in the event there is a possibility of discharge from the Content Pit similar to during summer 2010/2011 period when the last overtopping event occurred. If a rainfall event

similar to the summer 2010/2011 period was anticipated, water from Content Pit would be transferred to Golden Butterfly Pit which has a much greater volume and more available freeboard during the maximum pit lake level scenario to accept water from Content Pit.

Golden Butterfly North Pit

The Golden Butterfly North Pit meets ANZECC (2000) livestock drinking water guidelines and receives a limited amount of surface runoff from the area to the immediate north-east. The water is expected to remain fresh over several centuries before turning saline and brackish. Golden Butterfly North Pit is also considered a groundwater sink, with little to no capacity to influence groundwater quality except within the immediate void footprint (HLA-Envirosciences 2001). Croydon Shire Council has used water from this pit lake in the past for irrigation of recreational areas.

RGS (2020) determined in the modelling results section of their report (refer Figure 9-2 of **Appendix G**) the Golden Butterfly North Pit would not record an overtopping event during the nominated period (i.e. the maximum pit lake level did not exceed the spillway level).

Golden Butterfly Pit

The Golden Butterfly Pit Lake has low pH (acidic) and elevated levels of sulphate, aluminium, arsenic, cadmium, copper, nickel and zinc. Water discharge to surrounding areas is restricted by the abandonment bund. The pit has been made inaccessible to vehicles for safety reasons and the pit water levels are regularly monitored through use of a gauging station. HLA-Envirosciences (2001) considered overtopping of Golden Butterfly Pit extremely unlikely to occur even during the wettest years on record. Even with a potential rise in groundwater levels equivalent to the top of the pit under a worst-case scenario, there would still be 3.7 m of freeboard in the pit after a 90 percentile wet season. This is accurate providing ongoing integrity of the pit bunding to ensure that no surface runoff from surrounding areas can enter the pit. A series of monitoring bores were established to understand if water from the Golden Butterfly Pit was permeating into surrounding aquifers, however, the results indicated that this did not occur (HLA-Envirosciences 2001).

RGS (2020) determined in the modelling results section of their report (refer Figure 9-1 of **Appendix G**) the Golden Butterfly Pit would not record an overtopping event during the nominated period (i.e. the maximum pit lake level did not exceed the spillway level).

Lady Isabella Pit and Content Pit

Lady Isabella Pit showed no danger of overtopping in hydrogeological modelling or physical assessment during heavy rainfall events in early 2011. At full capacity, Lady Isabella Pit is approximately 5 m higher than Content Pit. Vehicle access to Lady Isabella is also restricted for safety, through extension of the abandonment bund across the access ramp. Additionally, Lady Isabella Pit also has a water level gauging station installed for continuous water level monitoring.

Content and Lady Isabella Pits were both treated with limestone in 2012 in order to bring the pH to a neutral level and therefore, the overall water quality to ANZECC (2000) stock water guidelines. The EA was then amended in order to permit discharges from both pits during extreme rainfall events in addition to Croydon Shire Council and a local pastoralist receiving approval to extract water from the pits for construction and stock watering purposes. This was approved to keep pit water levels low and stop any potential future overtopping, which has been achieved, as evident from monitoring data (refer **Appendix H** – Attachments A and B).

RGS (2020) determined in the modelling results section of their report (refer Figures 9-3 and 9-4, respectively of **Appendix G**) that Lady Isabella Pit would not record an overtopping event during the nominated period or modelled five-year period (i.e. the maximum pit lake level did not exceed the spillway level).

2.4.8.2 Materials Balance

A materials investigation was conducted by Woodward Clyde (1996) (**Appendix I**) at the Content and Golden Butterfly waste rock dumps and their surrounds. In accordance with EA Condition C2-2(i) a materials balance was prepared at the time to determine what was required for rehabilitation of the waste rock dumps and is reproduced in **Table 8**.

Table 8. Materials Balance

Material Requirements/Sources	Volume (m^3)
Material Requirements	
Content hardstand area	
Rock mulch and soil	10,000
Sand	450
Clay	45
Material Sources	
Golden Butterfly waste rock dump – east haul ramp	
Rock mulch	6,000
External sources	
Rock mulch and soil	5,000
Sand	450
Clay	45

No materials are required to be stored onsite to support further maintenance or rehabilitation works. Therefore, no additional material will be stockpiled onsite.

2.4.8.3 Waste Rock Dumps

All rehabilitation works required to meet Condition C1-2 and C1-3 of the EA for the Content waste rock dump and Golden Butterfly waste rock dump have been completed. Details for each of the waste dumps are outlined below.

Golden Butterfly Waste Rock Dump Reclamation

In 1996, Golden Butterfly Waste Rock Dump was re-profiled with a rock fill surface protection layer 400 mm thick and re-spread with soil using earthmoving equipment and a grader. Soil on surface areas were ripped to a depth of 250 to 300 mm prior to sowing with 16 species of native seed and being top-dressed with fertiliser at 500 kg per ha. The area was fertilised again in 2004 which improved levels of phosphorus in the soil.

Prior to revegetation works, Golden Butterfly Waste Rock Dump was capped with an engineered clay and capping cover system (600 mm thickness, permeability $<10^{-8}$ m/s), a rock fill surface protection layer and topsoil layer coupled with construction of a key trench around the dump perimeter (**Appendix I** – Section 4.3.2). During extreme rainfall events, excess water from the dump surface is engineered to spill down rock lined drains that follow the original haul ramp to discharge to the western tributary of Slaughteryard Creek. Additionally, an open seepage collection trench was excavated along the eastern toe of the waste rock dump. Over the 14 years water monitoring was undertaken at this location, no seepage or other contaminant discharge had been observed (**Appendix H** – Section 3.1).

Golden Butterfly waste rock dump shows there is potential for adequate and diverse plant communities to grow. Unfortunately, illegal grazing significantly impacted the landform in terms of overall vegetative cover as a success criterion required by the EA during the initial growth phase. However, now vegetation is established

any impacts are minimal. Despite this, the vegetation performance demonstrates that rehabilitation of the Golden Butterfly Waste Rock Dump has been met (**Appendix E** – Section 2.3.1).

Content Waste Rock Dump Reclamation

The Content Waste Rock Dump was also capped with an engineered cover system consisting of a clay and capping layer (600 mm thickness, permeability <10-8 m/s) and a rock fill surface protection layer 400 mm thick and topsoil layer in 1996 (**Appendix I** – Section 4.3.2).

The northern-most section of the waste rock dump, the upper surface was not levelled to the same degree as the remainder of the dump, resulting in some ponding during extreme rainfall. General erosion control works were conducted on the north-western aspect of the dump in 2009/2010 to address the formation of several small gullies on the upper crest. Back fill material sourced from Golden Butterfly Waste Rock Dump was used to fill these depressions, and to reduce any infiltration through the waste rock dump. No excavation took place on top of any capped areas to avoid any potential impacts to the capping layer integrity. Subsequent rainfall and surface runoff have not caused further erosion. Continual monitoring and review will be undertaken to ascertain if potential problems are developing in order to schedule any remedial erosion control action.

Revegetation was undertaken as part of the 1996 Rehabilitation Program concurrently with Golden Butterfly waste rock dump revegetation activities, including re-profiling and re-spreading with soil using earthmoving equipment and a grader. Soil on surface areas were ripped to a depth of 250 to 300 mm prior to sowing with 16 species of native seed and being top-dressed with fertiliser at 500 kg/ha. This area was also fertilised again in 2004 which improved levels of phosphorus in the soil.

At this time, the rehabilitation and revegetation status of the western batter was considered to meet criteria and no further capping was constructed on this side. It was later discovered that some seepage occurred from the western side, however these impacts were not identified at the mining lease boundary. It should be noted the Water Management Strategy (Barrick 2018) (**Appendix H** – Section 3.1) outlines a proposed measure to excavate a subsurface trench at the western foot of the Content waste rock dump and installing a collector pipe to drain any contaminated seepage to the Content Pit. However, it should be noted, these activities were undertaken in July 2002. In support of this, Section 3.1 of **Appendix H** also stated that no further drainage management measures are considered necessary for the Content waste rock dump area.

The *Croydon ML 5248 Status Report* (Aurion Gold 2002) is provided in **Appendix I** and describes the remediation and rehabilitation works undertaken until 2002 after comments were received back from the EPA on the Final Rehabilitation Report, particularly that the Content Hardstand was devoid of vegetation and required further remedial works. Aurion Gold organised and managed remedial works at the Content Hardstand (area adjacent to the Content Waste Rock Dump) in July 2002 (**Appendix I**).

The Remedial Earthworks section of **Appendix I** describes in detail the works undertaken at the Content waste rock dump and Content hardstand. It should be noted earthworks were planned to cut a toe drain along the side of the Content waste rock dump as it was assumed this would show evidence of acid rock drainage. However, it was realised that groundwater was actually the cause of white efflorescence on the surface of the Content hardstand area. As such, the following key activities were undertaken (**Appendix I**), including:

- A trench was cut 52 m long and 1.5 m deep on the downslope side, along the toe of the Content waste rock dump next to the Content hardstand area
- Trench spoil was disposed of in the Content Pit
- Two additional trenches were cut from the nearest side of the Content waste rock dump to drain to Content Pit. The purpose of this was based on local advice that drainage used to run in this direction, this would then allow the water table to lower underneath the waste rock dump
- The Content hardstand was re-profiled and clean sand and soil was brought in to cover the area
- Seeds were collected from surrounding native vegetation and other species, this was distributed over the Content hardstand and fresh soil once earthworks were completed

The Content waste rock dump meets revegetation success criteria in the PMLP; however, it also suffers from the impacts of illegal grazing. The impacts of illegal grazing were large during the initial growth phase of rehabilitation, however, now it is established, the impacts are minimal. Based on all the available information, there is no indication that the waste rock dumps would need further rehabilitation.

2.4.8.4 Hardstand Areas

There were two historical hardstands, Golden Butterfly hardstand, immediately west of the Golden Butterfly Pit, and Content hardstand, immediately west of the Content waste rock dump. Material from the hardstand areas was removed after mining activities ceased prior to rehabilitation. Material was reclaimed by excavating all material until the ground surface had been exposed (**Appendix D**). Rehabilitation of the hard stand areas was undertaken in 1996 and the same method of revegetation used for the waste rock dumps was utilised for the hardstand areas in January 1997 (i.e., seed planting, six monthly monitoring during the first year and annual monitoring thereafter). Hardstand areas were recorded as being on a trajectory to becoming a stable ecosystem and meeting rehabilitation relinquishment criteria. Remedial earthworks were also undertaken at the Content hardstand area in July 2002 (refer section above for details).

2.4.8.5 Sediment Dam

There was one historical sediment dam in the north-west corner of the lease which has been backfilled and revegetated alongside other reclamation activities in 1996. There is no visible evidence of this structure, however an indicative location as per the PMLP is shown on **Figure 7**. There is no further information available in regard to the construction or rehabilitation activities of the sediment dam.

Stock Watering Dam

The stock watering dam is not a dam but a natural surface depression that fills after rainfall and then evaporates (i.e., it does not hold water) and was not created or disturbed due to mining activities. Croydon Shire Council do not use the water in this dam and it is fenced off to prevent stock from accessing it. This is reflected in the EA as it is not listed as a disturbance area.

The stock watering dam is north of Golden Butterfly Pit and captures runoff from the surrounding natural catchment to the east of the mining area (i.e. this structure does not capture mine water and does not form part of the overall mine water management infrastructure). It is also noted in the Receiving Environment Monitoring Plan (Section 6.5 of the REMP, Appendix F within **Appendix K**) that the stock watering dam is not hydrologically connected to discharges from the pit lakes.

2.4.8.6 Stormwater Diversion Bunds

Stormwater diversion bunds were constructed around the open pits and designed to withstand a 1 in 100 year critical duration rainfall event (**Appendix I** – Section 4.1 and Appendix B). These bund structures were constructed to redirect all surface water runoff away from the pit areas to reduce the risk of overtopping (**Appendix I** – Appendix B, Section B2.5). These bunds are integral to the permanent operation of the pits as approved structures and will not be removed and do not require maintenance at this time.

2.4.8.7 Roads and Tracks

Roads/tracks were rehabilitated in accordance with off-lease analogue sites as per Condition C2-1 of the EA. Some roads and tracks remain in place, however their eventual decommissioning has been accounted for in this PRC Plan and the associated PRC Plan Schedule (**Appendix A**).

2.4.8.8 Associated Activities

Other rehabilitation activities that were completed as part of the major capping activities were:

- Backfilling of open drill holes and removal of associated rubbish
- Backfilling of non-heritage listed open mine shafts
- General site clean-up
- Construction of surface drainage features to collect surface water drainage from the Content waste rock dump to allow surface water sampling
- Reclamation of 10-15,000 m^3 of arsenopyrite-rich material from an area adjacent to the lease controlled by Union Mining due its highly reactive nature and leachate production which had capacity to report to compliance monitoring locations for ML5248 (**Appendix D** – Appendix 1).

All exploration drill holes were located, plugged, and covered over in compliance with commitments in Appendix 1 and 2 of the Final Rehabilitation Report (**Appendix D**). Jubilee does not have access to maps showing the locations of all previous drill holes and exploration drill holes onsite, as such this information cannot be provided, nor can any associated spatial files/figures for these locations be provided. It is understood that there are no visible signs or evidence of the location of exploration drill holes on the site.

Other Studies / Activities

During the 2010/11 wet season, temporary flood mitigation works were undertaken to pump pit water from the Content Pit to the Golden Butterfly Pit to reduce risk of potential discharge due to overtopping. This reduced the water level in the Content Pit by 4 m and increased the level in of Golden Butterfly Pit by 1 m. There was some discharge from the Content Pit in early 2011, however, water in Content Pit is of sufficient quality and poses no threat to the environment should any further overtopping events occur (refer **Appendix H** – Attachments A and B).

Both Content and Lady Isabella Pits have water quality that meets ANZECC (2000) stock water guidelines except for the Lady Isabella Pit for fluoride. The EA was subsequently amended in 2012 to reflect this and allows for releases from Content and Lady Isabella pits. The Golden Butterfly North Pit has also been historically used to supplement Croydon town water supply from 1990 – 1995 and therefore does not present a danger to the surrounding environment (HLA-Envirosciences 2001). Time series graphs included in the Croydon Gold Mine Water Management Strategy (Wilson 2018) clearly show an improving trend in water quality versus time within these pits (refer **Appendix H** – Attachments A and B).

An investigation undertaken by HLA-Envirosciences (2001) indicated during extremely wet years, there was some risk of open pit lakes overtopping. Unprecedented high rainfall totals in 2008/2009 tested this risk but did not cause overtopping from any of the four pits, however, some overtopping did occur from Content Pit in early 2011 during another extremely high rainfall event.

This did not result in any adverse impacts as water quality in the Content Pit is not hazardous, and any future overtopping during extreme rainfall events would be allowed under the amended EA (2012). HLA-Envirosciences also undertook a site water balance which indicated that all pit lakes are groundwater sinks and have limited capacity to influence groundwater quality beyond the footprint of the pits (refer **Appendix L**).

As the Project is non-operational, water would only be required for ongoing rehabilitation and reclamation activities. Water for any potential works would be sourced from the Golden Butterfly North Pit.

Further details around water inflow to and outflow from the ML boundary, construction details of the mine pits and dams, and previous water quality and water treatment is unavailable due to the age of the site and lack of supporting documentation in regard to these aspects.

2.4.9 Contaminated Land

A search of the Environment Management Register/Contaminated Land Register (EMR/CLR) was undertaken in 2020. At the time, the two main lots over the mining activities were listed as Lot 1 SP178689 and Lot 952 SP178689 and both were listed on the EMR. It should be noted Lot 1 SP178689 was listed on the EMR as it occurred over historical lots Lot 4 AP5928 and Lot 1 AP5928 which are on the EMR. New searches may need to be undertaken however as based on currently mapped tenure, Lot 1 SP178689 is no longer listed. It appears Lot 1 SP178689, may now be Lot 1 SP269692, however this needs to be confirmed.

Regardless of Lot/Plan numbers however, the lots (areas) within ML5248 are currently managed in accordance with the EA EPML0950913 and the relevant management plans. In accordance with Condition C7-1 a contaminated land assessment is anticipated to be undertaken, however this would be at the end of mine life. As the Project is not at the end of its mine life, a contaminated land investigation/assessment is not required at this time. Allowance for a Contaminated Land Investigation has been made.

2.4.10 2016 Audit

An Environmental Compliance Site Audit was undertaken by Envirofin Consulting (Envirofin) in 2016 and assessed a total of 82 EA audit requirements for the site, refer **Appendix M**. The report found no non-

compliance in accordance with EA rehabilitation conditions, that residual voids do not impact upon groundwater or the surrounding environment, that waste rock dump landforms were stable and that all monitoring equipment, water level/quality meters were calibrated and in good working order (Envirofin 2016).

Additionally, an Audit Statement made by a Senior Auditor (name withheld redacted by DES under CTPI 49-Sch4) in the Environmental Program – Quality Society of Australasia (now Exemplar Global) in 2001 as part of the Final Rehabilitation Report states:

"*I have conducted an audit of documentation and evidence against commitments in the approved Plan of Operations and conditions of the EA for the Croydon Gold Mine and consider that these commitments have been met for this project.*

The Final Rehabilitation Report that has been prepared for this project is accurate and reflects the current status of the site. Rehabilitation is complete and the completion criteria nominated in the 1996 (Amended) Decommissioning Plan for the site (the Plan of Operations) have either been met or are considered inappropriate for the site. I consider that there are no on-going monitoring requirements and that any maintenance required is no different to that normally undertaken on similar land in the region.

I consider that the financial surety held over ML5248 is no longer required and can be cancelled."

It is apparent that all that was still required to certify rehabilitation of the site was confirmation from the local Council. However, this correspondence was either not received or not available at the time of writing this report and is likely no longer relevant.

Given the above, it is assumed that rehabilitation has not yet been accepted by DES and hence this PRC Plan attempts to fill some of these gaps.

3 COMMUNITY CONSULTATION

This section of the PRC Plan outlines information on community/stakeholder consultation.

3.1 Stakeholder Consultation

Historically, it is understood that community consultation has been undertaken periodically and as needed (from the 1880s to now). In that time however, there has understandably been quite a few different mine owners/operators and records of community consultation have not always been kept. Jubilee acquired the Project relatively recently (2016) and since that time have undertaken several rounds of both formal and informal community consultation with plans for additional future consultation.

The objectives of any community consultation are to:

- Identify stakeholders who have an interest in the Project
- Facilitate two-way engagement with stakeholders
- Provide accurate, timely and relevant information on the Project
- Identify any concerns or potential issues stakeholders may have with the Project
- Develop appropriate strategies to mitigate any concerns
- Address any stakeholder issues and concerns

3.1.1 Relevant Stakeholders

For the purpose of this PRC Plan, the community area has been defined as the communities and surrounding areas of the town of Croydon and the Croydon Shire Council Local Government Area. This area encompasses directly impacted landholders as well as members of the Croydon community and various organisations (including government, industry, service providers, adjoining landholders and community groups) who may have an interest in rehabilitation and the post mining land use of the Project site. **Table 9** provides a categorisation of the stakeholders as they relate to the identified stakeholder groups.

Table 9. Categorisation of Relevant Stakeholders

Category	Relevant Stakeholder
Direct landholders	Landholders whose property the mine may be located. Property owners within the mine lease (ML5248)
Adjoining landholders	Residents located adjoining the Project site which may experience impacts, such as visual impacts, dust, traffic. Adjoining neighbours to ML5248
Federal, State and Local Government representatives	Government representatives at the Federal, State and local level, including, local representatives and Government agencies responsible for the regulation of the Project. Police, emergency services, drug and alcohol services, housing, Indigenous, employment and social services. Many of these are provided by Croydon Shire Council due to the size of the town
Indigenous stakeholders	Traditional owner groups, local land councils, other Indigenous organisations, where these are related to the Project area
Business operators and representatives	Business operators and employees in the locality that could experience indirect impacts on business operations. Regional business groups, local accommodation operators and local Chambers of Commerce
Special interest groups	Community organisations and groups such as social clubs/associations, schools, childcare facilities and environmental groups
Local community	Residents or visitors to the Croydon Shire region may have an interest in the Project

3.1.2 Consultation Tools and Information

A range of consultation tools have been utilised in the past and will continue to be utilised as needed moving forward. These tools include:

- Direct stakeholder contact, such as telephone calls, emails, and face-to-face meetings
- Website (https://jmetals.com.au/)
- Project enquiry form

Moving forward, other tools will be able to be utilised, such as:

- Project newsletters and fact sheets
- Public information sessions
- Feedback forms
- Project phone number and email address
- Advertisements and media

3.1.3 Consultation Register

Key consultation undertaken since Jubilee acquired the site in 2016 has been detailed in **Table 10**.

Table 10. Consultation Register

Timing	Stakeholder	Format	Information Provided/Discussed
2017 to 2021	Informal consultations with landholders, native title holders, and adjoining landowner communications as part of the ML renewal process	Telephone calls and informal meetings	• General updates • Timelines and work plans • Company information
18/08/22	Croydon Shire Council	PowerPoint presentation and meeting	• Company update • Permitting background • Proposed mining activities • Timeline • Collaboration with Council
15/12/22	Croydon Shire Council	PowerPoint presentation and meeting	• End of year update • Community support (e.g., Croydon FNQ Wildlife Rescue) • Areas for future collaboration
17/02/23	Croydon Shire Council	PowerPoint presentation and meeting	• 2023 planning update • Timeline and field work plan • Planned community interactions, including first official community engagement meeting

3.1.4 Consultation Outcomes

Throughout community consultation Jubilee have received consistent positive feedback. In terms of the already established and approved PMLU/NUMAs, no specific concerns have been raised by any stakeholders. It is acknowledged that options for retaining/transitioning any infrastructure will be discussed with interested landowners if the topic arises.

3.1.5 Community Consultation Plan

A formalised Stakeholder/Community Consultation Plan has not been developed by Jubilee as the Project is currently not operational. Ongoing community consultation however will continue, ensuring that any rehabilitation to be carried out under this PRC Plan is well communicated to the community. Should the

Project transition into an operational stage in the future, a Stakeholder/Community Consultation will be developed, an overview of what may be included is provided in **Table 11**.

Table 11. Community Consultation Plan

Stakeholder	Format	Information that may be Provided/Discussed	How Feedback/ Comments will be Considered
Landholders (direct and adjoining)	Direct stakeholder contact (face-to-face meetings, telephone calls, emails), project newsletters and fact sheets, feedback forms, project phone/ email	Project overview, site history, overview of PRC Plan/ rehabilitation process, anticipated PMLUs and NUMAs, feedback on proposed plan	Feedback will be considered in the context of PRC Plan updates and eventual site surrender. This could include retention of infrastructure for example
Indigenous stakeholders	Direct stakeholder contact (face-to-face meetings, telephone calls, emails), project newsletters and fact sheets, feedback forms, project phone/ email	Project overview, site history, overview of PRC Plan/ rehabilitation process, anticipated PMLUs and NUMAs, feedback on proposed plan	Feedback will be considered in the context of future PRC Plan updates and eventual site surrender. This could include retention of infrastructure for example
Federal, State, Local Government representatives	Direct stakeholder contact (face-to-face meetings, telephone calls, emails), project phone/ email	Project overview, site history, anticipated PMLUs and NUMAs, feedback on proposed plan	Feedback into PRC Plan itself will help strengthen the rehabilitation strategy
Business operators, special interest groups, wider local community	Public information sessions, project newsletters and fact sheets, feedback forms, project phone/ email, advertisements, media	Project overview, site history, overview of PRC Plan/ rehabilitation process, anticipated PMLUs and NUMAs, feedback on proposed plan	Community feedback and potential support is critically important to the success of the PRC Plan and eventual complete rehabilitation/ surrender of the site

3.2 Public Interest Considerations

As outlined in **Section 5** of this PRC Plan, the NUMAs are understood to be pre-approved and the EA holder is not required to undertake the Public Interest Evaluation process.

4 POST MINING LAND USE

As defined in the current approved EA, the post mining land uses for the site are stated per Schedule C – Table 1 (reproduced here as **Table 12**).

Table 12. Mining Activities and Rehabilitation Objectives

Landform (refer EA, Schedule H – Map 1)	Surface area (ha)	Rehabilitation Objectives		
		Post-mine land description	Land classification[1]	Analogue site identification
Golden Butterfly North Pit	1.6	Non-beneficial land use	Class VIII	Sites to be rehabilitated to a standard nominated in the rehabilitation program developed in accordance with Condition C2-1 based on analogue sites
Golden Butterfly Pit	5.1	Non-beneficial land use	Class VIII	
Lady Isabella Pit	1.7	Non-beneficial land use	Class VIII	
Content Pit	2.1	Non-beneficial land use	Class VIII	
Content Dump	6.3	L.I.G.[2] / disturbed native habitat	Class VI or better	
Golden Butterfly Dump	15.2	L.I.G.[2] / disturbed native habitat	Class VI or better	
Content Hardstand	2.0	L.I.G.[2] / disturbed native habitat	Class VI or better	
Golden Butterfly Hardstand	0.5	L.I.G.[2] / disturbed native habitat	Class VI or better	
Sediment Dams	1.5	L.I.G.[2] / disturbed native habitat	Class VI or better	
Roads/Tracks	3.5	L.I.G.[2] / disturbed native habitat	Class VI or better	

[1] Technical guidelines for the Environmental Management of Exploration and Mining in Queensland (DME) 1995. [2] L.I.G. (Low Intensity Grazing) defined by criteria listed in Land Use Acceptance criteria.

Essentially, the EA requires ML5248 (except for the four open pits) to be rehabilitated to a post mine land use of low intensity grazing/disturbed native habitat. The four open pits are required to be rehabilitated to a post mine land use of 'non-beneficial land use' which can be translated into a modern-day Non-Use Management Area (NUMA).

No changes are proposed to the pre-defined, pre-approved PMLU and NUMAs for the site.

4.1 Assessment of PMLU Options

As no changes are proposed to the pre-approved PMLU (low intensity grazing/disturbed native habitat), no assessment of other PMLU options has been completed.

4.2 Methodology for Determining PMLU Options

As mentioned, no changes are proposed to the pre-approved PMLU (low intensity grazing/disturbed native habitat) and therefore, it was not necessary to develop a methodology to determine PMLU options nor to undertake an evidence-based comparison and justification for the PMLU against alternative options.

4.2.1 Legislative Considerations / Constraints

From a legislative point of view, the current PMLU (low intensity grazing/disturbed native habitat) and NUMA aligns with the *Croydon Shire Planning Scheme 2019* which zones the Project area as rural. The current PMLU/NUMA is considered highly appropriate to this zoning and will represent a consistent use of the Project area with surrounding landforms/uses. No other legislation (at a State/Commonwealth level) has been identified as relevant to the land use of the surrounding area. There are also no development approvals relevant to the land.

4.2.2 Detailed Description of Nominated PMLU/s

There is one nominated and approved PMLU for the Project site (excluding the four pit areas which are NUMAs). This PMLU is low intensity grazing/disturbed native habitat. According to the EA, the land classification for this PMLU is defined as Class VI or better under the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME) 1995*. The return of the site to low intensity grazing/disturbed native habitat provides a beneficial environmental outcome as it provides both opportunity for low intensity grazing as well as habitat/ecosystem services.

Vegetation types and land suitability as they relate to the PMLU are outlined in the PRC Plan Schedule (**Appendix A**), along with completion criteria on measuring the success of rehabilitation.

This outcome is consistent with surrounding land uses and means there will be no permanent (mining-related) changes to these Project areas. Options for retaining/transitioning any infrastructure will be discussed with interested landowners if the topic arises.

5 NON-USE MANAGEMENT AREAS

The final rehabilitated landform will contain four NUMAs, namely the four open pits:

- Golden Butterfly Pit
- Golden Butterfly North Pit
- Content Pit
- Lady Isabella Pit

It is noted that the PRC Plan Guidelines state that where a NUMA has already been identified in a land outcome document (such as an EA) and are able to be transitioned into the PRC Plan Schedule, the applicant is not required to comply with Section 126C(1)(g) or (h) or 126D(2) or (3) of the EP Act. Any NUMAs transitioned into the PRC Plan Schedule are not required to complete the information requirements under Section 126C(1)(j) of the EP Act in this section for those NUMAs. However, the legislative requirements under Section 126C(1)(d) of the EP Act still apply.

The four NUMAs in this case can be taken to be pre-approved NUMAs as they are identified in a land outcome document (the EA) where the land outcome, the same or substantially similar to a NUMA has been stated. As the NUMAs can be taken to be pre-approved, the EA holder is not required to:

- Justify the proposed NUMA/s
- 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

In accordance with Section 126C(1)(d) of the EP Act, the extent to which each NUMA, as identified in the PRC Plan Schedule, is consistent with:

- The outcomes of consultation within the community in developing the plan
- Any strategies or plans for the land of a local government, the State or the Commonwealth

Jubilee acknowledges that all NUMAs are required to be managed in a way that achieves best practice management and minimises risks to the environment.

6 VOIDS IN FLOOD PLAINS

The PRC Plan Guidelines state that where a NUMA has already been identified in a land outcome document and is able to be transitioned into the PRC Plan Schedule, the application is not required to comply with Sections 126C(1)(g) or (h) or 126D(2) or (3) of the EP Act. Where a land outcome document has a pre-approved land outcome for a void with a location specified, flood plain modelling is not required.

The four NUMAs for this Project are understood to be pre-approved NUMAs (as they are identified in a land outcome document (the EA)) where the land outcome, the same or substantially similar to a NUMA has been stated. Additionally, each pre-approved NUMA has a specified location outlined in the current, approved EA. Therefore, it is understood that compliance with Sections 126C(1)(g) or (h) or 126D(2) or (3) of the EP Act is not required and no flood plain modelling is needed.

7 REHABILITATION MANAGEMENT METHODOLOGY

The rehabilitation management methodology section of the PRC Plan outlines the general rehabilitation practices and the various reporting that contributed to the development of the rehabilitation management methodology. This section also provides an overview of the methodology's development and the proposed implementation measures for the nominated PMLU and NUMA.

7.1 General Rehabilitation Practices

As per the PRC Plan Guideline, this section outlines the range of information applicable to the PRC Plan which underpins its development and shaped the historic rehabilitation method. All proposed methods/techniques are designed to rehabilitate the land to a stable condition in a way that supports the rehabilitation/ improvement milestones under the PRC Plan Schedule.

7.1.1 Hydrogeology

Historical information on hydrogeology has been derived from Section 5.2 of the PMLP (**Appendix E**). As identified in the PMLP, it is expected that the area covered by ML5248 is a hard rock geological terrain with groundwater hosted in the upper weathered rock horizon and deeper fractured rock aquifers associated with the mineral deposit. The aquifers are therefore not considered a potential resource. Groundwater quality is expected to reflect the mineralised nature of the country rock and bore yields are likely to be highly erratic due to the expected lack of hydrogeological interconnectivity between fractures. Regional groundwater levels are believed to be some 15 m below ground surface and any groundwater exploration would have to target geological structures.

7.1.1.1 Fractured Rock Aquifers

Groundwater monitoring and pit lake recovery trends support the hypotheses that the deeper fractured rock aquifers are highly variable in water quality and have limited connectivity. Figure 5 in **Appendix E** shows the conceptualised hydrogeology in the Golden Butterfly Pit area. Groundwater levels on either side of the pit differ by up to 5 m and water qualities differ significantly. It is suggested, based on groundwater quality data (Tables 9-11 of **Appendix E**) that a major geological contact exists between bores GBMB2 and GMMB3. This is borne out by the geology and the different water quality found in Golden Butterfly North Pit (Table 7 of **Appendix E**).

All four pits now contain pit lakes largely as a result of groundwater inflow at depth from expected rock aquifers. The differing pit water qualities reflect country rock geology and varying mineralisation within the ore deposit through which the groundwater is moving prior to entering the pits.

A hydrogeological study by HLA Envirosciences 2001 (**Appendix D**) showed that historic rainfall and evaporation data indicate a relatively large deficit (due to short wet season and high evaporation during most of the year) and that even in the wettest years there is no risk of the pit lakes overtopping. A simple water balance indicates that the pit lakes are expected to act as groundwater sinks and have limited capacity to influence groundwater quality much beyond the immediate footprint of the pit.

7.1.1.2 Unconfined Alluvial Aquifer – Slaughteryard Creek

The Slaughteryard Creek unconfined alluvial aquifer previously exploited by the original town water supply borefield is located off ML5248 and approximately 2 km from Golden Butterfly Pit. Although there are no bore logs for the town borefield, it is believed that it utilised the shallow unconfined alluvial aquifer associated with Slaughteryard Creek. It is expected that the unconfined alluvial aquifer is locally recharged by surface water flow within the creek. Surface water recharge that can be attributed to the Golden Butterfly Pit lake is most unlikely and has been confirmed by groundwater monitoring over a ten year period (Tables 10-12, **Appendix E**).

7.1.1.3 Groundwater Management Requirements

A number of hydrogeological investigation/assessments were conducted in 2009 (Barrick 2010) with the aim to confirm the conceptual hydrogeological model. The hydrogeological investigation/assessment (Barrick 2010) was conducted in accordance with the EA conditions and concluded the following:

- Groundwater is not considered a significant water resource within the mining lease and does not support or recharge any surface water drainage system. Some groundwater contamination has occurred below sections of the Content waste rock dump and around the mine pits. This contamination is highly localised and of no environmental concern, except along the western toe of Content waste rock dump where remedial drainage measures are planned.
- There is no direct hydrogeological link between the Golden Butterfly Pit lake and the town borefield or Lakes homestead bore and no possibility of this alluvial aquifer being contaminated by pit lake seepage water.
- The mine pits which have been considered hydrogeological sinks have until recently been slowly filling with rain and groundwater seepage. The two southern pits (Golden Butterfly and Golden Butterfly North) remain groundwater sinks and are likely to always be sinks if all stormwater is diverted away from the surrounding area. Content and Lady Isabella Pits on the other hand have now filled with water to the extent that pit lake levels reflect local groundwater levels and hence currently represent hydrogeological flow through cells.
- The water quality in the pit lakes has improved over the past 20 years, and it is only Golden Butterfly Pit that currently has a true acid mine drainage problem. Access to this pit lake must be restricted at all times. The current water quality in the remaining pit lakes does not exclude their use for irrigation in the case of Golden Butterfly North and dust suppression (road construction) for Content and Lady Isabella. There is however an ongoing safety concern and issue that natural evaporation concentration will continue in all pit lakes, particularly during low rainfall cycles.
- Current water balance modelling and field observations suggests that the proposed surface drainage plan for the Golden Butterfly Pit area needs to be fully implemented before the next wet season. The relatively simple earth works proposed could significantly reduce seepage and groundwater recharge to the mine pits. It is also suggested that drainage measures be put in place to provide for potential managed discharge (spillage) from Content Pit. This is a precautionary measure that needs to be taken as this pit lake will at some stage briefly overtop and the excess water needs to be directed in a controlled manner to discharge into the adjacent Belmore Creek. Water quality is not considered an issue, should such a spill occur, particularly as it would only occur during extreme flood conditions.

More recently (as described in **Section 2.4.8.1** of this PRC Plan), RGS Environmental undertook a water balance assessment of the pit lakes in 2020 (**Appendix G**) which generated an independent model incorporating pit geometries, inflows and outflows over a five-year period. The results identified that during this period all pits were unlikely to have a spill event (RGS 2020). Hence, the potential for any uncontrolled releases is considered highly unlikely.

The model was developed conservatively using worst-case rainfall data from 2008 - 2012 and also assumed there was no anthropogenic extraction during this time. This resulted in a chance of Content Pit overtopping based on these assumptions and conditions.

RGS (2020) outlined a risk mitigation plan in the event there is a possibility of discharge from the Content Pit similar to during summer 2010/2011 period when the last overtopping event occurred. If a rainfall event similar to the summer 2010/2011 period was anticipated, water from the Content Pit would be transferred to the Golden Butterfly Pit which has a much greater volume and more available freeboard during the maximum pit lake level scenario to accept water from Content Pit.

RGS (2020) determined that the Golden Butterfly North, Golden Butterfly, and Lady Isabella Pits would not record an overtopping event during the nominated period (i.e. the maximum pit lake level did not exceed the spillway level).

7.1.2 Flooding

As outlined in **Section 2.1.4.3** of this PRC Plan, review of Queensland Globe (Queensland Government 2023) and FloodCheck Queensland (DoR 2022) has indicated that the Project area has not undergone historical flooding and is not likely to experience a one percent Annual Exceedance Probability (AEP) flood event.

The Queensland Floodplain Assessment Overlay (Queensland Government 2023) represents an estimate of areas potentially at threat of inundation by flooding. This overlay has not yet been refined by local governments and is considered to be an initial estimate. For the Project, it is estimated that in the event of a flood, the north-western portion of the Project area could be inundated. This area is shown on **Figure 9**.

As outlined in **Section 6** of this PRC Plan, modelling for the purpose of voids located within a flood plain has not been undertaken as the four NUMAs for this Project are understood to be pre-approved NUMAs. Therefore, it is understood that compliance with Sections 126C(1)(g) or (h) or 126D(2) or (3) of the EP Act is not required and no flood plain modelling is needed.

7.1.3 Soil and Capping Material Assessment

As the site has already been capped historically (refer **Section 2.4.8** for details) and soil resources already utilised, a soil and capping material assessment is not warranted at this time.

7.1.4 Waste Characterisation

Per **Section 2.4.8** of the PRC Plan, all final landforms were constructed when the Project was decommissioned/ closed in 1993 and when additional rehabilitation works were substantially completed in 1996/1997. The final landforms on ML5248 are dominated by low hills over the waste rock dumps, which are considered stable and compatible with existing topography in the area. The slope and cover design of the waste rock dumps were developed to provide low permeability encapsulation to contain any potential acid mine drainage (Barrick 2011b).

7.1.5 Landform Design

A final landform design that meets the current PRC Plan Guideline requirements is not available. A final landform design can be undertaken if/as needed for the PMLU and NUMA to demonstrate that the land will be safe and structurally stable. The final landform design could include:

- 3D design plans of the final landform
- Method of determining landform design
- Modelling predicting the long-term stability of the final landform design
- Method of construction
- Quality Assurance/Quality Control (QA/QC) requirements
- Limitations and assumptions of the landform design

7.1.6 Cover Design

The historic slope and cover design (refer **Section 2.4.8**) of the waste rock dumps were developed to provide low permeability encapsulation to contain any potential acid mine drainage (Barrick 2011b). The rehabilitation methodology (refer **Table 7**) involved clay capping, rock backfill and revegetation of both waste rock dumps. The Content hardstand was rehabilitated with sand, clay capping, rock, mulch, soil, and revegetation whilst the Golden Butterfly hardstand was rehabilitated in accordance with off-lease analogue sites as per Condition C2-1 of the EA. The sediment dam and roads/tracks were also rehabilitated in accordance with off-lease analogue sites as per Condition C2-1 of the EA.

All final landforms were constructed when the Project was decommissioned/closed in 1993 and when additional rehabilitation works were substantially completed in 1996/1997. The final landforms on ML5248 are dominated by low hills over the waste rock dumps, which are considered stable and compatible with existing topography in the area.

7.1.7 Water Management

A Water Management Strategy (**Appendix H**) is in place for the Project. Developed in 2018, the Water Management Strategy was prepared in accordance with EA Condition F10-1 and included within the Plan of Operations. Section 3 of the Water Management Strategy outlines the Drainage Management Plan for all post-mining related landforms, specifically:

7.1.7.1 Golden Butterfly Waste Rock Dump

The Water Management Strategy (**Appendix H**) outlined that the Golden Butterfly waste rock dump was capped with an engineered cover system consisting of a clay capping layer, a rock fill surface protection layer and topsoil layer during the reclamation works conducted in 1996/1997. During periods of extreme rainfall any excess water from the waste rock dump surface is engineered to spill down rock lined drains that follow the original haul ramp to discharge to the western tributary of Slaughteryard Creek.

In addition, an open seepage collection trench was excavated along the eastern toe of the waste rock dump. Water monitoring was conducted at this trench for more than 14 years and no seepage or contaminant discharge was observed. The trench also collects surface runoff from the natural catchment to the east of the waste rock dump and channels this water into the western tributary of Slaughteryard Creek. Additional details of the reclamation works conducted in 1996/1997 are provided in the PMLP (Appendix A of **Appendix E**).

No further drainage management measures are considered necessary for the Golden Butterfly waste rock dump area.

7.1.7.2 Content Waste Rock Dump

The Content waste rock dump was capped with an engineered cover system consisting of a clay capping layer, a rock fill surface protection layer and topsoil layer during the reclamation works conducted in 1996/1997. At the time the rehabilitation and revegetation status of the waste rock dump western batter was considered adequate and no capping was constructed on this section of the waste rock dump (HLA-Envirosciences 2001).

The northern most section of the waste rock dump upper surface was not levelled to the same degree as the remainder of the dump. Subsequently some surface ponding has been noted to occur during extreme rainfall events. General erosion control works were conducted to the north-western part of the waste rock dump in 2009/2010. Several small gullies were beginning to form on the upper crest where water was concentrated in deep vehicle rut marks and localised depressions. Back fill material, sourced from the Golden Butterfly waste rock dump east haul ramp, was utilised to fill these localised depressions to reduce infiltration through the waste rock dump. No excavation was conducted on the top surface of the waste rock dump to avoid potential impacts to the integrity of the clay capping layer. Subsequent rainfall and surface runoff has not caused a recurrence and no further general erosion control works on the Content waste rock dump are currently planned.

No further drainage management measures are considered necessary for the Content waste rock dump area.

7.1.7.3 Golden Butterfly Pit

A water balance conducted by HLA-Envirosciences (2001) indicates that based on historic rainfall and evaporation data there is no risk of the Golden Butterfly Pit overtopping even during the wettest rainfall cycles. The abandonment bund restricts any surface water discharge into the pit from surrounding areas. The pit represents a groundwater sink with limited capacity to influence groundwater quality much beyond the immediate footprint of the pit. The upper section of the access ramp to the pit has been engineered to restrict any vehicle access and the abandonment bund has been extended across the access ramp. The extension of the abandonment bund further reduces the amount of surface water reporting to the Golden Butterfly Pit. A water level gauging station has been installed so that pit water levels may be regularly monitored.

7.1.7.4 Golden Butterfly North Pit

The water quality in the Golden Butterfly North Pit is expected to remain fresh for some time however it is considered that the water will become brackish and even saline with time (i.e., hundreds of years). The pit

represents a groundwater sink with limited capacity to influence groundwater quality much beyond the immediate footprint of the void. Two bores (a deep and shallow bore) have been drilled between the pit and Golden Butterfly waste rock dump to identify seepage which may be migrating towards the pit lake from the waste rock dump. Although the pit lake water quality is considered as a potential water resource, vehicle access to the pit has been restricted for safety reasons.

The upper section of the access ramp to the pit has been engineered to restrict any vehicle access and the abandonment bund has been extended across the access ramp with a gate installed. The extension of the abandonment bund further reduces the amount of surface water reporting to the Golden Butterfly North Pit. A water level gauging station has been installed so that pit water levels may be monitored.

7.1.7.5 Content Pit

An investigation conducted by HLA-Envirosciences (2001) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping. The 2008/2009 and 2009/2010 wet seasons resulted in extraordinary rainfall totals. In recognition of the possibility of a discharge from the Content Pit, short-term remediation works were undertaken involving the transfer of water from Content Pit to Golden Butterfly Pit to minimise the risk of Content Pit overtopping during the 2010/2011 wet season. Content Pit was decreased by approximately four metres during 2010 (with a subsequent increase of one meter in Golden Butterfly Pit). Nevertheless, in early 2011 Content Pit began discharging water which continued until April 2011 when no flow was observed to be entering receiving streams. This event shows that the conceptual hydrogeological model in terms of Content Pit, in view of the additional rainfall data available, inadequately describes the physical situation.

A possible addition to the hydrogeological model for the Content Pit is the inclusion of a hydraulic connection with the Lady Isabella Pit. The Lady Isabella Pit when full is approximately five metres higher in elevation than the Content Pit discharge level. This elevation difference provides a hydraulic driving force which the relative close proximity of the Lady Isabella Pit to Content Pit and possible connecting fracture zones and/or fault lines enabling water flow.

The upper section of the access ramp to the pit has been engineered to restrict vehicle access and the abandonment bund has been extended across the access ramp with a gate installed. The extension of the abandonment bund further reduces the amount of surface water reporting to the Content Pit. Additional diversion drains were installed during 2009/2010 to ensure surface water flow in the vicinity of Content Pit is maintained as much as possible to avoid ponding which may increase groundwater infiltration and possible input into Content Pit. A water level gauging station was installed so that pit water levels may be monitored.

7.1.7.6 Lady Isabella Pit

The 2008/2009 and 2009/2010 wet seasons had extraordinary rainfall totals which resulted in the Lady Isabella Pit being full to capacity during early 2011, but with no overtopping and discharge observed. This event shows that the conceptual hydrogeological model in terms of Lady Isabella Pit, in view of the additional rainfall data available, inadequately describes the physical situation.

A possible addition to the hydrogeological model for the Lady Isabella Pit is the inclusion of a hydraulic connection with Content Pit. The Lady Isabella Pit when fill is approximately five metres higher in elevation than the Content Pit discharge level. This elevation difference provides a hydraulic driving force which with the relative close proximity of the Lady Isabella Pit to Content Pit and possible connecting fracture zones and/or fault lines enabling water flow.

The upper section of the access ramp to the pit has been engineered to restrict vehicle access and the abandonment bund has been extended across the access ramp. The extension of the abandonment bund further reduces the amount of surface water reporting to the Lady Isabella Pit. A water level gauging station was installed so that pit water levels may be monitored.

7.1.7.7 Water Balance Assessment (2020)

As described in **Section 2.4.8.1** of this PRC Plan, RGS undertook a more recent water balance assessment of the pit lakes in 2020 (**Appendix G**). RGS determined in the modelling results section of their report that Golden Butterfly Pit, Golden Butterfly North Pit, and Lady Isabella Pit would not record an overtopping event during the nominated period or modelled five-year period (i.e. the maximum pit lake level did not exceed the spillway level).

With regards to Content Pit, and to address the concern for a repeat spill event, RGS worked to amend the Stage 2 model to a Stage 3 level of development (**Appendix G**). The scope of work for Stage 3 includes utilising measured data from site (e.g. utilising existing water levels during each model run, using measured bathymetry to derive updated stage area storage curves, detailed survey data to optimise key model parameters, and measured permeability to improve runoff co-efficient. The inclusion of this data in the model will lead to reduced uncertainty. The Stage 3 optimised model will include a Dashboard (operational window to simulate water management options) and can then be used as an operational tool by the proponent to verify how the implementation of management options that could reduce the potential for a spill event.

7.1.8 Revegetation

The Final Rehabilitation Report (HLA-Envirosciences 2001, **Appendix D**) details the rehabilitation undertaken and summarises the lease relinquishment criteria for the establishment of vegetation. The most recent report on the vegetation monitoring provides an assessment in November 2000. The report concluded that "*the rehabilitation of the Croydon site is progressing towards self-sustaining ecosystems (*i.e. meeting the vegetation criteria described in Table 7 of **Appendix D***) in terms of:*

- *Vegetation density and composition of the rehabilitation sites are trending towards those of the natural site; and*
- *Landscape processes such as soil stability, infiltration capacity and nutrient recycling capacity are gradually trending toward those of the natural sites*"

Sixteen tree and shrub species were included in the seed mix used during the 1996-1997 revegetation program. Most of these were recorded in at least one quadrat during the November 2000 monitoring (Table 8, **Appendix D**). In addition, other species were recorded at some sites; these reflect either difficulty in identification or self-seeding from surrounding vegetation. In all, nineteen tree and shrub species were recorded at the revegetation sites. Of these, seven were acacias, seven were eucalypts and five belonged to other genera, including *Melaleuca*, *Atalaya*, *Erythrophleum* and *Hakea*.

7.1.9 Tailings Storage Facilities

Not applicable, there are no Tailings Storage Facilities currently on the site.

7.1.10 Voids

As per condition C5-1 of EA EPML0095091 - Residual Voids, or the contents of residual voids, must not cause any environmental harm other than the environmental harm caused within the footprint of the residual void itself, voids do not need to be backfilled or rehabilitated beyond their current state.

7.1.11 Underground Mining

Not applicable.

7.1.12 Built Infrastructure

Not applicable, no built infrastructure that requires decommissioning/demolishment is currently onsite.

8 RISK ASSESSMENT

8.1 Risk Assessment Framework

A risk assessment was undertaken in accordance with AS/NZS ISO 31000:2018 *Risk Management – Guidelines* and *HB203:2006 Environmental Risk Management Principles and Processes*. The criteria adopted for assessing risk levels of identified hazards is shown in **Table 13**. Analysis of the likelihood and consequence was conducted to determine the risk rating given against each hazard (refer **Table 14** and **Table 15**).

The risk assessment matrix in **Table 16** provides a summary of the hazard analysis and risk assessment as it relates to the PRC Plan. The risk assessment also identified the risk of a stable condition for land not being achieved and includes mitigation measures outlining how this risk will be managed.

Table 13. Risk Assessment Criteria

Likelihood	Consequence				
	Extreme 5	Major 4	Moderate 3	Minor 2	Insignificant 1
Almost Certain 5	Extreme (25)	Extreme (20)	Extreme (15)	High (10)	Moderate (5)
Likely 4	Extreme (20)	Extreme (16)	High (12)	Moderate (8)	Low (4)
Possible 3	Extreme (15)	High (12)	Moderate (9)	Moderate (6)	Low (3)
Unlikely 2	High (10)	Moderate (8)	Moderate (6)	Low (4)	Low (2)
Rare 1	Moderate (5)	Low (4)	Low (3)	Low (2)	Very low (1)

Table 14. Likelihood Scale

Level	Descriptor	Definition
1	Rare	Unlikely to occur during a lifetime or very unlikely to occur
2	Unlikely	Could occur about once during a lifetime or more likely not to occur than to occur
3	Possible	Could occur more than once during Project lifetime or more likely not to occur than to occur
4	Likely	Will probably occur in most circumstances
5	Almost Certain	Is expected to occur in most circumstances

Table 15. Consequence Scale

Level	Descriptor	Definition
1	Insignificant	Very low environmental and health impacts confined to a small area within the Project area Prompt (typically within a shift) clean-up Negligible loss of human, social, financial, or built capital/wellbeing Negligible media coverage First aid injury
2	Minor	Low environmental and health impacts confined within the Project area Short-term (typically within a week) clean-up Small but noticeable loss of human, social, financial or built capital/wellbeing, can be easily rehabilitated Regulation breaches without fine or litigation Negative local media coverage Complaint from community Medical treatment injury/ occupational health effects/ Restricted Work Injury
3	Moderate	Reversible off-site environmental health impacts, requiring shot-term clean-up (weeks) Onsite medium term (months) clean-up Moderate, noticeable loss of financial or built capital/wellbeing Regulation breaches resulting in fine or prosecution Negative media coverage at local/regional level over more than one day Lost time/disabling injury/ occupational health effects/multiple medical treatments
4	Major	Major, off-site, environmental and health impacts requiring medium-term clean-up (months) Onsite impact requiring significant clean-up effort (years) Substantial loss of financial or built capital/wellbeing, will attract public concern Major litigation at operation level Negative national media cover age Fatality or permanent incapacity/health effects
5	Extreme	Prolonged or severe, off-site or regional environmental and health impacts requiring long-term clean-up (years) with irreversible residual damage Extreme permanent loss of, financial or built capital/ wellbeing, with anticipated major public outrage Major litigation or prosecution at parent company level Loss of environmental licence Fatalities or permanent injuries from single incident

8.2 Risk Treatment

The risk assessment has incorporated a comprehensive list of risks based on events which have the potential to enhance, delay or accelerate the rehabilitation of the site. The causes and sources of risk, their impacts, and the likelihood that those consequences can occur has also been explored.

The risk treatment component of the risk assessment outlines the reasons for selecting the treatment option/s, proposed actions, and reporting/monitoring requirements.

Table 16. Qualitative Risk Assessment – PRC Plan

Risk ID	Hazard / Risk	Potential Impact/s	Risk Rating	Mitigation Measures / Risk Treatment	Residual Risk Rating
1	Stability of landform not being achieved for RAs	• Stability of landform not being achieved, meaning the PMLU for the relevant RAs cannot be achieved • Inherent greater erosion risks • Impacts to rehabilitation timing and achievement of rehabilitation milestones	**High (12)**	• Progressive rehabilitation to minimise mining related footprint and maximise land available for the PMLU • Topsoil and subsoil management and records to be maintained of materials origin • Exposed areas to be rehabilitated to achieve a suitable level of ground cover to minimise the potential for scouring	**Moderate (6)**
2	Insufficient management of contractors for closure and rehabilitation works	• Poorly executed rehabilitation works resulting in delays to achieving rehabilitation milestones • Increased costs associated with re-training, upskilling, or seeking new contractors	**Moderate (9)**	• Ensure appropriate contractual arrangements are in place prior to commencement of works • Undertake progressive reviews of site works to ensure works are being completed appropriately	**Low (4)**
3	Climate change / extreme weather events – progressive rehabilitation	• Progressive rehabilitation success may be compromised through loss of vegetation and increased erosion • Changes in drought patterns, leading to reduced rainfall may inhibit plant growth • Damage from strong winds may result in unsuccessful planting • Changes in rainfall patterns can result in major flooding • Rehabilitation failure due to bushfires, and harsher/ more extreme fire weather • Unsuccessful rehabilitation planting resulting from climate change impacts may result in setbacks to the closure planning program	**Moderate (6)**	• Monitoring rehabilitated areas on a regular basis will ensure that original objectives set out in the PRC Plan are achieved. In the circumstance that rehabilitation activities do not achieve the desired outcomes in the PRC Plan, procedures will be reviewed and adapted to achieve compliance • Jubilee will monitor changes to the climate over the life of the Project and update rehabilitation strategies based on climate projections from the Bureau of Meteorology and CSIRO and expert advice from suitably qualified personnel	**Low (4)**
4	Heavy rainfall or extended periods of drought during first	• Poor seed establishment • Erosion of RAs • Loss of topsoil and scouring of land	**Moderate (9)**	• Monitoring rehabilitated areas on a regular basis will ensure early detection of poor performance	**Low (4)**

Risk ID	Hazard / Risk	Potential Impact/s	Risk Rating	Mitigation Measures / Risk Treatment	Residual Risk Rating
	months after initial planting	• Flooding of Project site, potentially causing surface water contamination		• In years of inadequate rainfall, watering can be undertaken at regular intervals from November to February • Provision of sufficient water • Supplementary seed may be required during years which experience extreme events (e.g., prolonged drought) • All relevant site personnel and contractors to be trained in accordance with performed activities	
5	Fire	• Natural fires may result in loss of planted stock • Loss of vegetation cover may result in increased erosion and soil loss • Failure to achieve milestone criteria pertaining to vegetation cover	**Moderate (9)**	• Maintain a firebreak • Ongoing implementation of Monitoring and Maintenance Program	**Moderate (6)**
6	Proliferation of weed species	• Inappropriate weed management during revegetation may result in proliferation of weeds within RAs, causing limited establishment of target species • Potential to impact the achievement of subsequent rehabilitation milestones	**Moderate (6)**	• Vehicle washdown procedures for vehicles entering the site from weed infested areas • Implementation of weed monitoring to allow for the identification of weed infestations and treatment • Invasive species awareness training • Implementation of weed control and management measures	**Low (4)**
7	Insufficient Monitoring and Maintenance Program	• Inability to provide sufficient evidence that closure and rehabilitation activities have been carried out in accordance with the approved PRC Plan • Potential for re-work that has not been provisioned for, resulting in financial loss • Delay in surrendering the EA	**High (12)**	• Ongoing review of Monitoring and Maintenance Program • Utilise historic monitoring reports/results for continual improvement and to identify areas which may require further work in order to achieve subsequent rehabilitation milestones	**Moderate (6)**
8	Retained pits and/or infrastructure pose a physical safety threat to humans or wildlife	• Injury/death to humans or wildlife	**High (12)**	• Restricted site access • Maintenance of fencing • Maintenance of adequate signage	**Moderate (8)**

9 REHABILITATION MILESTONES AND COMPLETION CRITERIA

9.1 Rehabilitation Milestones

Rehabilitation milestones and criteria that need to be fulfilled to track progress against the PRC Plan Schedule have been provided in **Table 17** for ease of reference. It is noted that a requirement of the PRC Plan Guideline is to include reference maps attached to the PRC Plan Schedule identifying the boundary of each rehabilitation/improvement area, these reference maps have been included here as **Figure 9** and **Figure 10**, as well as within **Appendix A**.

9.1.1 Development of Rehabilitation Milestones, Criteria and Outcomes

The development of rehabilitation milestones and criteria have been derived from historical site-based documents such as the current, approved EA, the Post Mine Land Use Plan, Rehabilitation Reports, Rehabilitation Monitoring Program, and related management plans/reports. Where able, these milestones and criteria have been directly adopted, however in some instances it was necessary to contemporise these milestones and criteria to better fit the PRC Plan format.

The milestone criteria are objective target levels or values that can be measured to quantitatively demonstrate achievement of milestones and ultimate success of biophysical processes undertaken as part of the PRC Plan. These criteria have been developed in accordance with the PRC Plan Guideline which references the use of SMART (Specific, Measurable, Achievable, Reasonable/Relevant and Time-specific) principles. To ensure that indicators remain relevant, monitoring of indicators will start as soon as possible and continue until the application to surrender the area has been approved by the Administering Authority.

All rehabilitation milestones, management milestones, and their respective criteria, justification, indicators, and outcomes have been provided in **Table 17**.

629000E
630000E
631000E
632000E
7990000N
7989000N
7988000N

1SP269692
755SP273179
952SP178689
8SY21
3CP895985
5SY12
34SP296957

Content Pit
Lady Isabella Pit
Golden Butterfly North Pit
Golden Butterfly Pit
Norman River
Croydon Gold Mine (ML 5248)

0 200 400 m
N
Scale: 1:12,500@ A3
Datum: GDA2020
Projection: MGA zone 54

Data Source:
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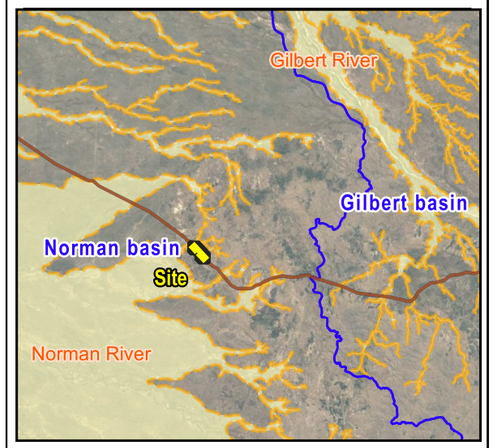
epic ENVIRONMENTAL



Legend

- Site boundary
- Cadastre (DCDB)
- Maximum disturbance area
- Roads and tracks
- State controlled roads

Post mining land use

- Low intensity grazing/Disturbed native habitat

Floodplain extent (QFAD) Level 1

- Rapid hazard assessment

Historical site infrastructure

- Pit
- Access track

Jubilee Metals
Progressive Rehabilitation and Closure Plan
Croydon Gold Mine

Figure 9
Final Site Design

629000E
630000E
631000E
632000E
7990000N
7989000N
7988000N

1SP269692
755SP273179
952SP178689
3CP895985
5SY12
8SY21
34SP296957

Access track (RA4)
Content Pit (IA3)
Sediment Dam (RA3)
Lady Isabella Pit (IA4)
Content Hardstand (RA2)
Laydown Area (RA5)
Content Waste Rock Dump (RA1)
Croydon Gold Mine (ML 5248)
Access track (RA4)
Golden Butterfly Waste Rock Dump (RA1)
Other Mining Disturbance (RA6)
Access track (RA4)
Golden Butterfly North Pit (IA2)
Laydown Area (RA5)
Golden Butterfly Hardstand (RA2)
Golden Butterfly Pit (IA1)

0 200 400 m
Scale: 1:12,500@ A3
Datum: GDA2020
Projection: MGA zone 54

N

Data Source:
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epic ENVIRONMENTAL

Legend

- Site boundary
- Cadastre (DCDB)
- Improvement areas
- Rehabilitation areas
- Roads and tracks
- State controlled roads
- Access track

Non use management area

- Pit

Post mining land use

- Low intensity grazing/Disturbed native habitat

Jubilee Metals
Progressive Rehabilitation and Closure Plan
Croydon Gold Mine

Figure 10
Reference Map

Table 17. Rehabilitation Milestones, Criteria, Justification and Outcomes

Rehabilitation Area/ Improvement Area Milestone	Applicable Rehabilitation/ Improvement Area/s	Completion/ Milestone Criteria	Justification for Criteria	Rehabilitation/ Improvement Indicators	Rehabilitation/ Improvement Outcomes
Rehabilitation Milestone (RM)					
RM1 – Landform reshaping/ re-profiling	RAs 4 and 6	1. No observable subsidence, rock falls and/or slope slippage	To establish a stable condition for land	Visual inspection following decommissioning and removal	Create a landform that is safe for humans and wildlife into the foreseeable future Create a stable landform Create a non-polluting landform Ensure minimal post mining impacts on surface water catchments
		2. Incidence of erosion (e.g. natural rates of erosion)	To establish a stable condition for land and to ensure any drainage follows appropriate drainage paths	Visual inspection (as required) by a suitably qualified person	
		3. Geotechnical investigation to be completed by a suitably qualified engineer	An investigation needs to be undertaken by a suitably qualified engineer to ensure the final landform is geotechnically stable post reshaping/re-profiling of landform	Certification provided by a geotechnical engineer that the final landform is geotechnically stable	
RM2 – Surface preparation	RAs 4, 5 and 6	1. Ripping undertaken and penetrates at least 300 mm into soil profile	To encourage water infiltration and grass root development to a depth that is sufficient for adequately stabilising surface soils	Visual inspection by a suitably qualified person during ripping activities	Create a landform that is safe for humans and wildlife into the foreseeable future Create a stable landform Create a non-polluting landform
		2. Placement of subsoil 300 mm (minimum) across the rehabilitation area	Subsoil will be applied with a minimum thickness of 300 mm to support plant growth. This is a standardised depth and has been successfully applied to rehabilitated mine sites in Queensland	Visual inspection by a suitably qualified person	
		3. Placement of topsoil 100 mm (minimum) across the rehabilitation area	Topsoil will be placed with a minimum thickness of 100 mm to provide sufficient depth for vegetation growth	Visual inspection by a suitably qualified person	
		4. Application of ameliorants on subsoil and/or topsoil if required	Ameliorants may be required to improve cohesion with the subsoil/ topsoil and to sustain nitrogen levels	Outcomes implemented as a result of any soil health and suitability assessment/s completed by a suitably qualified person	
RM3 – Revegetation	RAs 4, 5 and 6	1. Revegetation campaign to seed target species at a rate of 10-15 kg/ha to establish a self sustaining natural vegetation cover	Standard rates used for rehabilitating degraded landscapes. The sow rate of subsequent seeding campaigns will be informed upon review of monitoring data which will provide insight into germination success/ vegetation cover	Visual inspection (as required) by a suitably qualified person during seeding works	Create a landform that is safe for humans and wildlife into the foreseeable future Create an appropriate PMLU for the area Establish vegetation communities that resemble those likely to have been onsite pre-mining and which blend with the surrounding landscape and vegetation Establish functional, self-sustaining vegetation communities
		2. Timing of seeding (sowing), best undertaken in December/January to coincide with elevated levels of surface soil moisture	Sowing in the wet season will improve the probability of seed germination	Visual inspection (as required) by a suitably qualified person during seeding works	
		3. Seed to be sown at no more than 1 cm depth. Seeds to be raked in following seed broadcasting	To enhance the probability of seed germination by protecting the seed from rapid desiccation and predation from birds and other animals	Visual inspection (as required) by a suitably qualified person during seeding works	
		4. Stock to be initially excluded from rehabilitation areas, with gradual controlled low intensity grazing of domesticated stock to be re-introduced	To reduce impact to rehabilitation areas (grazing by cattle)	Visual inspection by site management	
		5. Firebreak maintained along edge of Mining Lease until rehabilitation complete	Extreme fires can kill rehabilitation areas or act to reduce vegetation cover	Visual inspection by a suitably qualified person on a monthly basis	

Rehabilitation Area/ Improvement Area Milestone	Applicable Rehabilitation/ Improvement Area/s	Completion/ Milestone Criteria	Justification for Criteria	Rehabilitation/ Improvement Indicators	Rehabilitation/ Improvement Outcomes
RM4 – Achievement of surface requirements	RAs 4, 5 and 6	1. Revegetation cover to exceed the 70th percentile among monitoring and control sites	Floristic patterns are subject to seasonal fluctuations in response to numerous factors including rainfall, disturbance, and climate	Ground cover density to be assessed with ten separate 1 m by 1 m quadrats spaced at even intervals along a transect line. Within each quadrat, the percentage ground cover composition of vegetation, litter, rock, or bare earth is to be estimated. The dominance of each species of vegetation recorded in each quadrat is to be measured and recorded by a suitably qualified person	Create a landform that is safe for humans and wildlife into the foreseeable future Create an appropriate PMLU for the area Establish vegetation communities that resemble those likely to have been onsite pre-mining and which blend with the surrounding landscape and vegetation Establish functional, self-sustaining vegetation communities
		2. Dry matter production is comparable to surrounding areas of the Project. Nutrient cycling is occurring and leaf litter is assisting in limiting erosion on the soil/spoil surface	Relative dominance of each species should be taken into account when estimating total biomass and then compared to surrounding areas/pre-existing site data	Visual inspections by a suitably qualified person	
		3. Planting success for 60 percent strike rate and 70 percent uptake	Seeds of local provenance (Croydon Shire region) and representative of regional ecosystems will primarily be used for rehabilitation	Visual inspection (as required) by a suitably qualified person	
		4. Revegetation 80 percent comparable to surrounding regional ecosystems	Seeds of local provenance (Croydon Shire region) and representative of regional ecosystems will primarily be used for rehabilitation	Visual inspection (as required) by a suitably qualified person	
		5. Abundance of persistent weeds are a maximum 10 percent of ground cover	Weeds are a major source of failure of rehabilitation efforts. It is imperative that new weed infestations are prevented and/or controlled at the earliest possible opportunity. Weed control and management is an important component of successful rehabilitation. The proponent is obliged under the *Biosecurity Act 2014* to prevent the spread of declared weeds, and some non-declared weeds can also severely impair the successful development of rehabilitation	Visual inspection (as required) by a suitably qualified person	
		6. No exposed topsoil with less than 5 percent ground cover will remain without seeding, erosion and sediment control during the wet season	To minimise the potential for erosion	Visual inspection (as required) by a suitably qualified person	
		7. No active rill, gully or sheet erosion is visible within the rehabilitation area five years after commencing rehabilitation	No active rill, gully or sheet erosion should be visible five years after rehabilitation activities commenced. Drainage should follow appropriate drainage paths. For the purposes of this criteria, these types of erosion have been defined as: - Rill: an individual eroded channel in the soil that is less than 300 mm deep (Catchments & Creeks 2012) - Gully: widespread soil erosion caused by flowing surface water. It consists of open, unstable channels that have been cut more than 30 cm deep into the ground (Queensland Government 2020) - Sheet: the removal of an even layer of surface soil through the actions of raindrop impact and stormwater runoff (Catchments & Creeks 2012)	Visual inspection (as required) by a suitably qualified person to confirm there is no active rill, gully, or sheet erosion present on final landform	
		8. Stocking rates maintain self sustaining vegetation	To reduce impacts to rehabilitation areas (grazing by cattle) monitoring of pasture conditions to maximise yield will need to be undertaken	Annual assessment of carrying capacity by a suitably qualified person	

Rehabilitation Area/ Improvement Area Milestone	Applicable Rehabilitation/ Improvement Area/s	Completion/ Milestone Criteria	Justification for Criteria	Rehabilitation/ Improvement Indicators	Rehabilitation/ Improvement Outcomes
RM5 – Achievement of post-mining land use to stable condition	RAs 2-6	1. Final landform is safe and geotechnically stable with certification from a suitably qualified engineer	To ensure final landform stability, certification from a suitably qualified person that the land is safe and geotechnically stable is required	Certification from a suitably qualified person	Create a landform that is safe for humans and wildlife into the foreseeable future Create a stable landform Create a non-polluting landform Create an appropriate PMLU for the area Ensure minimal post mining impacts on surface water catchments Establish vegetation communities that resemble those likely to have been onsite pre-mining and which blend with the surrounding landscape and vegetation Establish functional, self-sustaining vegetation communities
		2. Provision of a final rehabilitation report, including monitoring records	To ensure final landform stability and achievement of the PMLU, it is necessary to provide a final rehabilitation report	Provision of final rehabilitation report by a suitably qualified person	
		3. Grazing intensity managed to ensure sustainable grazing outcome	To reduce impact to rehabilitation areas, grazing by cattle needs to be carefully managed by land manager/s	Annual assessment of carrying capacity by a suitably qualified person	
		4. Surface water complies with the water quality criteria outlined in the EA	Surface water quality at monitoring locations to remain within site specific water quality criteria outlined in the conditions of the EA. These limits may be revised and any amendments relating to rehabilitation will be provided to the Administering Authority if/as needed	Assessment undertaken as required in accordance with the conditions of the EA	
		5. Groundwater complies with the groundwater criteria outlined in the EA	Groundwater quality at monitoring locations to remain within site groundwater quality criteria outlined in the conditions of the EA. These limits may be revised and any amendments relating to rehabilitation will be provided to the Administering Authority if/as needed	Assessment undertaken as required in accordance with the conditions of the EA	
RM6 – Investigation and/or remediation of contaminated land	RAs 1, 2, 3, 5 and 6	1. Contaminated land investigation which outlines recommended actions completed by a suitably qualified person	A contaminated land investigation completed by a suitably qualified person is necessary to ensure that risks to human health and the environment have been appropriately managed. The site investigation may include (as required): - Contaminated land site investigation undertaken in accordance with Schedule B2 (Guideline on Site Characterisation) of the *National Environmental Protection (Assessment of Site Contamination)* - Preparation of a Remediation Action Plan (RAP) - A validation program to confirm suitable remediation actions have been adequately implemented and the site is suitable for the final PMLU	Contaminated land investigation completed by a suitably qualified person as required	Create a landform that is safe for humans and wildlife into the foreseeable future Create a stable landform Create a non-polluting landform Create an appropriate PMLU for the area Ensure minimal post mining impacts on surface water catchments
		2. Removal or onsite treatment of contaminated water (e.g. hydrocarbons, brine, metals etc.) per recommendations	As required, it will be necessary to either remove or treat onsite contaminated water to ensure appropriate remediation and a safe, non-polluting site	Certification from a suitably qualified person as required	
		3. Removal and appropriate disposal of any contaminated materials per recommendations	As required, it will be necessary to remove and dispose of contaminated materials to ensure a safe and non-polluting site	Certification from a suitably qualified person as required	
		4. Onsite remediation of hydrocarbon contaminated soils per recommendations	As required, onsite remediation of hydrocarbon contaminated soils will be undertaken to ensure a safe and non-polluting site	Certification from a suitably qualified person as required	
		5. Conduct validation testing to confirm that contaminated soils have been removed/remediated	Once any contaminated soils have been removed and/or remediated, it is necessary to undertake validation testing. This can be included as part	Certification from a suitably qualified person as required	

Rehabilitation Area/ Improvement Area Milestone	Applicable Rehabilitation/ Improvement Area/s	Completion/ Milestone Criteria	Justification for Criteria	Rehabilitation/ Improvement Indicators	Rehabilitation/ Improvement Outcomes
			of the contaminated land investigation if needed and will ensure a safe, non-polluting site/PMLU		
Improvement Area Management Milestone (MM)					
MM1 – Achievement of sufficient improvement	IAs 1-4	1. Certification by a suitably qualified person that pits will not cause environmental harm outside the Mining Lease boundary	To ensure a non-polluting landform, certification from a suitably qualified person is required	Certification from a suitably qualified person as required	Create a landform that is safe for humans and wildlife into the foreseeable future Create a non-polluting landform Ensure minimal post mining impacts on surface water catchments
		2. Certification by a suitably qualified person that water quality in pits will not cause environmental harm to the surrounding environment	To ensure a non-polluting landform that does not cause environmental harm to the surrounding environment/surface water catchments, certification from a suitably qualified person is required	Certification from a suitably qualified person as required	
		3. Certification by a suitably qualified person that pit areas are safe to humans and wildlife, with access restrictions in place	To ensure a safe final landform, certification from a suitably qualified person is required	Certification from a suitably qualified person as required	

9.2 Method to Achieve Stable Condition

The method to achieve a stable condition in accordance with the milestone criteria will be derived from the pre-existing Post Mine Land Use Plan, Rehabilitation Reports, Rehabilitation Monitoring Program, and related management plans/reports and contemporised where necessary to ensure legislative compliance.

9.3 Completion Criteria Assessment

The certification or final sign-off of rehabilitation requires adequate information to be provided by the applicant in a rehabilitation report. Rehabilitation monitoring records will continue to be collected and once site recovery is successful, will form part of a revised final rehabilitation report and EA surrender application. Annual assessment of rehabilitation against the completion criteria is important for two reasons:

- First, it allows an early detection of failure, reducing the costs of remediation
- Second, it allows for growth trajectories to be calculated, providing a robust argument for low likelihood of future failure and evidence for mining lease relinquishment

9.4 Adaptive Management

Rehabilitation must be adaptive in order to achieve completion criteria. Jubilee will adaptively implement the PRC Plan to mitigate uncertainty that may arise throughout the process where the plan is not delivering completion criteria.

Adaptively implementing the PRC Plan is critical to achieving the plan's objectives, for example where adjustment actions and arrangements to enhance effectiveness can be made to deliver improvements. To maintain an adaptive approach, Jubilee will:

- Effectively schedule monitoring of newly rehabilitated areas on an annual basis to make informed decisions on risk management, auditing and reporting activities
- Collect and incorporate new data/information as a result of implementing the plan, with new findings from data collected or from new information derived from external sources
- Commit to periodically reviewing risks, including those in response to the changing risk level, new information, changing circumstances, or the results from implementing corrective actions
- On an annual basis, undertake a review of the effectiveness of management measures with significant levels of uncertainty and relatively long implementation timeframes, upon which the plan is highly dependent
- Review the PRC Plan as soon as possible where there are indications of rehabilitation failure/s

10 MONITORING AND MAINTENANCE

10.1 Monitoring and Maintenance Program

A Rehabilitation Monitoring Program has been historically developed for the Project. The Program identifies and describes the monitoring systems that will be carried out to demonstrate how Project milestones will be achieved. Refer **Appendix F** for Rehabilitation Monitoring Program.

10.2 Monitoring Systems

The Rehabilitation Monitoring Program is utilised by Jubilee to monitor rehabilitation activities and outcomes over the life of the Project. The objective of the program is to evaluate the progress of rehabilitation towards fulfilling long term land use objectives and performance criteria as well as to implement adaptive management techniques that promote successful and timely interventions. The Rehabilitation Monitoring Program was prepared in accordance with EA Condition C2-2. As a minimum, the long-term monitoring will:

- Compare monitoring results against rehabilitation objectives and targets
- Identify possible trends and areas for improvement
- Assess and monitor stability of landscape in accordance with milestones
- Link to records of rehabilitation to determine causes and explain results
- Assess effectiveness of environmental controls implemented
- Where necessary, identify modifications required for the monitoring program, rehabilitation practices, or areas requiring research
- Compare flora species present against original seed mix and assess vegetation health
- Where applicable, assess native fauna species diversity and the effectiveness of habitat creation for target fauna species

10.2.1 Identification of Reference Sites

Reference/control sites have been identified in the Rehabilitation Monitoring Program in relation to stream sediment monitoring/the receiving water monitoring programme and vegetation monitoring (refer **Appendix F**).

10.2.2 Annual Returns and Auditing

The annual return will include an evaluation of the EA holder's rehabilitation activities against the PRC Plan schedule, including the effectiveness of environmental management carried out under the schedule, for the year to which the annual report relates. This includes reporting on whether rehabilitation and management milestones have been met, and whether conditions imposed on the PRC Plan schedule have been complied with.

In addition to annual reports, new legislation will require mandatory three yearly audits of the PRC Plan schedule to be provided to the Administering Authority within four months after the audit was carried out. As part of the adaptive management of rehabilitation at the Project, audit reports will also be used to assess performance and provide an early warning of necessary corrective actions and will be prepared by a person that meets the requirements under the relevant guideline approved by the chief executive.

11 REFERENCES

Aurion Gold 2022, *Croydon ML5248 Status Report*.

Barrick Gold of Australia 2011a, *Croydon Gold Mine – Post Mine Landuse Plan*, Barrick Australia.

Barrick Gold of Australia 2011b, *Croydon Gold Mine – Rehabilitation Monitoring Program*, Barrick Australia.

Barrick Gold of Australia 2016, *Croydon Gold Mine Annual Groundwater Monitoring Report 2016*, Barrick Australia.

Barrick Gold of Australia 2018, *Croydon Gold Mine – Water Management Strategy*, Barrick Australia.

BoM 2022, *Climate Statistics – Croydon Township*, viewed November 2022, http://www.bom.gov.au/climate/averages/tables/cw_029012.shtml.

CSIRO 2012, *Water Resource Assessment for the Carpentaria Region, A report to the Australian Government from the CSIRO Great Artesian Basin Water Resource Assessment*, 21 December 2012.

DE 2013, Matters *of National Environmental Significance Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999*, Department of the Environment, Australian Government, Canberra. Accessed at: https://www.dcceew.gov.au/sites/default/files/documents/nes-guidelines_1.pdf.

Doody, T.M., Hancock, P.J. and Pritchard, J.L. 2019, *Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems*, Report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment and Energy, Commonwealth of Australia 2019.

Eamus D., Froend R., Loomes R., Hose, G. and Murray, B. 2006, 'A functional methodology for determining the groundwater regime needed to maintain the health of groundwater-dependent vegetation', *Australian Journal of Botany*, 54: 91–114.

Engeny 2023, *Surface Water Impact Assessment* (Draft, Unpublished), Engeny, Brisbane.

Envirofin Consulting 2016, *Croydon Gold Mine – Environmental Compliance Audit Report ML5248.*

HLA-Envirosciences 2001, *Final Rehabilitation Report – Croydon Gold Mine*, HLA-Envirosciences.

RDM Hydro, Croydon Gold Project Groundwater Assessment (Draft, Unpublished), RDM Hydro, Brisbane.

RGS 2020, *Summary Report on the GoldSim ERC Modelling*, RGS Brisbane.

Richardson, S., Ervine, E., Froend R, Boon, P., Barber, S. and Bonneville, B., 2011, *Australian groundwater-dependent ecosystem toolbox part 1: Assessment framework, Waterlines Report*, National Water Commission, Canberra.

Wave 2022, Croydon Gold Project Definitive Feasibility Study (Unpublished), Wave International.

WetlandInfo - State of Queensland, 2020, *Queensland Springs Database*. Downloaded from QSpatial.

Wilson Minerals Pty Ltd 2018, *Croydon Gold Mine Water Management Strategy*, Wilson Minerals, Brisbane.

Woodward Clyde 1996, *Croydon Gold Mine (Amended) Decommissioning Plan for ML5248*, Woodward Clyde.

APPENDIX A PRC PLAN SCHEDULE

Post-mining land uses (PMLU)										
Rehabilitation area	RA1									
Relevant activities	Waste Rock Dumps (Content and Golden Butterfly)									
Total rehabilitation area size (ha)	21.5									
Commencement of first milestone: RM6	10/12/2023									
PMLU	Low Intensity Grazing / Disturbed Native Habitat									
Date area is available	10/12/23	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx
Cumulative area available (ha)	21.5									
Milestone completed by	10/12/33	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx
Milestone Reference	**Cumulative area achieved (ha)**									
RM6	21.5									

1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
2) Insert new columns to the blue table to match rehabilitation milestone dates.
3) Insert new rows to the blue table to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area	RA2									
Relevant activities	Hardstand Areas (Content and Golden Butterfly)									
Total rehabilitation area size (ha)	2.5									
Commencement of first milestone: RM5	10/12/2023									
PMLU	Low Intensity Grazing / Disturbed Native Habitat									
Date area is available	10/12/23	10/12/30	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx
Cumulative area available (ha)	2.5									
Milestone completed by	10/12/30	10/12/33	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx
Milestone Reference	**Cumulative area achieved (ha)**									
RM5	2.5									
RM6		2.5								

1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
2) Insert new columns to the blue table to match rehabilitation milestone dates.
3) Insert new rows to the blue table to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area	RA3									
Relevant activities	Sediment Dam									
Total rehabilitation area size (ha)	1.5									
Commencement of first milestone: RM5	10/12/2023									
PMLU	Low Intensity Grazing / Disturbed Native Habitat									
Date area is available	10/12/23	10/12/30	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx
Cumulative area available (ha)	1.5									
Milestone completed by	10/12/30	10/12/33	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx
Milestone Reference	**Cumulative area achieved (ha)**									
RM5	1.5									
RM6		1.5								

1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
2) Insert new columns to the blue table to match rehabilitation milestone dates.
3) Insert new rows to the blue table to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area	RA4									
Relevant activities	Roads/Tracks									
Total rehabilitation area size (ha)	3.5									
Commencement of first milestone: RM1	10/12/2040									
PMLU	Low Intensity Grazing / Disturbed Native Habitat									
Date area is available	10/12/40	10/12/43	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx
Cumulative area available (ha)	3.5									
Milestone completed by	10/12/43	10/12/48	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx
Milestone Reference	**Cumulative area achieved (ha)**									
RM1	3.5									
RM2	3.5									
RM3	3.5									
RM4	3.5									
RM5		3.5								

1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
2) Insert new columns to the blue table to match rehabilitation milestone dates.
3) Insert new rows to the blue table to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)											
Rehabilitation area				RA5							
Relevant activities				Laydown Areas							
Total rehabilitation area size (ha)				1.6							
Commencement of first milestone: RM2				10/12/2030							
PMLU				Low Intensity Grazing / Disturbed Native Habitat							
Date area is available	10/12/30	10/12/33	10/12/38	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	
Cumulative area available (ha)	1.6										
Milestone completed by	10/12/33	10/12/38	10/12/40	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	
Milestone Reference	**Cumulative area achieved (ha)**										
RM2	1.6										
RM3	1.6										
RM4	1.6										
RM5		1.6									
RM6			1.6								

1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
2) Insert new columns to the blue table to match rehabilitation milestone dates.
3) Insert new rows to the blue table to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area	RA6									
Relevant activities	Other Mining Disturbance									
Total rehabilitation area size (ha)	5.6									
Commencement of first milestone: RM1	10/12/2030									
PMLU	Low Intensity Grazing / Disturbed Native Habitat									
Date area is available	10/12/30	10/12/33	10/12/38	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx
Cumulative area available (ha)	5.6									
Milestone completed by	10/12/33	10/12/38	10/12/40	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx
Milestone Reference	**Cumulative area achieved (ha)**									
RM1	5.6									
RM2	5.6									
RM3	5.6									
RM4	5.6									
RM5		5.6								
RM6			5.6							

1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
2) Insert new columns to the blue table to match rehabilitation milestone dates.
3) Insert new rows to the blue table to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Non-use management area (NUMA)										
Improvement area	IA1									
Relevant activities	Open Pit/Pit Lake - Golden Butterfly Pit									
Total size (ha)	5.1									
Commencement of first milestone: MM1	10/12/2023									
NUMA	Pit Lake									
Date area is available	10/12/23	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx
Cumulative area available (ha)	5.1									
Milestone completed by	10/12/35	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx
Milestone Reference	**Cumulative area achieved (ha)**									
MM1	5.1									

1) Insert new columns to the yellow table to include further management milestone dates.
2) Insert new columns to the blue table to match management milestone dates.
3) Insert new rows to the blue table to include additional management milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. MM1).

Non-use management area (NUMA)										
Improvement area	IA2									
Relevant activities	Open Pit/Pit Lake - Golden Butterfly North Pit									
Total size (ha)	1.6									
Commencement of first milestone: MM1	10/12/2023									
NUMA	Pit Lake									
Date area is available	10/12/23	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx
Cumulative area available (ha)	1.6									
Milestone completed by	10/12/35	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx
Milestone Reference	**Cumulative area achieved (ha)**									
MM1	1.6									

1) Insert new columns to the yellow table to include further management milestone dates.
2) Insert new columns to the blue table to match management milestone dates.
3) Insert new rows to the blue table to include additional management milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. MM1).

Non-use management area (NUMA)										
Improvement area	IA3									
Relevant activities	Open Pit/Pit Lake - Content Pit									
Total size (ha)	2.1									
Commencement of first milestone: MM1	10/12/2023									
NUMA	Pit Lake									
Date area is available	10/12/23	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx
Cumulative area available (ha)	2.1									
Milestone completed by	10/12/35	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx
Milestone Reference	**Cumulative area achieved (ha)**									
MM1	2.1									

1) Insert new columns to the yellow table to include further management milestone dates.
2) Insert new columns to the blue table to match management milestone dates.
3) Insert new rows to the blue table to include additional management milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. MM1).

Non-use management area (NUMA)										
Improvement area	IA4									
Relevant activities	Open Pit/Pit Lake - Lady Isabella Pit									
Total size (ha)	1.7									
Commencement of first milestone: MM1	10/12/2023									
NUMA	Pit Lake									
Date area is available	10/12/23	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx	10/12/xxxx
Cumulative area available (ha)	1.7									
Milestone completed by	10/12/35	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx	xx/xx/xxxx
Milestone Reference	**Cumulative area achieved (ha)**									
MM1	1.7									

1) Insert new columns to the yellow table to include further management milestone dates.
2) Insert new columns to the blue table to match management milestone dates.
3) Insert new rows to the blue table to include additional management milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. MM1).

Milestone reference	Rehabilitation milestone	Milestone criteria
RM1	Landform reshaping/re-profiling	1. No observable subsidence, rock falls and/or slope slippage 2. Incidence of erosion (e.g. natural rates of erosion) 3. Geotechnical investigation to be completed by suitably qualified engineer
RM2	Surface preparation	1. Ripping undertaken and penetrates at least 300 mm into soil profile 2. Placement of subsoil 300 mm (minimum) across the rehabilitation area 3. Placement of topsoil 100 mm (minimum) across the rehabilitation area 4. Application of ameliorants on subsoil and/or topsoil if required
RM3	Revegetation	1. Revegetation campaign to seed target species at a rate of 10-15 kg/ha to establish a self sustaining natural vegetation cover 2. Timing of seeding (sowing), best undertaken in December/January to coincide with elevated levels of surface soil moisture 3. Seed to be sown at no more than 1 cm depth. Seeds to be raked in following seed broadcasting 4. Stock to be initially excluded from rehabilitation areas, with gradual controlled low intensity grazing of domesticated stock to be re-introduced 5. Firebreak maintained along edge of Mining Lease until rehabilitation complete
RM4	Achievement of surface requirements	1. Revegetation cover to exceed the 70th percentile among monitoring and control sites 2. Dry matter production is comparable to surrounding areas of the Project. Nutrient cycling is occurring and leaf litter is assisting in limiting erosion on the soil/spoil surface 3. Planting success for 60 percent strike rate and 70 percent uptake 4. Revegetation 80 percent comparable to surrounding regional ecosystems 5. Abundance of persistent weeds are a maximum 10 percent of ground cover 6. No exposed topsoil with less than 5 percent ground cover will remain without seeding, erosion and sediment control during the wet season 7. No active rill, gully or sheet erosion is visible within the rehabiliation area five years after commencing rehabilitation 8. Stocking rates maintain self sustaining vegetation
RM5	Achievement of post-mining land use to stable condition	1. Final landform is safe and geotechnically stable with certification from a suitably qualified engineer 2. Provision of a final rehabilitation report, including monitoring records 3. Grazing intensity managed to ensure sustainable grazing outcome 4. Surface water complies with the water quality criteria outlined in the EA 5. Groundwater complies with the groundwater criteria outlined in the EA
RM6	Investigation and/or remediation of contaminated land	1. Contaminated land investigation which outlines recommended actions completed by a suitably qualified person 2. Removal or onsite treatment of contaminated water (e.g. hydrocarbons, brine, metals etc.) per recommendations 3. Removal and appropriate disposal of any contaminated materials per recommendations 4. Onsite remediation of hydrocarbon contaminated soils per recommendations 5. Conduct validation testing to confirm that contaminated soils have been removed/remediated

1) Insert new rows below the table to record more Rehabilitation Area Milestones for the project
2) Ensure all Rehabiitation Milestones recorded in this table align with those included in the RA sheets in this form.
3) See the PRCP guideline before developing site-specific Rehabilitation Area Milestones

Milestone reference	Management milestone	Milestone criteria
MM1	Achievement of sufficient improvement	1. Certification by a suitably qualified person that pits will not cause environmental harm outside the Mining Lease boundary 2. Certification by a suitably qualified person that water quality in pits will not cause environmental harm to the surrounding environment 3. Certification by a suitably qualified person that pit areas are safe to humans and wildlife, with access restrictions in place

1) Insert new rows below the table to record more Improvement Area Milestones for the project
2) Ensure all Management Milestones recorded in this table align with those included in the IA sheets in this form.
3) See the PRCP guideline before developing site-specific Improvement Area Milestones

629000E
630000E
631000E
632000E
7990000N
7989000N
7988000N

1SP269692
755SP273179
952SP178689
8SY21
3CP895985
5SY12
34SP296957

Content Pit
Lady Isabella Pit
Golden Butterfly North Pit
Golden Butterfly Pit
Norman River
Croydon Gold Mine (ML 5248)

0 200 400 m
N
Scale: 1:12,500@ A3
Datum: GDA2020
Projection: MGA zone 54

Data Source:
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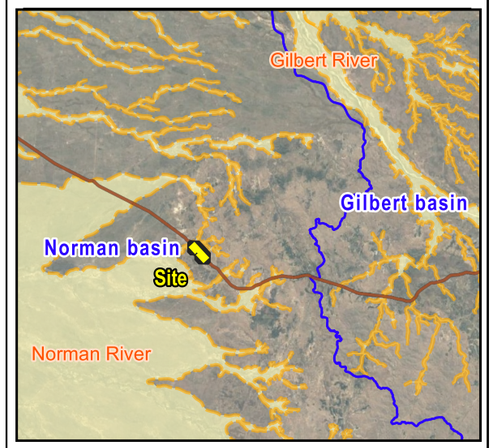

Legend

- Site boundary
- Cadastre (DCDB)
- Maximum disturbance area
- Roads and tracks
- State controlled roads

Post mining land use

- Low intensity grazing/Disturbed native habitat

Floodplain extent (QFAD) Level 1

- Rapid hazard assessment

Historical site infrastructure

- Pit
- Access track

Jubilee Metals
Progressive Rehabilitation and Closure Plan
Croydon Gold Mine

Figure 9
Final Site Design

629000E
630000E
631000E
632000E
7990000N
7989000N
7988000N

1SP269692
755SP273179
952SP178689
3CP895985
5SY12
8SY21
34SP296957

Access track (RA4)
Content Pit (IA3)
Sediment Dam (RA3)
Lady Isabella Pit (IA4)
Content Hardstand (RA2)
Laydown Area (RA5)
Content Waste Rock Dump (RA1)
Croydon Gold Mine (ML 5248)
Access track (RA4)
Golden Butterfly Waste Rock Dump (RA1)
Other Mining Disturbance (RA6)
Access track (RA4)
Golden Butterfly North Pit (IA2)
Laydown Area (RA5)
Golden Butterfly Hardstand (RA2)
Golden Butterfly Pit (IA1)

0 200 400 m
Scale: 1:12,500@ A3
Datum: GDA2020
Projection: MGA zone 54

N

Data Source:
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Legend

- Site boundary
- Cadastre (DCDB)
- Improvement areas
- Rehabilitation areas
- Roads and tracks
- State controlled roads
- Access track

Non use management area

- Pit

Post mining land use

- Low intensity grazing/Disturbed native habitat

Jubilee Metals
Progressive Rehabilitation and Closure Plan
Croydon Gold Mine

Figure 10
Reference Map

APPENDIX B ECOLOGICAL ASSESSMENT REPORT

Ecological Assessment Report

Jubilee Metals
Croydon Gold Mine
ML5248
BEC220011.01
16 December 2022

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1 INTRODUCTION

This report details terrestrial ecology values associated with the Croydon Gold Mine (the Project). The Project is located in north Queensland on the border of the Gulf Plains and Einasleigh Uplands Biogeographic Regions and is 154 km east of Normanton and 524 km west of Cairns, on land described as Mining Lease (ML) 5248. The Project lies within the Croydon Shire Local Government Area (LGA) (refer **Figure 1**).

The proponent, Jubilee Metals PLC (Jubilee), is intending to reinstate and expand historical gold mining operations in the Croydon area. The Project will involve the reactivation of an existing decommissioned open cut gold mine.

Ecological values identified in this report are based on desktop review of available information followed by site surveys to confirm the presence of vegetation communities, native flora and fauna species, and their habitats.

1.1 Scope of this report

Epic Environmental Pty Ltd (Epic) was engaged by Jubilee to complete a baseline assessment of the ecological values of the site and assess the significance of potential project impacts to Matters of National Environmental Significance (MNES) and Matters of State Environmental Significance (MSES) based on site assessments carried out by Epic personnel in 2020 and 2022. This report includes the results of both site assessments, identification of the site ecological values and an assessment of the significance of the project impacts on the identified values.

1.2 Project Description

Jubilee proposes to re-start mining and processing operations at Croydon Gold Mine within ML5248 (**Figure 1**). The proposed Project is currently understood to include the following works:

- Construction and operation of a processing facility
- Vertical and lateral mining at multiple pits:
  - Golden Butterfly North Pit
  - Golden Iguana Pit
  - Potentially Lady Isabella Pit.
- Redistribution of water between mining pits
- In-pit tailing storage facility at Content Pit and Lady Isabella Pit
- Tailings storage facility for use after the in-pit tailing options are fully utilised.

620000E
630000E
640000E
650000E
8000000N
7990000N
7980000N

Gulf Developmental Road
Tablelands System
Tabletop Road
Mine Access Road Golden Gate
Clothilda Road
Croydon Gold Mine
(ML 5248)
Croydon
Coralie Road
Moonlight Creek
Claraville Road
Mittagong Road
Alehvale Road
Gulf Developmental Road

0 2 4 km
N
Scale: 1:120,000@ A3
Datum: GDA2020
Projection: MGA zone 54

Data Source:
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© State of Queensland (Department of Transport and Main Roads) 2020
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Legend
- Site boundary
- Railways
- Roads and tracks
- State controlled roads
- Major watercourses

Jubilee Metals
Proposed Mine Tenements
Ecological Assessment Report
Croydon Gold Mine

Figure 1
Site overview

2 RELEVANT LEGISLATION

2.1 Commonwealth Legislation

2.1.1 Environment Protection and Biodiversity Conservation Act 1999

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the key piece of Commonwealth legislation governing environmental protection in Australia. Administered by the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW), the EPBC Act defines and protects nine Matters of National Environmental Significance (MNES) including:

- World heritage properties
- National heritage places
- Wetlands of international importance (listed under the Ramsar Convention)
- Listed threatened species and ecological communities
- Migratory species protected under international agreements
- Commonwealth marine areas
- The Great Barrier Reef Marine Park
- Nuclear actions (including uranium mines)
- A water resource in relation to coal seam gas development and large coal mining development.

Under Part 3 of the EPBC Act, a person must not undertake an action (e.g. a project, a development, an undertaking, an activity or a series of activities, or an alteration of any of these things) that will have, or is likely to have, a significant impact on a protected matter, without approval from the Minister. If after all reasonable avoidance and mitigation measure have been taken, there is still a residual impact on a protected matter, an offset may be required where the impact is, or is likely to be, significant.

2.1.2 EPBC Act Environmental Offsets Policy 2012

The EPBC Act Environmental Offsets Policy October 2012 (EOP) provides upfront guidance on the role of offsets in environmental impact assessments, and how the DCCEEW considers the suitability of a proposed offset. The EOP aims to improve environmental outcomes through the consistent application of best practice offset principles, provide more certainty and transparency, and encourage advanced planning of offsets.

2.2 Queensland State Legislation

2.2.1 Environmental Protection Act 1994 and Environmental Protection Regulation 2019 (EP Regulation)

The objective of the *Environmental Protection Act 1994* (EP Act) is to protect Queensland's environment and to promote ecologically sustainable development. The EP Act defines a General Environmental Duty under which all persons in Queensland have a responsibility to not carry out an activity that causes or is likely to cause environmental harm, and to take all reasonable and practicable measures to prevent or minimise the harm. The EP Act also regulates Environmentally Relevant Activities (ERAs). ERAs are activities that require an Environmental Authority (EA) prior to activities commencing. Resource activities (mining) are defined under the EP Act as a resource ERA for which an EA is required. Under the EP Act applications for an EA must consider and address impacts to mapped Category A, B or C Environmentally Sensitive Areas (ESA). Potential ESAs could include national parks, state forests, world heritage areas, Ramsar wetlands, nationally important wetlands, 'endangered' or 'of concern' REs and Essential Habitat. The objective of the Environmental Protection Regulation 2019 (EP Regulation) is to provide the basis for effective and efficient administration and enforcement of the provisions of the EP Act

Where activities involve tampering with 'animal breeding places', the tampering may be authorised by application to the Queensland Government Department of Environment and Science (DES) through an approved species management program.

2.2.2 Environmental Offsets Act 2014

The *Environmental Offsets Act 2014* (EO Act) is intended to counterbalance significant residual impacts of particular activities on prescribed environmental matters by way of environmental offsets. This is achieved primarily through establishment of a framework for environmental offsets, recognition of protection given to prescribed environmental matters under other legislation, provision for National, State and local matters of environmental significance to be prescribed environmental matters, and coordination of implementation of the framework in conjunction with other legislation.

2.2.3 Nature Conservation Act 1992

The *Nature Conservation Act 1992* (NC Act) regulates environmental impacts of development through the requirement for vegetation clearing permits, species management programs and other permits. A clearing permit is required to clear protected plants unless an exemption applies. In general, clearing of Critically Endangered, Endangered, Vulnerable or Near Threatened protected plants will require a clearing permit. Clearing permit applications are assessed on a case-by-case basis and approvals will be subject to conditions.

2.2.4 Vegetation Management Act 1999

The *Vegetation Management Act 1999* (VM Act) regulates clearing of vegetation in Queensland. The VM Act aims to conserve Queensland's biodiversity through vegetation management. The VM Act does not apply on mining leases and assessment of the application for the mining lease will assess the vegetation clearing activities required as part of mining activities at the site.

2.2.5 Biosecurity Act 2014

The *Biosecurity Act 2014* (Biosecurity Act) ensures a consistent, modern, risk-based and less prescriptive approach to biosecurity in Queensland. The Biosecurity Act provides comprehensive biosecurity measures to safeguard the economy, agricultural and tourism industries, environment, and way of life from pests, diseases, and contaminants. Decisions made under the Biosecurity Act will depend on the likelihood and consequences of risk, allowing for more appropriate management of risks.

Under the Biosecurity Act a person who has control over a 'Restricted Matter' must not do the following:

- Category 3: You must not distribute this restricted matter. This means it must not be given as a gift, sold, traded or released into the environment unless the distribution or disposal is authorised in a regulation or under a permit
- Category 4: You must not move this restricted matter to ensure that it does not spread into other areas of the state
- Category 5: You must not keep or be in possession or control of this restricted matter
- Category 6: You must not feed this category of restricted matter. Feeding for the purpose of preparing for or undertaking a control program is exempted.

The Proponent has a statutory duty of care 'general biosecurity obligation (GBO)' under the Biosecurity Act (s23). Under the GBO, the Proponent must:

- Take all reasonable and practical steps to prevent or minimise each biosecurity risk
- Minimise the likelihood of causing a 'biosecurity event', and limit the consequences if such an event is caused
- Prevent or minimise the harmful effects a risk could have, and not do anything that might make any harmful effects worse.

3 ASSESSMENT METHODS

3.1 Desktop assessment

Prior to commencing the field survey, desktop assessments were carried out to identify species and ecological communities of conservation significance (both MNES and MSES) that potentially occur within the Project area. Flora and fauna values of conservation significance in this report refer to:

- Flora and fauna species listed as Critically Endangered, Endangered or Vulnerable under the EPBC Act
- Flora and fauna species listed as Critically Endangered, Endangered, Vulnerable or Near Threatened under the NC Act
- Threatened Ecological Communities (TEC) listed under the EPBC Act
- Regional Ecosystems listed as Endangered or Of Concern under the VM Act
- Fauna species listed as Migratory under the EPBC Act due to their inclusion under one or more of the following:
    - Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)
    - China-Australia Migratory Bird Agreement (CAMBA)
    - Japan-Australia Migratory Bird Agreement (JAMBA)
    - Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

The desktop assessment also aimed to identify other environmental values relevant to the site including Environmentally Sensitive Areas (ESAs) and MSES.

3.1.1 Data sources

Flora and fauna records listed in publicly available databases and other resources were investigated to identify species that are likely to inhabit the site. These resources included:

- DCCEEW Protected Matters Search Tool (PMST) (records within a 10 km radius of the point -18.1848, 142.2326, located in the centre of the site) (DCCEEW 2022a)
- Queensland Government Wildlife Online (WildNet) database (records within a 50 km radius around the point -18.1848, 142.2326) (DES 2022a)
- Atlas of Living Australia (ALA), a web-based search tool that is a partnership between CSIRO, Australian museums, herbaria and other biological collections, and the Australian Government (ALA 2022)
- DES Matters of State Environmental Significance (MSES) mapping
- DES Map of Environmentally Sensitive Areas
- Department of Resources (DoR) Regulated Vegetation Management Map and Vegetation Management Supporting Map, including Regional Ecosystems (RE), essential habitat, watercourse and wetland mapping
- DES certified RE mapping (Version 12.2) (DES 2022b)
- The *Biodiversity Planning Assessment Gulf Plains Bioregion 1.1 Fauna Expert Panel Report* (DEHP 2015).

3.2 Nomenclature and Taxonomy

The common names of many flora and fauna species frequently vary between regions, and many species lack them altogether. Taxonomy of flora presented in this report follows that currently endorsed by the Queensland Herbarium in the Census of Queensland Flora 2021 (Queensland Herbarium 2021). The taxonomy of fauna follows the Australian Faunal Directory (ABRS 2022). In this report, flora and fauna species are referred to initially by both their common and scientific names and then for ease of reading, only by their common name (where the species has a common name).

3.3 Field assessment

3.3.1 Survey timing conditions

The flora and fauna surveys were conducted over two days on separate site visits: 18 November 2020 and 26 October 2022. In accordance with the *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland* (Eyre et al. 2022) surveys in the Einasleigh Uplands and Gulf Plains Bioregions should be carried out in late spring to summer (November - January). Both site visits were carried out in the late spring period.

The nearest weather station providing continuous temperature and rainfall data is the Georgetown Airport station (approximately 130 km to the east). On the day of the November 2020 survey temperatures ranged between 21.9 and 38.9°C. For the October 2022 survey, temperature ranged between 26.1 and 38.1°C (BoM 2022). No rainfall was recorded during either field survey.

3.3.2 Survey personnel

The flora survey was led by Senior Environmental Scientist Dr Oliver Robertson.

Dr Oliver Robertson

Oliver has a PhD in ecology and 14 years of experience in undertaking flora and fauna surveys across Queensland. Oliver has extensive experience in undertaking surveys for threatened species management plans and environmental monitoring programs pertaining to both flora and fauna in the terrestrial environment. He has carried out training in the assessment of Regional Ecosystems and BioCondition assessments. Oliver has been involved in environmental compliance assessments for a broad range of industries and government sectors including road and rail transport, energy, communications, and defence. He is familiar with environmental legislative requirements in Queensland and is also familiar with the nuances of the Biodiversity Conservation Act 2016 in New South Wales. Oliver is suitably qualified to conduct Protected Plants Flora Surveys in accordance with the *Flora Survey Guidelines - Protected Plants* (DES 2020).

The fauna survey was led by fauna ecologist Terry Reis.

Terry Reis

Terry has a Bachelor of Science in Australian Environmental Studies (Honours I) and has been a fauna ecologist for more than 20 years. He is skilled in the identification of mammals, birds, reptiles and frogs and has conducted fauna surveys in all of Queensland's 13 bioregions. His expertise includes baseline survey, habitat assessment and targeted survey for conservation significant species. He has extensive experience in impact assessment, environmental regulation, specialist ecological studies, technical review and project management and design. Terry has provided expert advice to a number of organisations/bodies including the Squatter Pigeon Recovery Team and Brigalow Belt Reptile Recovery Team (Commonwealth and Queensland Governments, respectively). Terry is on the Birds Queensland Records Appraisal Committee and assesses records of rare birds for the State.

3.3.3 Flora survey methods

The flora survey methodology was focused on the ground-truthing of mapped vegetation communities across the site. The entire Project area was not surveyed. Information collected at survey sites is considered representative of the wider area and extrapolated with the aid of aerial imagery and current mapping. This approach is considered suitable for landscape due to the limited variation in vegetation communities. A combination of Secondary and Quaternary RE sites were surveyed for the assessment of vegetation communities within the Project area. Secondary and quaternary sites were surveyed in accordance with the *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland V6.0* (Neldner et al. 2022).

3.3.3.1 Secondary sites

Secondary sites were used to identify REs with the quantification of vegetation community condition and floristic species composition. At a minimum the following data were recorded at each quaternary survey site:

- RE type
- Vegetation condition
- Dominant, co-dominant, sub-dominant and associated flora species, median height and cover for each strata level
- Ecologically dominant layer (EDL)
- Structural classification (Specht & Specht 2000) (i.e. grassland, open-woodland, woodland)
- Landform
- Soil type
- Weed species and density
- Disturbance.

3.3.3.2 Quaternary sites

Quaternary sites were used to ground-truth the extent, classification and condition of vegetation communities within the Project area. At each quaternary site the following data were recorded:

- RE type
- Condition (i.e. remnant, regrowth, non-remnant)
- Dominant flora species at each strata level
- EDL strata
- EDL cover and median height
- Structural classification (Specht & Specht 2000) (i.e. grassland, open-woodland, woodland).

3.3.3.3 Incidental records

Observations of novel flora species within the site were recorded. These observations were typically made during travel between RE survey sites. Particular attention was given to potential conservation significant flora species and Biosecurity matters.

3.3.4 Fauna survey methods

Based on the small extent of the site, prolonged history of disturbance on the mine site and perusal of photos of the site and aerial imagery showing vegetation and general habitat condition, trapping and extensive fauna survey techniques were not considered warranted for either site visit. The site visits largely relied on habitat assessment observations to identify the likelihood that habitats on site would support those conservation significant fauna species identified by the desktop assessment. Hence, survey techniques were limited to direct observation, identification by call and searching for tracks, scats and other signs. A limited amount of active searching was also conducted.

3.3.4.1 Habitat assessment

Fauna habitat assessments were completed across the site to ascertain the quality and availability of habitat, particularly for the potential presence of Gouldian Finch. Seventeen sites were selected during the fauna surveys and assessed for the following features:

- Ground cover
  - grass cover
  - bare ground
  - other cover
  - woody debris
  - surface rocks
- Presence of favoured annual and perennial grasses (e.g., *Alloteropsis semialata* and *Chrysopogon fallax*) (Dostine et al. 2001; Payne 2010).

- Presence of tree hollows
- Presence of weeds
- Nearby water source
- Soil type
- Presence of soil cracks
- Level of disturbance (i.e. cattle and fire).

3.3.4.2 Incidental records

Survey techniques consisted of direct observation, identification by call and searching for tracks, scats, and other signs. A limited amount of active searching was also conducted. Target taxa included diurnal birds, reptiles and mammals.

3.3.5 Permits and ethics approvals

The field survey was completed in accordance with the following Queensland Government permits and approvals:

- Scientific Use Registration Certificate (Department of Agriculture and Fisheries) – (Registration No. SUR001535)
- Research Permit (Department of Environment and Science) – (Permit No. WA0027840)
- Animal Ethics Approval (Department of Agriculture and Fisheries) – (Reference No. CA 2020/06/1377).

3.4 Likelihood of occurrence assessment

Following the field survey, a likelihood of occurrence assessment was carried out to categorise the potential for threatened flora and fauna to occur based on the habitat observed within the Project area and surrounds. The assessment provides the following criteria:

- Known to occur
  - Observed onsite during surveys
- Likely to occur
  - Observed close to site during surveys and suitable habitat occurs within site, or
  - Database records occurring close to site (within 5 km) and suitable habitat occurs within site
- Potential to occur
  - Database records occurring in wider area (>5 km and < 50 km) and suitable habitat occurs within site, or
  - Database records occurring close to site (within 5 km) and marginally suitable habitat occurs although remains relatively isolated (due to vegetation clearing)
- Unlikely to occur
  - No database records in wider area and/or
  - Habitat present is generally unsuitable and/or
  - Site generally outside of known distribution of species.

4 DESKTOP REVIEW RESULTS

4.1 Existing Environment

4.1.1 Bioregion

The site is located within the Gilberton Plateau biogeographic subregion of the Gulf Plains Bioregion (GPB). The GPB encompasses over 219,000 km^2 extending across a substantial area of north-west Queensland stretching from the south-east edge of Cape York Peninsula west to the border of the Northern Territory and stretching as far south as the McKinlay area. Away from the coastal areas of the Gulf of Carpentaria the vegetation features a mixture of monsoonal woodlands and predominantly treeless plains which are similar to the grasslands associated with the adjacent Mitchell Grass Downs bioregion. The site region features a monsoonal climate with the majority of rainfall occurring from December to March.

4.1.2 Mining tenure

The proposed mining area lies adjacent to the Gulf Development Road and immediately north-west of Croydon township. The site is subject to an existing EA (EPML00950913) over ML5248. The mine will occur entirely within the ML and no boundary changes are proposed. There are areas within ML5248 that are excluded from the approved mining tenement, this includes the railway line and a residential property.

4.1.3 Land use

4.1.3.1 Historic land use

Historic mining operations occurred within the mine site from the late 1880s for approximately 30 years and recommenced in 1987 to 1990. The mine site was decommissioned in 1993 and rehabilitated until 1997. Monitoring and maintenance activities have continued since mining activities ceased.

4.1.3.2 Existing land use

Mining related landforms that remain on ML5248 consist of open pits which now contain approved pit lakes, rehabilitated waste rock dumps and infrastructure areas such as roads and tracks, abandonment bunds, water management structures and rehabilitated hardstand areas. These are summarised as follows:

- Golden Iguana Pit (previously Golden Butterfly pit) (**Plate 1**)
- Golden Butterfly North Pit
- Golden Butterfly Waste Rock Dump (historically rehabilitated)
- Content Pit
- Content Waste Rock Dump (historically rehabilitated)
- Lady Isabella Pit
- Abandonment bunds across the four pits' access ramps
- Water diversion bunds and rehabilitated sediment dams adjacent to the Content and Golden Butterfly waste rock dumps
- Rehabilitated hardstand areas adjacent to Content and Golden Butterfly waste rock dumps
- Existing roads and tracks.

A water pump and tank are located in the southern area of the ML, which is operated by Croydon Shire Council. This tank supplies water to the town of Croydon as extracted from the Golden Butterfly North Pit. A condition of the ML is that Jubilee is not to affect the use of the water tank without first obtaining prior written permission.

The Golden Butterfly North Pit is also used by farmers for stock water purposes to support grazing on the adjoining Belmore Station. Recreational activities such as fishing and swimming also occur in this pit.

Some of the existing tracks within the ML form part of the Croydon Adventure Trails network used for mountain bike riding, trail running, bush walking and bird watching (Croydon Shire Council 2019).

The land uses surrounding the mine site include:

- Agricultural (grazing and stock watering)
- Rural residential
- Commercial.

Plate 1. Golden Iguana Pit

4.1.4 Topography, geology and soils

The landform of the site is described as gently undulating plains mostly comprised of poorly consolidated sediments and granitoids with a section of mudrock (refer to **Table 1**). Topography of the site ranges from 110 m Australian Height Datum (AHD) elevation in the north to 130 m AHD in the south of the ML (QG 2022).

Table 1. Surface geology

Rock unit name	Map symbol	Lithological summary	Dominant rock	Age
Claraville beds>Esmeralda Granite	Tpc>PLgee	Clayey quartzose sand and sandy mud; minor grave	Poorly consolidated sediments	Pliocene - pleistocene
Esmeralda Granite,TQr-QLD,Tf-Gt	PLgee,TQr,Tf	Very coarse to medium-grained (muscovite) biotite granite, porphyritic in part	Granitoid	Mesoproterozoic

4.1.5 Wetland and watercourse mapping

The proposed mining area is intersected by two streams (stream order 1), one in the northern extent and one in the southern extent close to the township of Croydon (**Figure 2**).

4.2 Matters of National Environmental Significance

The DCCEEW Protected Matters Report (PMR) identifies MNES protected under the EPBC Act considered as potentially occurring within the Project area and surrounds. The PMR identified two categories of MNES potentially present in the Project area or surrounds (as summarised in **Table 2**). A copy of the PMR is provided in **Appendix A**.

Table 2. EPBC Act PMR summary

MNES	PMR search result and relevance to Project
World heritage properties	Not applicable
National heritage places	Not applicable
Wetlands of International Importance	Not applicable
Great Barrier Reef Marine Park	Not applicable
Commonwealth Marine Area	Not applicable
Listed Threatened Ecological Communities	Not applicable
Listed threatened species:	Nine species listed threatened to be present (refer **Appendix A**)
Listed migratory species	Thirteen species listed as Migratory predicted to be present (refer **Appendix A**)

4.3 Matters of State Environmental Significance

The Queensland Government Environmental Reports Online portal identified two MSES as present within the Project area (refer to **Figure 2**):

- Regulated vegetation (remnant) located within a defined distance from the defining banks of a relevant watercourse identified on the VM Act watercourse and drainage feature map
- 8.98 ha of threatened (endangered or vulnerable) wildlife habitat occurs with the southern portion of the site in close vicinity to Croydon. The habitat appears based on a species record of Gouldian Finch (*Chloebia gouldiae*) although the record data is unavailable. The Gouldian Finch is listed as Endangered under both the NC Act and EPBC Act.

A copy of the MSES Report is provided in **Appendix A**.

4.4 Environmentally sensitive areas

Both category B and category C Environmentally Sensitive Areas (ESA) are mapped within the site including:

- Queensland Heritage Register Places (category B) - historical building in the north-west corner of the site and historic rail line along the south-west boundary of the site (**Figure 2**)
- Dams and Weirs (category C) – Golden Butterfly North pit.

4.5 Flora values

4.5.1 Regulated vegetation and Regional Ecosystems

Current regulated vegetation mapping for the site includes Category B (remnant), Category C (high-value regrowth), and Category X (non-remnant) areas (refer **Appendix A**). The extent of regulated vegetation category area is provided in **Table 4**.

Table 3. Extent of regulation vegetation types within the site

Regulated vegetation category	Area (ha)
B (remnant vegetation)	86.1
C (high-value regrowth)	10.0
X (non-remnant)	78.3

Current RE mapping for the site includes three mixed RE polygons comprised of five REs. A short description of each RE as well as Biodiversity status under the EP Act and class under the VM Act of each RE is provided in

Table 4. The extent of regulated vegetation and current RE mapping is illustrated in **Figure 2**. No endangered or of concern REs are mapped within the site.

Table 4. Description and extent of Regional Ecosystems mapped within the site

RE	Description[1]	EP Act (biodiversity) status	VM Act status
2.3.29	*Melaleuca viridiflora* +/- *M. citrolens, M. stenostachya* low woodland in depressions and broad valleys on solodised soils in the east	No concern at present	Least concern
2.5.9	*Eucalyptus microneura* woodland on plains and plateaus on earths, podsolics and skeletal soils	No concern at present	Least concern
2.5.19	*Eucalyptus tetrodonta, E. chartaboma, Erythrophleum chlorostachys, Corymbia pocillum* in mixed woodlands on sand sheets on Mesozoic sandstone plateaus	No concern at present	Least concern
2.7.2	*Acacia shirleyi, Eucalyptus shirleyi, Corymbia setosa* subsp. *pedicellaris* or *Melaleuca acacioides* woodland on low scarps on skeletal soils	No concern at present	Least concern
9.12.33	*Eucalyptus microneura* +/- *Corymbia pocillum* low open woodland on igneous rocks	No concern at present	Least concern

[1]Taken from REDD – Regional Ecosystem Description Database (V12.0) (Queensland Herbarium 2021)

4.5.2 Conservation significant flora

Review of the Queensland DES Protected Plants Survey Trigger mapping no area mapped as 'high-risk' for the presence of protected plants occurs within the Project area.

The PMR report predicted no threatened flora species listed as threatened under the EPBC Act occurring within or near the site. The Wildlife Online database search results identified one near-threatened flora species as previously recorded in the wider area:

- *Leptospermum pallidum* (Near Threatened – NC Act) – two records 26 km south-east of the site (ALA 2022).

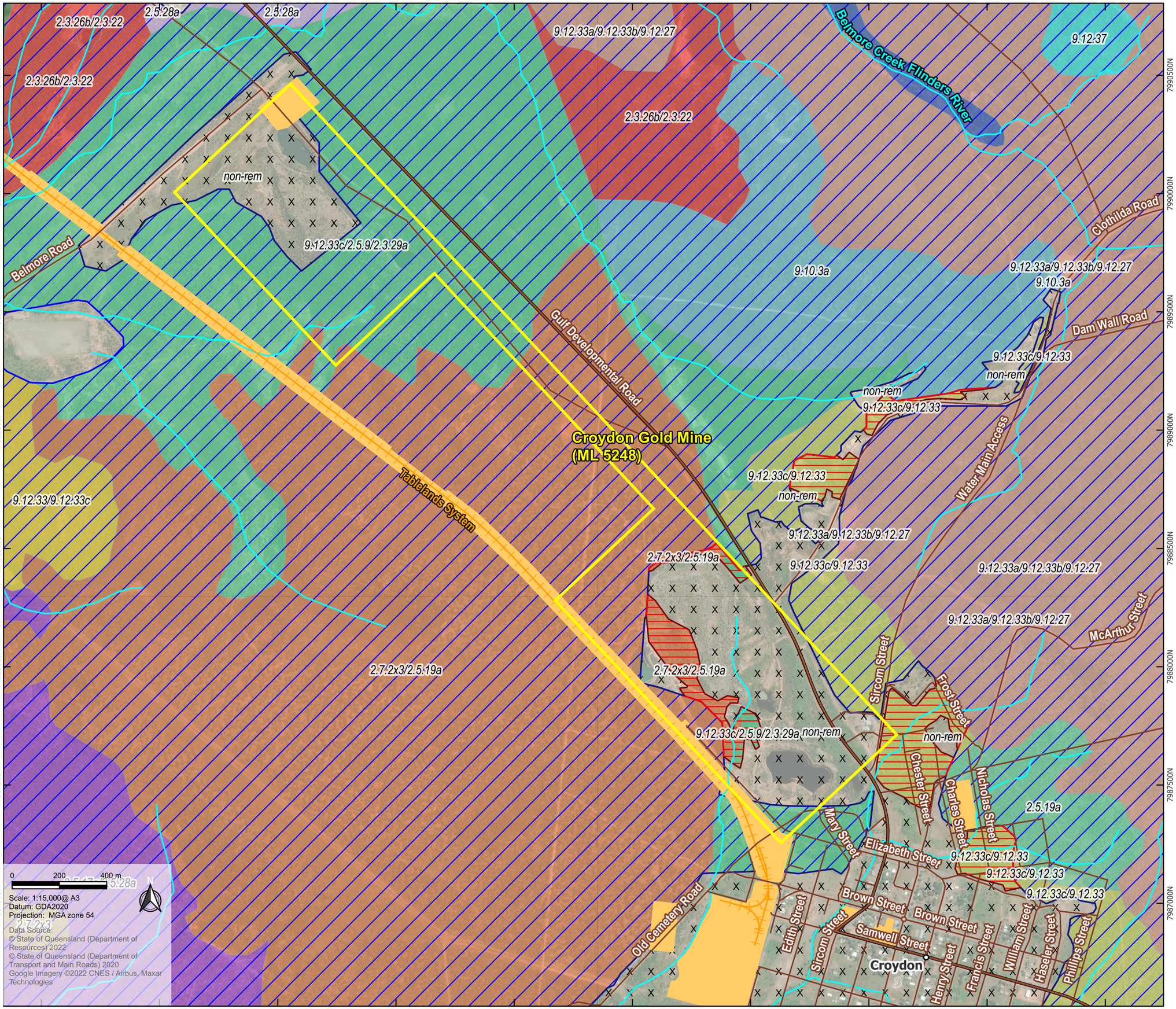
4.6 Fauna values

4.6.1 Conservation significant fauna

The desktop review identified 11 fauna species listed as threatened under the NC Act and/or EPBC Act, and a further 13 species listed as Migratory (under the EPBC Act) and Special Least Concern (under the NC Act) as potentially occurring within the wider area surrounding the site (refer **Appendix A** for database search results). The PMR report predicted the potential presence of nine fauna species listed as Vulnerable, Endangered or Critically Endangered under the EPBC Act. The Wildlife Online search results identified records of three threatened fauna species listed under both the NC Act and EPBC Act. The search also identified one species listed as Special Least Concern under the NC Act: Short-beaked echidna (*Tachyglossus aculeatus*).

Historical database records identify four threatened fauna species within 50 km of the site:

- Gouldian Finch (*Chloebia gouldiae*) (Endangered – NC Act and Endangered – EPBC Act) – three records to the east of the site, including one record 6 km from site (ALA 2022)
- Black-throated Finch (southern subspecies) (*Poephila cincta cincta*) (Endangered – NC Act and Endangered – EPBC Act) – two records from WildNet (WO 2022)
- Painted Honeyeater (*Grantiella picta*) (Vulnerable – NC Act and Vulnerable – EPBC Act) – one record from WildNet (WO 2022)
- Red Goshawk (*Erythrotriorchis radiatus*) (Endangered – NC Act and Vulnerable – EPBC Act) - the nearest record of the species is located 16 km east south-east of the site (ALA 2022).



epic ENVIRONMENTAL

Legend

- Site boundary
- Railways
- Roads and tracks
- State controlled roads

Environmentally Sensitive Area

- Queensland Heritage Register Place

Regional Ecosystems v12.02

- 2.3.26b/2.3.22
- 2.5.17a/2.5.28a
- 2.5.19a
- 2.5.28a
- 2.5.5a/2.5.14c/2.5.30/2.3.34c
- 2.7.2x3
- 2.7.2x3/2.5.19a
- 9.10.3a
- 9.12.33/9.12.33c
- 9.12.33a/9.12.33b/9.12.27
- 9.12.33c/2.5.9/2.3.29a
- 9.12.33c/9.12.33
- 9.12.37
- 9.3.13
- Non-remnant

Regulated Vegetation Management v6.0

- Category B
- Category C
- Category X

Watercourse (VM Act) v6.0

- Minor

Jubilee Metals
Proposed Mine Tenements
Ecological Assessment Report
Croydon Gold Mine

Figure 2
Regulated vegetation
and current RE mapping

Filepath: ...BAA\BAA220037.01 Jubilee Metals Croydon Gold Approvals\Workspaces\BEC220011.01 Ecology\Ecological Assessment Report\Croydon Gold Mine\Rev 0\Figure 2 Regulated vegetation and current RE mapping.qgz

5 FIELD ASSESSMENT RESULTS

5.1 Flora Survey Results

5.1.1 Flora species diversity

A total of 52 flora species were identified within the site across the two site surveys, including three non-native species. The flora assemblage is largely comprised of eucalypt canopy species, softwood scrub understorey trees, acacia shrubs and perennial tussock grasses. A full list of recorded flora species is provided in **Appendix B.**

5.1.2 Ground-truthed Regional Ecosystems

A total of 10 secondary RE assessments and two quaternary RE assessments were completed across the site (**Figure 3**). Ground-truthing of current RE mapping of the site confirmed the presence of three vegetation communities analogous to three RE types, water bodies, and non-remnant areas impacted by historical mining activities and vegetation clearing. The description, status and area of each RE is provided in **Table 5**, and the extent illustrated in **Figure 3**. Further detail regarding vegetation community floristic, structure and representative photos is provided in the following sections. Secondary and quaternary RE assessment data is provided in **Appendix C**.

Table 5. Ground-truthed REs

Vegetation community	RE	Regulated vegetation category	EP Act (biodiversity) status	Extent within site (ha)
Remnant woodland on Mesozoic sandstone plateaus	**2.5.19a**	B	No concern at present	23.6
	2.5.9			48.5
Remnant low open-woodland on granite hills	**9.12.33c**			3.4
Regrowth woodland on Mesozoic sandstone plateaus	**2.5.19a**	C		13.3
	2.5.9			11.3
Water	-	X	-	6.9
Non-remnant				67.4

5.1.2.1 Remnant woodland on Mesozoic sandstone plateaus

This vegetation community occurs on eroded sand sheets and is the most extensive, dominating the northern and central portions of the site (**Plate 2**). The structure of the community is variable, including woodland, open-woodland and low open-woodland. The community is co-dominated by Queensland Woollybutt (*Eucalyptus chartaboma*), Gilbert River Box (*Eucalyptus microneura*), Georgetown Bloodwood (*Corymbia pocillum*), and Cooktown Ironwood (*Erythrophleum chlorostachys*) with a median height range of 8.5-10.5 m and canopy cover range of 4-18%. A low sub-canopy was usually present and co-dominated by Gulbarn (*Melaleuca citrolens*), Gilbert River Box, Catkin Wattle (*Acacia julifera*), Townsville Wattle (*Acacia leptostachya*), Cooktown Ironwood, Georgetown Bloodwood, Yellow Berry Bush (*Denhamia cunninghamii*), and Breadfruit (*Gardenia vilhelmii*) with a height range of 3-7 m and canopy cover range of 5-29%. A sparse to mid-dense shrub layer was dominated by *Acacia* spp. including Catkin Wattle, Townsville Wattle and Silver-leaved Wattle (*Acacia holosericea*) with a height range of 0.6-5 m and a cover range of 1-35%. Ground cover was sparse to very-sparse and dominated by *Aristida* spp. including *Aristida dominii*, *Aristida superpendens* and *Aristida sciuroides*. Associated herbs included Spiny Sida (*Sida spicata*), Sacred Basil (*Ocimum tenuiflorum*) and *Triumfetta micracantha*. This vegetation community was subject to a moderate level of disturbance, largely due to historical mining activities.

Plate 2. Remnant woodland on Mesozoic sandstone plateau representative photo

5.1.2.2 Remnant low open-woodland on granite hills

This vegetation community occurs on shallow stony soils over granite hills in the southern portion of site (**Plate 3**). The structure of the community is described as low open-woodland. The community is co-dominated by Cooktown Ironwood with associated Georgetown Bloodwood with a median height of 6.5 m and canopy cover of 8%. A low sub-canopy of Cooktown Ironwood occurred with a height of 5 m and canopy cover of 5%. A sparse shrub layer was dominated by Hopbush (*Dodonaea physocarpa*) with a height of 1.8 m and a canopy cover of 15%. Ground cover was very sparse and dominated by *Aristida* spp. including *Aristida superpendens* and *Aristida sciuroides*. Associated herbs included Spiny Sida and *Triumfetta micracantha*. This vegetation community was subject to a relatively low level of disturbance.

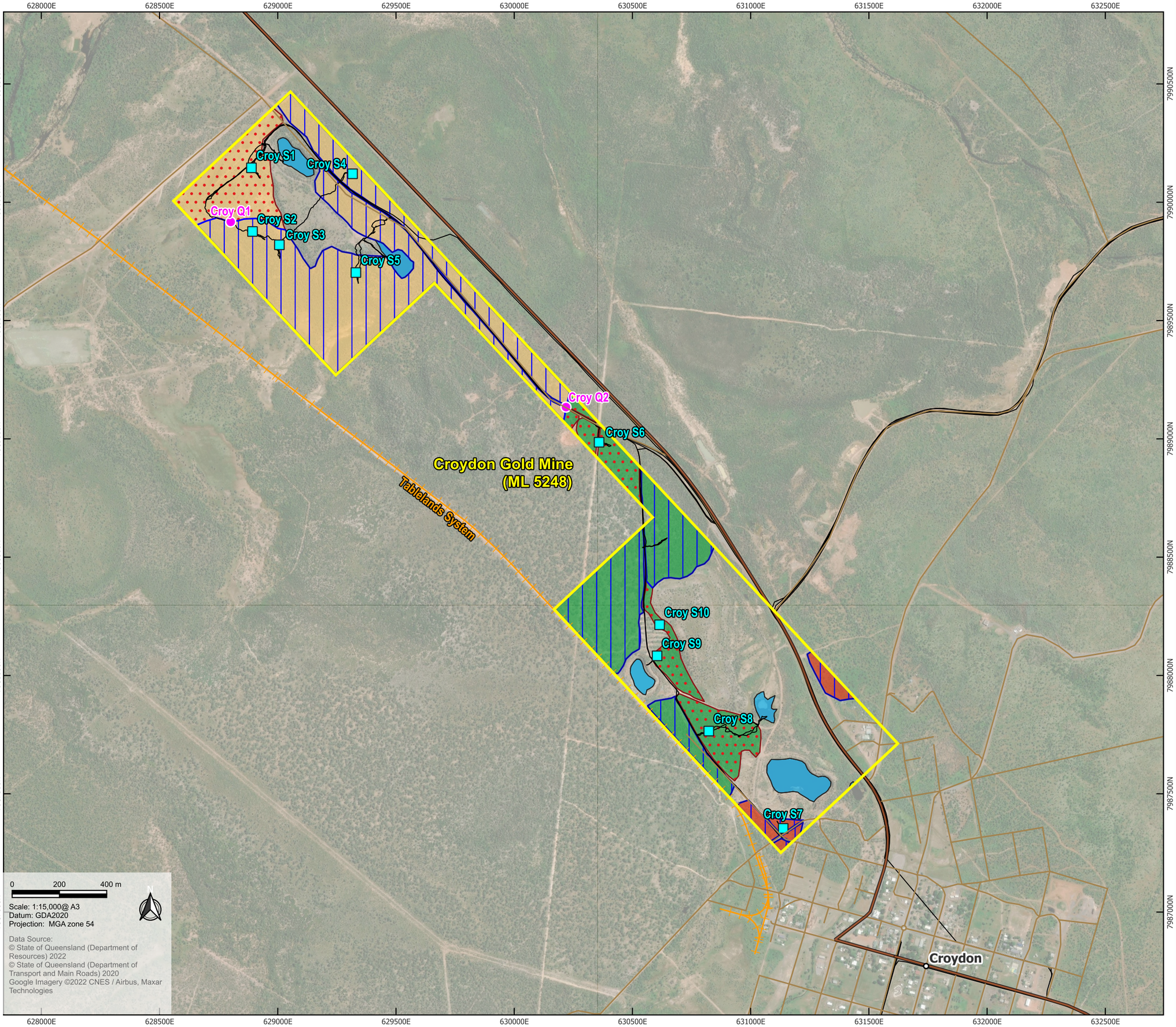
Plate 3. Remnant low open-woodland on granite hills

5.1.2.3 Regrowth woodland on Mesozoic sandstone plateaus

This vegetation community occurs on eroded sand sheets subject to historical tree clearing and mining activities in the south and far northern portion of the site (**Plate 4**). The structure of the community included woodland and low open-woodland. The community is co-dominated by Queensland Woollybutt, Georgetown Bloodwood, and Cooktown Ironwood with a median height range of 8-11 m and canopy cover range of 8-12%. A low sub-canopy was always present and co-dominated by Townsville Wattle (*Acacia leptostachya*), Cooktown Ironwood, and Smooth-leaved Quinine (*Petalostigma banksii*) with a height range of 5-6 m and canopy cover range of 5-15%. A sparse to very-sparse shrub layer was dominated by *Acacia* spp. including Catkin Wattle and Townsville Wattle with a height range of 1.5-1.9 m and a cover range of 4-10%. A very-sparse sub-shrub layer of *Tephrosia brachyodon* sometimes occurred. Ground cover was very sparse and dominated by *Aristida* spp. including *Aristida superpendens* and *Aristida sciuroides*. Associated herbs included Spiny Sida, Sacred Basil and *Triumfetta micracantha*. This vegetation community was subject to a very high level of disturbance, largely due to historical mining activities. More recent disturbance from exploratory drilling and bushfire is also evident (**Plate 5**).

Plate 4. Regrowth woodland on Mesozoic sandstone plateaus representative photo

Plate 5. Disturbance from historical and recent mining/exploration activities



epic ENVIRONMENTAL

Legend

- Site boundary
- Railways
- Roads and tracks
- State controlled roads
- Field tracks

Survey Site

- Secondary RE
- Quaternary RE

Ground-truthed Regional Ecosystems

- 2.5.19a
- 2.5.9
- 9.12.33c
- Water
- Non-remnant

Biodiversity Status

- Regrowth
- Remnant

Jubilee Metals
Proposed Mine Tenements
Ecological Assessment Report
Croydon Gold Mine

Figure 3
RE survey sites GTRE

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5.1.3 Threatened Ecological Communities

No TECs were recorded during the field assessment. None of the ground-truthed RE types are considered a component of any TEC.

5.1.4 Conservation significant flora species likelihood of occurrence assessment

No conservation significant flora species were identified during the field assessment. A single near-threatened (NC Act) flora species, *Leptospermum pallidum*, is considered a potential occurrence within the site (**Table 6**).

Near-threatened species are not MSES and threatened flora species are considered unlikely to occur within the site and are not considered further in this report.

Table 6. Likelihood of occurrence assessment of conservation significant flora species

Species	Status		Habitat and distribution	Likelihood of occurrence
	EPBC Act status	NC Act status		
Leptospermum pallidum	-	NT	Rocky slopes and cliff edges near Greenvale and Porcupine Gorge (Bean 1992).	**Potential**. Suitable habitat in the form of rocky slopes (RE 2.12.33c) occurs within the site. The nearest record of the species is located 26 km east south-east of the site (ALA 2022). The species was not observed within the sites during the field surveys.

5.1.5 Weed species

A total of three non-native flora species, were identified within the site (refer **Appendix B**):

- Neem Tree (*Azadirachta indica*)
- Purple Pigeon Grass (*Setaria surgens*)
- Hyptis (*Hyptis suaveolens*).

These species are not listed as restricted matters under the Queensland Biosecurity Act.

5.2 Fauna Survey Results

5.2.1 Fauna species diversity

The fauna surveys across the 2020 and 2022 site visits recorded a total of 55 native fauna species. The native fauna assemblage comprised two amphibians, one reptile, 50 bird and two mammal species (refer **Appendix D**).

5.2.2 Conservation significant fauna species

No conservation significant fauna species were identified within the site during the surveys. The surveys were both conducted in late spring, whilst the Painted Honeyeater is only likely to occur during the winter months as a non-breeding migrant. The species may still occur at the site.

5.2.3 Pest fauna

The field survey recorded three non-native fauna species listed as restricted under the *Biosecurity Act 2014*:

- Domestic Dog (*Canis familiaris*)
- Pig (*Sus scrofa*)
- Cane Toad (*Rhinella marina*).

5.2.4 Fauna habitat values

A total of 17 habitat assessment were completed across the site (**Figure 4**). Habitat assessment was primarily focussed on the two potential species: Gouldian Finch and Painted Honeyeater.

5.2.4.1 Gouldian Finch

At the time of the survey water was pooling in several areas of the study site and the pits from historical mining activities were partially full. Cattle disturbance was mostly low except for two survey sites where the disturbance was considered moderate. Small and medium sized hollows were recorded exclusively in stags and deadwood with one large hollow recorded. These hollows were all deemed to be unsuitable for Gouldian Finch breeding based on the known habitat/breeding hollow requirements for the species (i.e. small horizontal hollows in live timber). In addition, no grass species known to be preferred forage species for Gouldian Finch were observed within the site at the time of the survey and grass cover in general was relatively poor.

5.2.4.2 Painted Honeyeater

The presence of Flat-leaved Mistletoe (*Lysiana spathulata* subsp. *spathulata*) was recorded at two habitat assessment locations within the site. Mistletoe was recorded within regrowth RE 2.5.19a and remnant RE 2.5.9. Mistletoes are known and preferred foraging habitat for Painted Honeyeater. The species may utilise the habitat to forage during the non-breeding winter months. Ground-truthed RE polygons with mistletoe records were categorised as suitable habitat for the Painted Honeyeater. Ground-truthed RE polygons of the same RE type with no habitat assessment sites were also categorised as suitable habitat for Painted Honeyeater. The estimated extent of potential habitat for Painted Honeyeater within the site is 57.16 ha and illustrated in **Figure 4**. This is likely to be an overestimation of the actual extent of potential habitat present as mistletoes are unlikely to be present through the entirety of the mapped area.

5.2.5 Conservation significant fauna species likelihood of occurrence assessment

The likelihood of occurrence of threatened and migratory fauna species identified in the desktop assessment was assessed based on the known distribution and habitat requirements of the species, and the results of the fauna survey habitat assessments (**Table 7**).

5.2.5.1 Threatened fauna

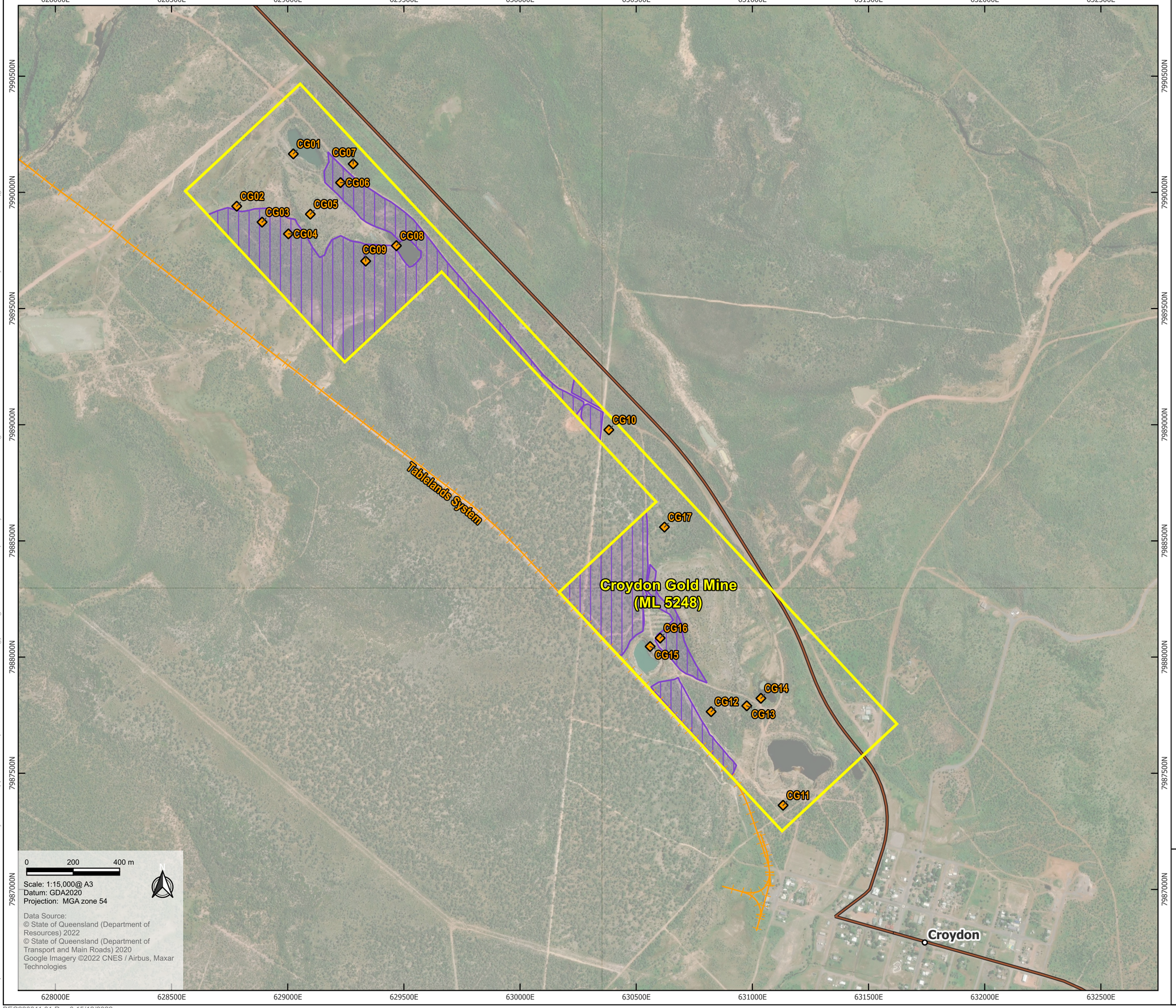
The likelihood of occurrence assessment of threatened fauna determined that a single species could possibly occur within the site (**Table 7**):

- Painted Honeyeater.

The remaining threatened fauna species area considered unlikely to occur within the sites and are not considered further in this report.

5.2.5.2 Migratory fauna

The likelihood of occurrence assessment of migratory fauna determined that no migratory species could possibly occur within the site (**Table 8**). All migratory fauna species area considered unlikely to occur within the site and are not considered further in this report.



epic ENVIRONMENTAL

Legend

- Site boundary
- Railways
- State controlled roads

Survey site

- Painted Honeyeater habitat
- Habitat assessment

Jubilee Metals
Proposed Mine Tenements
Ecological Assessment Report
Croydon Gold Mine

Figure 4
Habitat assessment sites and Painted Honeyeater suitable habitat

Filepath: -BAAIBAA220037.01 Jubilee Metals Croydon Gold Approvals\Workspaces\BEC220011.01 Ecology\Ecological Assessment Report\Croydon Gold Mine\Rev 0\Figure 4 Habitat assessment sites and Painted Honeyeater suitable habitat.qgz

Table 7. Likelihood of occurrence of threatened fauna species

Species	Status		Habitat and distribution	Likelihood of occurrence
	EPBC Act	NC Act		
Curlew Sandpiper (*Calidris ferruginea)*	CE, M	CE	The species migrates to coastal regions of Australia with scattered location inland (DE 2015a). This species usually forages and roosts in intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms (DE 2015a).	**Unlikely**. Suitable habitat for the species does not occur within the site. Waterbodies within mining pits area not suitable for the species. The nearest record of the species is located 120 km east of the site (ALA 2022).
Red Goshawk (*Erythrotriorchis radiatus*)	V	E	Sparsely dispersed across 15% of coastal and sub-coastal Australia, from the Kimberley in Western Australia to north-eastern New South Wales (DCCEEW 2022b). Also recorded along major rivers in central Australia, most likely to be transient birds (DCCEEW 2022b). Recent records in Queensland suggest that both southern and northern Queensland birds are in existing national parks or state forests with a strongholds in north-east Queensland and eastern Cape York Peninsula (DERM 2012). The species prefers landscapes containing a mosaic of habitats including coastal and sub-coastal tall open forest, woodland and rainforest edges. Forests of intermediate density are particularly favoured, as are ecotones between variably dense habitats. Habitat utilisation is influenced by the location of large populations of birds (primary prey). It is rarely encountered over agricultural land as it avoids open habitats. Nesting occurs in tall trees within 1 km of permanent water, generally in open, biologically rich forest or woodland (TSSC 2015).	**Unlikely**. Suitable habitat for the species does not occur within the site. No large watercourses intersect the site. The nearest record of the species is located 16 km east south-east of the site (ALA 2022).
Gouldian Finch (*Chloebia gouldiae*)	E	E	Habitat is usually open woodlands dominated by Eucalyptus trees with ground cover of Sorghum (*Sarga* spp.), *Schizachyrium* spp. and spinifex (*Triodia* spp.), and usually within 2-4 km of perennial waterholes or springs. Known breeding habitat are areas with the favoured grass species, a nearby water source and unburnt hollow bearing trees (*Eucalyptus brevifolia* or *E. tintinnans*) located in rocky hills. The species was formerly widespread throughout tropical Queensland but recently recorded from only a few sites around the Atherton Tablelands and Gregory Range, and in far western Queensland (TSSC 2016).	**Unlikely**. Suitable tree hollows for breeding were not observed within the site. Wet season foraging habitat was also not observed, with preferred grasses (i.e. *Chrysopogon fallax*, *Alloteropsis semialata,* Sorghum or *Schizachyrium* spp) not detected within the site. There are a number of likely older Australian Museum records located 6 km east of the site. There are no collections dates associated with the records and there is a 10 km uncertainty placed on the record location (i.e. the actual location of the

Species	Status		Habitat and distribution	Likelihood of occurrence
	EPBC Act	NC Act		
				records may not be as indicated) (ALA 2022). The nearest recent record is from 2022 and located 115 km east south-east of the site. Pools of surface water within the site may support occasional vagrant birds but the site is very unlikely to support a local population.
Grey Falcon (*Falco hypoleucos*)	V	V	The Grey Falcon is poorly known and is considered to be Australia's rarest falcon and rarest Falco species in the world (Schoenjahn 2013). Resident or nomadic visitor to inland parts of all mainland states. Also recorded from most of Australia except Cape York Peninsula and South-east Queensland Mainly occurs where annual rainfall is <500 mm (Garnett et al. 2011). Can occur in the Murray-Darling Basin, Lake Eyre Basin, and central Australia. The species is confined to the arid and semi-arid area, habitat is generally timbered lowland plains that are crossed by tree-lined watercourses, and adjacent treeless areas, grasslands (including spinifex and tussock) and open woodlands that are used for foraging (Garnett et al. 2011) (Olsen and Olsen 1986). This species lays eggs in the nests of other birds, particularly corvids, preferring high elevation such as tall trees along watercourses and telecommunication towers (Garnet et al. 2021).	**Unlikely**. Suitable habitat for the species does not occur within the site, although marginal foraging habitat does occur in the form of open woodland. The nearest record of the species is located 101 km north-east of the site (ALA 2022).
Australian Painted Snipe (*Rostratula australis*)	E	E	This species occurs in all states of Australia but is most common in eastern Australia. Well-known from the Murray-Darling basin. Other sightings include the Channel Country and the Fitzroy basin, and recently from the floodwater plains of coastal central and north Qld. Suspected to be regular migrants to coastal floodwater plains, in autumn and winter (DEECCW 2022b). Generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. The species has been recorded to utilise areas lined with trees, or that have some scattered fallen or washed-up timber. Breeding occurs in shallow wetlands with areas of bare wet mud and both upper and canopy cover nearby, typically from or near small islands in fresh water wetlands (DEECCW 2022b).	**Unlikely**. Suitable habitat for the species does not occur within the site. The nearest record of the species is located 116 km east south-east of the site (ALA 2022).

Species	Status		Habitat and distribution	Likelihood of occurrence
	EPBC Act	NC Act		
Masked Owl (Northern) (*Tyto novaehollandiae kimberli*)	V	V	The species typically inhabits coastal and upland areas. Sclerophyll forest and woodland, often near ecotones with open areas, such as grassland, heath or canefields, and typically grassy or with a mosaic of sparse and dense ground-cover (Debus 2012). Occurs from Townsville north and west, possibly inland to the Barkly Tableland in NT (Woinarski & Ward 2007). Distribution mapping by the Queensland Government (Butler & Laidlaw 2012) shows all Queensland records of this subspecies to be coastal or subcoastal, and restricted to the Townsville area and further north around Cairns.	**Unlikely**. Suitable habitat for the species does not occur within the site. The nearest record of the species is a record from 2018 from Rungulla National Park (located 160 km south-east). The veracity of this record cannot be verified. All other records are over 300 km east of the site (ALA 2022). The site is beyond the known distribution of the subspecies.
Painted Honeyeater (*Grantiella picta*)	V	V	Sparsely distributed from south-eastern Australia to north-western Queensland and eastern Northern Territory (Garnett & Crowley 2000). The greatest concentrations of the bird and almost all breeding occurs on the inland slopes of the Great Dividing Range in NSW, Victoria and southern Queensland (DCCEEW 2022b). The species forages on mistletoes in eucalypt forests/woodlands, riparian woodlands of black box and river red gum, box-ironbark-yellow gum woodlands, *Acacia* dominated woodlands, paperbarks, *Casuarinas*, *Callitris*, and trees on farmland or gardens. The species prefers woodlands which contain a higher number of mature trees, as these host more mistletoes (DE 2015b).	**Possible**. Suitable non-breeding habitat for the species does occur within the site, with mistletoes observed at moderate density at some locations within the site. The nearest record of the species is from 2018 and located 51 km south-east of the site (ALA 2022). Although there are nearby records the site is on the northern edge of the species range of occurrence.
Black-throated Finch (White-rumped subspecies) *Poephila cincta cincta*	E	E	The species prefers grassy, open woodlands and forests, dominated by *Eucalyptus, Corymbia* or *Melaleuca*. Tussocks grasslands and freshwater wetlands also provide occasional habitat. The species is typically observed in riparian habitats or near water. The subspecies is currently only locally common in Queensland at sites near Townsville and Charters Towers, with records scattered throughout the Brigalow Belt North and Desert Uplands bioregions (BTFRT 2007).	**Unlikely.** The site is well beyond the current known distribution of the species as mapped by DCCEEW (2022b). There are two records of the subspecies identified in the Wildnet desktop search. The records are unverifiable and likely to be of the northern subspecies (*Poephila cincta atropygialis*).
Ghost Bat (*Macroderma gigas*)	V	E	The species occurs across a range of habitats, from arid Pilbara to tropical savanna woodlands and rainforests. During the daytime they roost in caves, rock crevices and old mines. Roost sites used permanently are generally deep natural caves or disused mines with a relatively stable temperature of 23°–28°C and a moderate to high relative humidity of 50–100 percent. The average foraging distance is approximately 2 km from the daytime roost (DCCEEW 2022b).	**Unlikely**. Suitable roosting habitat for the species does not occur within or near the site. Historical mining pits within the sites are too shallow and old mine shafts were collapsed and not suitable for roosting. The nearest record of the species is located 218 km east of the site (ALA 2022).

Species	Status		Habitat and distribution	Likelihood of occurrence
	EPBC Act	NC Act		
Bare-rumped Sheath-tailed Bat (*Saccolaimus saccolaimus nudicluniatus*)	V	E	Confined to coastal strip within 40 km of the ocean (DCCEEW 2022b). Occurs mostly in lowland areas, typically in a range of woodland, forest and open environments (Schulz & Thomson 2007; Reardon et al. 2010; Dennis 2012). Habitat adjacent to roosts include: Poplar Gum (*Eucalyptus platyphylla*), Carbeen (*E. tessellaris*) and Ghost Gum (*E. papuana*) woodlands at Ayr; Darwin Stringybark woodland (*E. tetrodonta*) with Clarkson's Bloodwood (*Corymbia clarksoniana*) and Carbeen, and gallery forest and rainforest at Iron Range; and at riverine vine forest with adjacent open forest/woodland at Coen (Compton & Johnson 1983; Murphy 2002; and Schulz & Thomson 2007). The Bare-rumped Sheathtail Bat has been suggested to forage over habitat edges such as the edges of rainforest and forest clearings (Churchill 1998).	**Unlikely**. Suitable habitat for the species does occur within the site, although the site is beyond the known distribution of the species. The nearest record of the species is located 397 km east of the site (ALA 2022).
Freshwater Sawfish (*Pristis pristis*)	V	-	Suitable habitat for the species includes creeks, rivers, inshore and offshore marine waters. The species is confined to coastal and sub-coastal regions between the Fitzroy River (Western Australia) and western Cape York (Queensland) (DCCEEW 2022b).	**Unlikely**. Suitable habitat for the species does not occur within the site. No connected aquatic environments occur within the site. The nearest record of the species is located 122 km north north-west of the site (ALA 2022).

Table 8. Migratory fauna likelihood of occurrence assessment

Species	Status		Habitat and distribution	Likelihood of occurrence
	EPBC Act	NC Act		
Oriental Cuckoo (*Cuculus optatus*)	M	SLC	Inhabits monsoon forest, rainforest edges, leafy trees in paddocks, river flats, roadsides, mangroves, islands (Pizzey & Knight 2012). The species is a regular nonbreeding migrant to coastal northern and eastern Australia. The Gulf of Carpentaria and Cape York Peninsula to the QLD-NSW border, including inland areas of eastern Queensland.	**Unlikely**. Suitable habitat for the species does not occur within the site. The nearest record of the species is located 105 km north-west of the site (ALA 2022).
Barn Swallow (*Hirundo rustica*)	M	SLC	Open country in coastal lowlands, often near water, towns and cities and also freshwater wetlands, paperbark Melaleuca woodland, mesophyll shrub thickets and tussock grassland (DE 2015c). This species usually occurs in northern Australia, from the Pilbara across the top end, to Fraser Island in Queensland, including offshore islands (Higgins et al. 2006)	**Unlikely**. Suitable habitat for the species does not occur within the site. The nearest record of the species is located 167 km north-west of the site (ALA 2022).
Grey Wagtail (*Motacilla cinerea*)	M	SLC	Near running water in disused quarries, sandy and rocky streams in escarpments and rainforests, sewage ponds, ploughed fields, airfields. Summer visitor mostly to northern Australia. Recorded in the Cairns/Townsville Region, and near Coen in Cape York Peninsula (Pizzey & Knight 2012).	**Unlikely**. Suitable habitat for the species does not occur within the site. The nearest record of the species is located 354 km west north-west of the site (ALA 2022).
Yellow Wagtail (*Motacilla flava*)	M	SLC	The species typically inhabits short grass and bare ground; swamp margins, sewage ponds, saltmarshes, playing fields, airfields, ploughed land and town lawns. The species is regularly recorded as a summer migrant to coastal northern Australia (Pizzey & Knight 2012). Eastern populations of the species mainly migrate to South Asia with some moving to Africa (BirdLife International 2019). The species is irregularly recorded as a summer migrant mainly to coastal northern Australia (Pizzey & Knight 2012).	**Unlikely**. Suitable habitat for the species does not occur within the site. The nearest record of the species is located 166 km north-west of the site (ALA 2022).
Common Sandpiper (*Actitis hypoleucos*)	M	SLC	The species has been recorded from a wide range of wetland habitats, of varying levels of salinity. The species typically forages in shallow water and on bare soft mud at the edges of wetlands (Geering et al. 2007; Higgins & Davies 1996). The Common Sandpiper is found along all coastlines of Australia, including several areas inland, but is concentrated to northern and western Australia (Blakers et al. 1984; Higgins & Davies 1996). In Queensland, areas of national importance occur in south-eastern Gulf of Carpentaria, and the Cairns foreshore (Watkins 1993). The south-eastern Gulf of Carpentaria is also a site of international importance (Bamford et al. 2008).	**Unlikely**. Suitable habitat for the species does not occur within the site. The nearest record of the species is located 118 km east of the site. The water filled pits are steep sided and do not provide muddy foraging substrate for the species (ALA 2022).

Species	Status		Habitat and distribution	Likelihood of occurrence
	EPBC Act	NC Act		
Sharp-tailed Sandpiper (*Calidris acuminata*)	M	SLC	Suitable habitat for the species includes muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation, lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, saltpans and hypersaline salt lakes inland (Higgins & Davies 1996). The species can also occur in flooded paddocks, sedgelands and ephemeral wetlands during wet conditions. Suitable marine habitats for the species include intertidal mudflats, inlets, estuaries or seashores, swamps and creeks lined with mangroves (Higgins & Davies 1996). The species is widespread along the coast of Queensland and very sparsely scattered inland, particularly in central and south-western regions (Higgins & Davies 1996). There are 39 international important sites across Australia, including four in Queensland at South-east Gulf of Carpentaria, Lake Machattie, Lake Yamma Yamma, and Lake Numalla (Bamford et al. 2008).	**Unlikely**. Suitable habitat for the species does not occur within the site. The nearest record of the species is located 3 km north-east of the site (ALA 2022). The water filled pits are steep sided and do not provide muddy foraging substrate for the species.
Pectoral Sandpiper (*Calidris melanotos*)	M	SLC	Typical habitat for the species comprises shallow fresh to saline wetlands, including coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands (Higgins & Davies 1996). The species is usually found in coastal or near coastal habitat but occasionally further inland. Also recorded in swamp overgrown with lignum. In Queensland, most records for the Pectoral Sandpiper occur around Cairns. There are scattered records elsewhere, mainly from east of the Great Divide between Townsville and Yeppoon. Records also exist in the south-east of the state as well as a few inland records at Mount Isa, Longreach and Oakey (Higgins & Davies 1996).	**Unlikely**. Suitable habitat for the species does not occur within the site. The nearest record of the species is located 116 km east of the site (ALA 2022). The water filled pits are steep sided and do not provide muddy foraging substrate for the species.
Oriental Plover (*Charadrius veredus*)	M	SLC	Oriental Plover is a non-breeding visitor and birds arrive in Queensland from the Northern hemisphere in September, with numbers increasing into December. Once in Australia the species is dispersive, responding to weather conditions. Oriental Plovers occur mostly on open grasslands in arid and semi-arid areas. The species prefers flat inland plains, sparsely vegetated with short grass. It also occurs on claypans, sporting fields, lawns, around the margins of terrestrial wetlands and in woodland and heathland that has been recently burnt (Lane 1987; Marchant & Higgins 1993).	**Unlikely**. Suitable habitat for the species does not occur within the site. The nearest record of the species is located 113 km south-west of the site (ALA 2022).
Latham's Snipe (*Gallinago hardwickii*)	M	SLC	In Australia the species typically occurs in permanent and ephemeral wetlands up to 2000 m above sea-level (Chapman 1969; Naarding 1981). They usually inhabit open, freshwater wetlands with low, dense vegetation (e.g. swamps,	**Unlikely**. Suitable habitat for the species does not occur within the site. The nearest record of the

Species	Status		Habitat and distribution	Likelihood of occurrence
	EPBC Act	NC Act		
			flooded grasslands or heathlands, around bogs and other water bodies) (Frith et al. 1977; Naarding 1983). However, they can also occur in habitats with saline or brackish water, in modified or artificial habitats, and in habitats located close to humans or human activity (Frith et al. 1977; Naarding 1983). Various other freshwater habitats can be used including bogs, waterholes, billabongs, lagoons, lakes, creek or river margins, river pools and floodplains (Frith et al. 1977; Naarding 1981, 1983). Known from all east coast areas. Extends inland over the eastern tablelands in south-eastern Queensland (and occasionally from Rockhampton in the north), and to west of the Great Dividing Range in New South Wales (Frith et al. 1977; Blakers et al. 1984; and Barrett et al. 2003). Occasionally recorded in south-western Queensland.	species is located 82 km east south-east of the site (ALA 2022). The water filled pits are steep sided and do not provide muddy foraging substrate for the species.
Oriental Pratincole (*Glareola maldivarum*)	M	SLC	Inhabits open plains, floodplains or short grassland (including farmland or airstrips), often with extensive bare areas. Often occur near terrestrial wetlands, such as billabongs, lakes or creeks, and artificial wetlands such as reservoirs, saltworks and sewage farms, especially around the margins. Also occurs along the coast, inhabiting beaches, mudflats and islands, or around coastal lagoons (DCCEEW 2022b).Widespread in northern Australia. Also widespread, but scattered inland, mostly north of 20°S. Karumba Plains, in Qld, is a nationally important site. When in Australia, Oriental Pratincoles are apparently dispersive and irruptive, with thousands of birds suddenly appearing, coinciding with arrival of thundery or cyclonic storms that may cause a dramatic increase in the number of insects, and leaving soon after (DCCEEW 2022b).	**Unlikely**. Suitable habitat for the species does not occur within the site. The nearest record of the species is located 82 km east south-east of the site (ALA 2022).
Osprey (*Pandion haliaetus*)	M	SLC	The species inhabits littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore (DCCEEW 2022b). The species has been recorded within a variety of wetland habitats including swamps and marshes; margins of rivers and lakes; damp or flooded grasslands, pastures or agricultural lands; reservoirs; sewage treatment ponds; drainage channels; salt pans and salt lakes; salt marshes; estuarine mudflats, tidal streams; mangrove swamps; coastal lagoons; and offshore reefs (DCCEEW 2022b). Occurs and breeds along all coastal areas of Qld. Occasionally travel inland along major rivers, particularly in northern Australia.Can occur in central Australia between May and December during years of average or above-average rainfall, when fish are abundant in inland waterways (DCCEEW 2022b).	**Unlikely**. Suitable habitat for the species does not occur within the site. The nearest record of the species is located 112 km north north-west of the site (ALA 2022).

6 POTENTIAL PROJECT IMPACTS AND MITIGATION RECOMMENDATIONS

6.1 Clearing of vegetation

Mining activities have potential to directly and indirectly impact a range of ecological values within the site, including vegetation communities and habitat for threatened flora and fauna. The clearing of vegetation for mining activities and associated infrastructure is the most significant and direct impact on the ecological values of the site. Land clearance is a key threatening process. Removal of habitat reduces the size of local populations of flora and fauna dependent on that habitat. These impacts are immediate and significant in the short-term and may have long-term effects.

For the purpose of this assessment, it has assumed that all areas within ML5248, with the exception of existing pits, will be subject to vegetation clearing for Project infrastructure (such as laydowns, administration buildings, car parking). In reality, this will not be the case and the impact of clearing will be much less than described. **Table 9** provides the proposed extent of vegetation clearing based on ground-truthed RE mapping.

Table 9. Extent of ground-truthed RE impacted by the proposed disturbance footprint

RE	Regulated vegetation category	Biodiversity Status (EP Act)	Potential impact area (ha)
2.5.19a	B	No concern at present	23.6
2.5.9			48.5
9.12.33c			3.4
2.5.19a	C		13.3
2.5.9			11.3

6.1.1 Threatened species habitat

6.1.1.1 Painted Honeyeater

The Project will result in the loss of a maximum of 57.16 ha of potential habitat for the Painted Honeyeater. The extent of Painted Honeyeater habitat loss is illustrated in **Figure 4**. Suitable woodland foraging habitat is provided by the presence of mistletoes, which are the primary food source for the species. Although Flat-leaved Mistletoe plants are present they are distributed unevenly across the site and absent from some areas of woodland, rendering them unsuitable as Painted Honeyeater habitat. The proposed impact area is therefore a conservative figure and very likely an overestimate of the potential habitat present. The species is a non-breeding migrant to the region, with sporadic occurrences during winter.

The impacts of vegetation clearing to Painted Honeyeater habitat will include permanent and temporary impacts (refer **Table 9**). The impacts of vegetation clearing for mining infrastructure and activities are likely to be permanent, whilst the impacts of vegetation clearing for temporary construction areas such as lay downs and camps will be temporary with the potential for rehabilitation (refer **Section 6.9**).

6.2 Habitat fragmentation

Highly fragmented habitats support fewer species than connected blocks of habitat of the same size. This is because fragmentation restricts dispersal of fauna and plant seeds between available habitat patches. The impacts of habitat fragmentation depend on the degree to which dispersal is inhibited by habitat gaps, the size of the remaining habitat fragments, and ecological attributes of the species. Considering the low, open structure of the vegetation communities associated with the surrounding landscape, the proposed Project activities are considered to have a minimal impact on reducing terrestrial habitat connectivity. The site is surrounded by extensive tracts of remnant vegetation. Moderate fragmentation of woodland habitat within the site has already occurred as a result of historical mining activities.

6.3 Direct mortality

Clearing of vegetation for the Project presents a risk of direct mortality or injury to fauna. Fauna of low mobility are at risk of injury or death from operation of heavy machinery for vegetation clearing and the construction of levees and other infrastructure. Educating employees and contractors with regards to fauna and flora may aid in reducing direct mortality as part of the project.

6.4 Dust

Earthworks and vehicular traffic associated with construction and mining activities can generate substantial amounts of dust during dry weather. The pronounced wet and dry seasons in northern Australia may make vegetation in these areas less susceptible to the impacts of dust. This is because most or all annual growth occurs during a period of the year when rainfall is highest. This coincides with the time of year when dust is least problematic, as rain inhibits the dispersal of dust in the air, and washes dust from leaves. Earthworks and vegetation removal will be limited to a short time frame so land will only be exposed to significant levels of dust for a short period. Dust can affect vegetation by covering surfaces and affecting photosynthesis, respiration and transpiration, resulting in injury and decreased productivity (Farmer 1993). Dust has also been known to provide adsorption surfaces for volatile contaminants that are subsequently deposited either by dry or wet deposition, causing respiratory ailments in animals and humans. Microclimatic changes such as these can affect areas great distances from roads, changing the vegetation composition (Coffin 2007).

6.5 Altered fire regimes

Most Australian vegetation types experience regular fires, and fire is important for maintaining structural attributes of vegetation, as well as facilitating seed germination of certain species (Catling et al. 2001). Fires of inappropriate intensity or timing can have detrimental impacts on native flora and fauna by:

- removing fallen timber and low vegetation used as shelter
- reducing the density or extent of fire-sensitive flora
- temporarily removing seeds, insects and other foods used by fauna
- leading to vegetation ‘thickening’, the unnatural increase in midstorey vegetation cover in response to infrequent fires, which results in a decrease in understorey density and diversity
- causing direct mortality to slow-moving fauna.

Open grassy woodlands in northern Australia are prone to bushfire and typically respond to fire with an increase in biodiversity. Extensive evidence of recent bushfire was observed across the site during the field survey. Eucalypt trees in recently burnt areas with coppice regrowth were also observed. The absence of fire in these ecosystems can lead to encroachment by woody shrubs and the loss of tussock grasses. It is assumed the Project will apply fire management measures (e.g. fuel load reduction) which may result in an alteration of the current fire regime for the site.

6.6 Surface water extraction and contaminants

Providing the design and operation of the Project and associated infrastructure and appropriate chemical/fuel storage facilities are undertaken in accordance with relevant legislation and standards, no impact from contaminants is anticipated.

Water for mine use will be extracted from the existing Golden Butterfly pit, which is an artificial impoundment. Project activities will also include the redistribution of water between mining pits which will be subject to natural seasonal recharge in the wet season. Golden Iguana pit and Lady Isabella pit are also artificial impoundments. As such, water balance modelling indicates most of the Project water needs will be met through onsite water management. There is potential for access to a local water bore field where a shortfall occurs. Impacts from surface water extraction are expected to be minimal.

6.7 Weeds and pest animals

One weed species and three species of feral animal were recorded in the site. The following activities have the potential to promote the proliferation of weeds and pests within the site, or introduce new weeds and pests from surrounding areas:

- increased vehicular traffic may introduce and spread weed seeds
- land clearance favours the establishment of weeds due to increased light and soil disturbance.

Weeds are uncommon in the region and no restricted flora species were observed within the site. The Project is not expected to increase the threat of weeds and pests in the area.

6.8 Summary of impacts

The primary ecological impact of the Project will be the clearing of remnant woodland vegetation. The Project has been assumed to result in the loss of 75.5 ha of remnant woodland and 24.6 ha of regrowth woodland, including 57.16 ha of potential Painted Honeyeater habitat. However, it is noted this is likely a substantial over-estimate of the actual clearing impact. The site area does not support any threatened plant species (MNES or MSES) or TECs. The ecological impacts of edge effects, habitat fragmentation, dust, altered fire regime, disturbance to plant species and cumulative impacts are expected to be negligible.

6.9 Recommended mitigation measures

6.9.1 Avoidance

Jubilee will commit to a range of measures to minimise impacts to the ecological values associated with the site. In the first instance, the detailed design process will aim to reduce the vegetation clearing footprint as much as is feasible and minimise impact to areas representing habitat for threatened species for the construction of infrastructure, stockpiles, and laydown areas. Where avoidance is not possible, a range of mitigation strategies will be implemented under an overarching Environmental Management Plan (EMP) covering construction and operational activities.

The EMP and relevant sub-plans will comprise a range of measures that will mitigate potential impacts to ecological values as outlined in **Table 10**.

6.9.2 Mitigation measures

Recommended mitigation strategies to reduce impacts to ecological values are presented in **Table 10**.

Table 10. Mitigation measures

Management Measure		Timing
Clearing of vegetation		
1	Where possible the overall construction footprint will be refined and minimised further during the final design process	Final design
2	Jubilee will develop an EMP prior to the commencement of construction. Vegetation clearing protocols will be established within both plans and will include the following mitigations measures at a minimum.	Pre-construction
3	Employees and contractors will be made aware of environmental obligations and compliance requirements through the site induction program.	Site induction
4	Vegetation clearing extents will be clearly demarcated with flagging or bunting prior to clearing to limit the area safely and reasonably required for permanent and temporary works	Prior to clearing
5	Targeted pre-clearance surveys will be carried out prior to vegetation clearing and will incorporate searches for protected plants and threatened fauna. Pre-clearance surveys will be carried out by suitably qualified ecologists prior to vegetation clearing.	Prior to clearing
6	A Site Environmental Officer (or similar) will be present during clearing and monitor vegetation clearing extents to ensure clearing does not extend beyond demarcated area and complies with the EMP.	During clearing

Management Measure		Timing
7	Revegetation and restoration will occur on areas no longer required for project activities (e.g. laydowns, tracks).	Ongoing
Direct mortality		
1	The Site Environmental Officer (or similar) will inspect sites prior to vegetation clearing and will be present to rescue fauna during vegetation clearing.	Prior to and during clearing
2	A fauna register will record all fauna encountered during clearing works including fauna incidents (injuries and mortality).	Pre-construction
3	Onsite speed limits will be established throughout the construction/operation areas to limit the potential for fauna mortality.	Ongoing
Species of National / State Significance		
1	Inductions will outline species of significance that may occur for personnel and contractors.	Induction
2	The Site Environmental Officer (or similar) will inspect sites prior to vegetation clearing (for the potential presence of threatened flora and fauna species) and will be present to rescue fauna during vegetation clearing.	Prior to and during clearing
3	Employees will be required to notify the Site Environmental Officer when a potential species of significance is observed. All encounters with a threatened species will be recorded in a fauna register.	Ongoing
Noise and lighting		
1	The pre-construction planning process will incorporate components (mechanical) and design elements to reduce construction noise that has potential to impact adjacent fauna habitat.	Pre-construction
2	The pre-construction planning process will incorporate the use of low light spill lighting components and directional lighting (away from adjacent fauna habitat and riparian areas) where night lighting is considered necessary.	Pre-construction
3	All construction machinery will be maintained as per manufacturer design specifications to ensure noise is minimised.	Ongoing
4	Onsite speed limits will be established to limit noise levels as a result of vehicle movements.	Ongoing
Dust		
1	The pre-construction planning process will incorporate design elements to reduce dust generating activities.	Pre-construction
2	Monitoring of air/dust emissions will be carried out in accordance with regulatory requirements, as required.	Pre-construction and ongoing
3	Dust from areas likely to be a source of airborne dust (such as tracks and stockpiles) will be suppressed using water trucks/wetting to keep dust related impacts to a minimum.	Ongoing
4	Monitoring of weather conditions will be carried out to inform construction activities and planning during high-wind weather conditions.	Ongoing
5	Ensure employees are made aware of potential dust generating activities and appropriate mitigation and management measures.	Ongoing
6	Onsite speed limits will be established to minimise dust caused by vehicle movements.	Ongoing
7	Areas subject to vegetation clearing and no longer required for construction will be subject to vegetation reinstatement as soon as is practicable as per the rehabilitation requirements.	Ongoing
Altered fire regimes		
1	Appropriate fire prevention regimes will require onsite staff to be vigilant of the potential for fire. Fire awareness training will be included during the site induction process.	Induction / ongoing
2	Monitoring of weather conditions will be carried out to inform construction activities and planning during high fire-risk weather conditions.	Ongoing
3	Jubilee will maintain communications with local representatives for the Queensland Fire and Emergency Services (QFES) regarding construction and mining activities and bushfire hazard conditions.	Ongoing

Management Measure		Timing
4	Appropriate fire breaks will be maintained around infrastructure.	Ongoing
5	Site will include designated smoking areas.	Ongoing
6	Onsite fire-fighting equipment will be regularly maintained, and staff training will be developed and implemented.	Ongoing
Waste		
1	General waste will be recycled where possible.	Ongoing
2	General waste will be disposed of appropriately. Waste tracking certificates should be kept and maintained as part of this process.	Ongoing
Weeds and Pest Animals		
1	A Weed and Pest Management Plan will be in place prior to construction works being carried out. The Plan will detail all required management measures and monitoring procedures.	Pre-construction
2	Vehicle wash-downs will be required for all new vehicles (including earthmoving and other construction machinery) entering the construction area.	Ongoing
3	Disposal and storage of putrescible wastes must be undertaken appropriately to ensure feral animals are not attracted to the construction area.	Ongoing
4	Storage of construction/operation materials to be carried out in a manner so as to not encourage the establishment of resident pest fauna.	Ongoing
5	Domestic animals, including pets, are not allowed onsite.	Ongoing
6	Regular monitoring of weed and pest occurrence in association with works areas.	Ongoing
Water Management		
1	An Erosion and Sediment Control Plan (ESCP) will be developed and implemented prior to construction commencing. The ESCP will be developed by a Certified Professional in Erosion and Sediment Control and be in accordance with the International Erosion Control Association Best Practice Erosion and Sediment Control (2008).	Pre-construction
2	Applicable materials/chemicals will be stored and handled in accordance with relevant legislative requirements and Australian Standards including: AS 3780:2008 – The storage and handling of corrosive substances AS 1940:2004 – The storage and handling of flammable and combustible liquids AS 3833:2007 – Storage and handling of mixed classes of dangerous goods in packaged and intermediate bulk containers.	Ongoing
3	All storage of chemicals and vehicle/machinery refuelling associated with construction works will be stored a minimum of 50 m from the nearest watercourse or wetland (including mine pits).	Ongoing
4	Spill response equipment (e.g. booms and absorbent materials) will be available at refuelling areas and other sites (where relevant). Staff will be trained in the appropriate use of spill response equipment.	Ongoing
5	Onsite washdown areas for vehicles/machinery will be located and clearly demarcated to prevent contaminated run-off from entering waterways and downstream marine waters.	Ongoing

7 SIGNIFICANT IMPACT ASSESSMENT

7.1 MNES

The EPBC Act defines and protects nine matters considered to be of MNES. Under Part 3 of the EPBC Act, a person must not undertake an action that will have, or is likely to have, a significant impact on a protected matter, without approval from the Minister. An assessment of the potential for significant impacts (SI) resulting from the Project activities was carried out on MNES considered as known, likely or possible occurrences within the Project area. The SI assessments have been carried out in accordance with the *MNES significant impact guidelines 1.1* (MNES Guidelines) (DE 2013).

The major impact on MNES species will likely occur during vegetation clearing for construction of the Project. Indirect impacts to threatened species and their habitats, particularly following the completion of construction, are expected to be minor at worst and manageable following the implementation of detailed mitigation measures (refer **Section 6.9**).

The only MNES considered a possible occurrence within the site is the Painted Honeyeater. An SI assessment for the Painted Honeyeater is provided in the following section.

7.1.1 Painted Honeyeater - significant impact assessment

Painted Honeyeater occurs from south-eastern Australia to north-western Queensland and the eastern Northern Territory (Higgins et al. 2001). Almost all breeding records and the greatest concentrations of individuals occur south of 26ºS, i.e. south of the Roma area in southern Queensland (Higgins et al. 2001; Barrett et al. 2003). Breeding and north-south movements are closely aligned with fruiting mistletoes (Barea & Watson 2007). Diet consists primarily of mistletoe fruit (mostly Amyema species), Painted Honeyeater being the most specialised of Australia's honeyeaters (Garnett et al. 2011). However, in the absence of mistletoe fruit, nectar and insects are regularly taken (Higgins et al. *2001*, Oliver et al. 2003). Painted Honeyeater is highly mobile and thinly spread over large areas (Watson 2012).

Painted Honeyeater occurs mainly in dry open woodlands and forests with a strong association with mistletoe (Higgins et al. 2001). The species prefers woodlands with many mature trees, as these host more mistletoes (Oliver et al. 2003). Woodlands dominated by acacias (e.g. *Acacia harpophylla*, *A. pendula*, *A. aneura*) are particularly favoured, but the species also occurs in Casuarina cristata, Allocasuarina luehmannii, Callitris glaucophylla and riparian woodland of Eucalyptus camaldulensis (Barea & Watson 2007; Garnett et al. 2011; Watson 2012). They also occur on plains with scattered eucalypts and in remnant trees on farmland (Higgins et al. 2001; Oliver et al. 2003) and in narrow linear strips such as roadsides (Bowen et al. 2009), where mistletoes can be abundant due to increases water as run-off from roads (Norton et al. 1995).

7.1.1.1 Relevance to the site

The species was not recorded during surveys of the site in 2020 or 2022. There are scattered records to the east of the site between Croydon and Georgetown. The nearest of these is a 2018 record from Littleton National Park and located 51 km from the site. Mapping of the species distribution indicates the site is on the far northern edge of its potential range of occurrence being located north of lands in which the 'species may occur' (CA 2021).

The presence of Flat-leaved Mistletoe was recorded at two habitat assessment locations within the site. The estimated extent of potential habitat for Painted Honeyeater within the site is 57.16 ha and illustrated in **Figure 4**. This is likely to be an overestimation of the actual extent of potential habitat present as mistletoes are unlikely to be present through the entirety of the mapped area.

7.1.1.2 Important populations and critical habitat

The species is seasonally nomadic and is considered to occur as a single sparely distributed population (Garnett et al. 2011). As such, an important population of the species cannot be attributed to the site.

The *National recovery plan for the Painted Honeyeater* Grantiella picta (CA 2021) describes the following habitats as critical habitats for Painted Honeyeater:

- Known or likely breeding habitats on the inland slopes of Great Dividing Range in New South Wales, Victoria and southern Queensland – not applicable to the site
- All preferred foraging species within known and likely foraging habitat particularly mistletoes of the genus *Amyema* growing on forest and woodland eucalypts and acacias – the site is located to the north of the species mapped area of occurrence and is not known or likely to occur
- All Key Biodiversity Areas with Painted Honeyeater identified as a trigger species – in Queensland the only area identified is Boodjamulla National Park which is over 350 km west of the site

The potential impacts on Painted Honeyeater were assessed against the significant impact criteria for Vulnerable species in the MNES Guidelines and the results shown below in **Table 11**. It has been assumed that all suitable Painted Honeyeater habitat within the site will be impacted by the Project.

The Project is considered unlikely to result in a significant impact on Painted Honeyeater. Given there is unlikely to be significant impact on the Painted Honeyeater and that there are no other identified MNES, there is no need to refer this Project under the EPBC Act.

Table 11. Significant impact criteria (Vulnerable species) – Painted Honeyeater

Criterion	Response
Lead to a long-term decrease in the size of an important population of a species	The site is on the northern edge of the species potential occurrence. The site provides seasonal non-breeding foraging habitat for the species. The species is considered a possible occurrence within the site, however an important population of the species will not occur. The nearest record of the species is located 51 km south-east of the site (ALA 2022). The Project is assumed to result in the loss of up to 57.16 ha of potential habitat for the species, although this is likely an overestimate. There is abundant similar extant habitat in the region surrounding the site which will not be impacted. The Project will not lead to a long term decrease in the size of an important population of Painted Honeyeater.
Reduce the area of occupancy of an important population	The site provides seasonal non-breeding foraging habitat for the species. The species is considered a possible occurrence within the site, however an important population will not occur. The nearest record of the species is located 51 km south-east of the site (ALA 2022). The Project is expected to result in the loss of 57.16 ha of suitable habitat for the species. The Project will not reduce the area of occupancy of an important population of Painted Honeyeater.
Fragment an existing important population into two or more populations	The site provides seasonal non-breeding foraging habitat for the species. The species is considered a possible occurrence within the site, however an important population will not occur. The species is nomadic and is thinly distributed across a large area. The nearest record of the species is located 51 km south-east of the site (ALA 2022). The Painted Honeyeater is a highly mobile species. The Project will not fragment an existing important population of Painted Honeyeater into two or more populations
Adversely affect habitat critical to the survival of a species	The site does not provide critical habitat for Painted Honeyeater. The nearest record of the species is located 51 km south-east of the site (ALA 2022). Extensive areas of low open-woodland surround the site. The project will not adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population	The site does not provide breeding habitat for the species and the species is not known to breed in the region. The species is considered a possible occurrence within the site, however an important population will not occur. The Project will not disrupt the breeding cycle of an important population of Painted Honeyeater.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The site provides seasonal non-breeding foraging habitat for the species. The Project is predicted to result in the loss of 57.16 ha of suitable habitat for the species, although this very likely an overestimation. The extent of habitat loss is considered insufficient to cause the species to decline. There is abundant similar habitat in the surrounding region which will remain intact. The Project is considered unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Criterion	Response
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	The species is threatened by habitat degradation from grazing by European Rabbits (*Oryctolagus cuniculus*), and predation by invasive species (e.g. Black Rats (*Rattus rattus*)) (DCCEEW 2022b). The site is beyond the known distribution of rabbits and Black Rats are likely to already occur due to the proximity of the site to the urban area associated with Croydon. The threat of invasive species will be mitigated with implementation of a Weed and Pest Management Plan. The Project is unlikely to result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable Painted Honeyeater habitat.
Introduce disease that may cause the species to decline	Mitigation measures during construction activities (i.e. through measures in the EMP) will assist in preventing the introduction and dispersal of infected material from vehicles prior to entering the proposed disturbance area. The Project is unlikely to introduce any disease that may cause the species to decline.
Interfere substantially with the recovery of the species	The approved conservation advice for the species (DE 2015c) identified the following conservation and management actions: • Protect all woodland from clearing in which painted honeyeaters have been regularly sighted, including remnant roadside vegetation and regrowth • Place all areas of public land that contain the species under secure conservation management, particularly those in timber reserves, transport corridors and areas owned by local government • Promote ecological management of woodland remnants and regrowth on public or private land, including maintaining adequate populations of mature trees and trees that host the species' preferred mistletoe species • Promote revegetation and land reclamation that recreates woodland habitat with a full complement of biodiversity, including the painted honeyeater • Control firewood collection from areas occupied by painted honeyeaters, and reduce grazing densities to a level where mistletoe host population dynamics are secured over the long term. The species has not been identified within the site. The site is located on the extreme northern edge of the species range of occurrence. There is no conceivable reason to believe Project would be likely to interfere substantially with the recovery of the species.
Assessment outcome	The Project is **unlikely** to result in a significant impact on Painted Honeyeater.

7.2 Matters of State Environmental Significance

With regard to MSES there are two matters mapped as present within the Project site:

- Regulated vegetation (remnant) located within a defined distance from the defining banks of a relevant watercourse identified on the VM Act watercourse and drainage feature map
- Protected wildlife habitat for a Vulnerable or Endangered species: Gouldian Finch

A third potential impact to a MSES (that is not mapped) is to landscape connectivity areas (as defined in the *Environmental Offsets Regulation 2014*). The Biodiversity Planning Assessment (BPA) for the Gulf Plains (GUP) bioregion has been completed. The site is not intersected by any state-wide biodiversity corridors. MSES connectivity areas are defined as areas of remnant vegetation outside urban areas containing prescribed REs that are required for ecosystem functioning. Impacts to connectivity values have been assessed using the DES 'landscape fragmentation and connectivity tool' as per the Queensland Environmental Offsets Policy: Significant Residual Impact Guideline (MSES Guideline) (DEHP 2014) (refer assessment output results in **Appendix E**). The results of the assessment found there would be no significant impact to connectivity areas as a result of the Project.

7.2.1 Regulated vegetation (remnant) located within a defined distance from the defining banks of a relevant watercourse

The relevant guideline for assessing significant residual impacts is the MSES Guideline (DEHP 2014). Assuming the entire ML is subject to vegetation clearing the Project will require clearing of Least Concern remnant vegetation (RE 2.5.9) along 325 m of one first order drainage line. For the region the 'defined distance' from

these watercourses is 25 m (as per the Queensland offsets policy). The total clearing of this MSES for the Project would require clearing of 1.6 ha of RE considered as a sparse structural category including clearing within 5 m of the defining bank. The MSES Guideline states clearing of RE up to 2 ha where in a sparse structural category RE for non-linear infrastructure does not constitute a significant residual impact on this MSES.

7.2.2 Protected wildlife habitat

The MSES Guideline provides significant residual impact criteria for assessing the potential impacts of a development on threatened species (as listed under the NC Act) where the species is present, or where the species habitat is predicted to occur (including the presence of protected wildlife habitat mapping). The criteria are very similar to that identified in the MNES Guidelines (refer impact criteria in **Table 11**). Habitat assessments carried out on the site targeted habitat features suitable for the species presence (small tree hollows and favoured grass species for foraging). The results of the habitat assessment (refer **Section 5.2.4.1**) and the likelihood of occurrence assessment for threatened species (refer **Table 7**) indicate the species is unlikely to occur on or near the site. As such, an assessment for significant residual impacts regarding Gouldian Finch is not considered warranted.

8 SUMMARY AND CONCLUSION

Jubilee Metals PLC is intending to reinstate and expand historical gold mining operations in the Croydon area. The Project will involve the reactivation of an existing decommissioned open cut gold mine.

A desktop review of ecological values predicted the potential presence of 11 threatened fauna species, 12 migratory fauna species and a single threatened flora species as potentially occurring within the site. Two MSES are considered to occur including remnant vegetation within a defined distance of a mapped watercourse and protected wildlife habitat for Gouldian Finch.

Two field surveys have been carried out across the site in 2020 and 2022 and recorded 52 flora species, including three non-native species. The flora assemblage included eucalypt canopy species, softwood scrub understorey trees, acacia shrubs and perennial tussock grasses. No conservation significant flora species were identified during the field survey but one flora species listed as Near Threatened under the NC Act may potentially occur.

Ground-truthing of the site confirmed the presence of three vegetation communities analogous to three RE types, water bodies, and non-remnant areas impacted by historical mining activities and vegetation clearing. All ground-truthed RE types have a Biodiversity status of No Concern at present under the EP Act.

The fauna survey recorded 55 native fauna species, including two amphibians, one reptile, 50 bird and two mammal species. The likelihood of occurrence assessment of threatened fauna determined that a single species, Painted Honeyeater, could possibly occur within the site. All other conservation significant species are considered unlikely to occur within the site.

An assessment of the Project's potential to cause significant impacts on MNES values was carried out. The Project is considered unlikely to result in a significant impact on Painted Honeyeater. Significant impacts are unlikely due to the relatively small extent of habitat loss and the lack of any evidence to suggest that the site provides critical habitat for Painted Honeyeater or supports an important population of the species. No other MNES values are present. Referral under the EPBC Act has not been deemed necessary.

An assessment of the Project's potential to have significant residual impacts on MSES values identified no impacts as occurring.

9 REFERENCES

ABRS 2022, *Australian Faunal Directory*. Australian Biological Resources Study, Canberra. Accessed at: https://biodiversity.org.au/afd/home

ALA 2022, *Atlas of Living Australia spatial portal.* Assessed at: https://www.ala.org.au/

Bamford, MD, Watkins, W, Bancroft, G, Tischler, J & Wahl 2008, *Migratory Shorebirds of the East Asian - Australasian Flyway: Population estimates and internationally important sites*. Department of the Environment, Water, Heritage and the Arts, Wetlands International-Oceania. Australian Government Canberra, Accessed at: http://www.environment.gov.au/biodiversity/migratory/publications/shorebirds-east-asia.html.

Barea, LP & Watson, DM 2007, *Temporal variation in food resources determines onset of breeding in an Australian mistletoe specialist*, Emu, vol. 107, pp. 203-209.

Barrett, G, Silcocks, a, Barry, s, Cunningham, R & Poulter, R 2003, *The New Atlas of Australian Birds, Birds Australia, Victoria, Melbourne.*

Bean, A 1992, The genus Leptospermum Forst. Et Forst.f. (Myrtaceae) in northern Australia and Malesia. *Austrobaileya,* vol. 3, pp. 645.

BirdLife International 2019*, Motacilla flava (amended version of 2018 assessment).* The IUCN Red List of Threatened Species 2019: e.T103822349A155602678. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T103822349A155602678.en. Accessed at: https://www.iucnredlist.org/species/103822349/155602678

Black-throated Finch Recovery Team (BTFRT), *National recovery plan for the black-throated finch southern subspecies Poephila cincta cincta*. Black-throated Finch Recovery Team, Department of Environment and Climate Change (NSW) and Queensland Parks and Wildlife Service. Report to the Department of the Environment and Water Resources, Canberra. Available from :http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-black-throated-finch-southern-subspecies-poephila-cincta-cincta. In effect under the EPBC Act from 08-Jan-2008

Blakers, M, Davies, S, & Reilly, P 1984, *The Atlas of Australian Birds.* Melbourne, Victoria: Melbourne University Press.

Boekel, C 1980, *Birds of Victoria River Downs Station and of Yarralin, Northern Territory. Part 1*. Australian Bird Watcher, vol. 8, pp 171-193.

BoM 2022, *Climate Data Online*, Bureau of Meteorology, Canberra. Accessed at: http://www.bom.gov.au/climate/data/index.shtml?bookmark=136&zoom=2&lat=-20.7065&lon=147.78&layers=B00000TFFFFFFFTFFFFFFFFFFFFFFFFFFTTT&dp=IDC10002-d

Bowen, M, McAlpine, C, House, A & Smith, G 2009, *Agricultural landscape modification increases the abundance of an important food resource: mistletoes, birds and brigalow*, Biological Conservation, vol. 142, pp. 122-133.

Butler, D & Laidlaw, M 2012, Species profile—*Tyto novaehollandiae kimberli* (masked owl (northern subspecies)), Department of Environment and Science, Queensland Government, Brisbane. Available at: https://apps.des.qld.gov.au/species-search/details/?id=1097#.

Carruthers, R 1966, Waders in the Gulf Country. *Australian Bird Watcher*. vol 2, pp. 211-214.

Catling, P, Coops, N & Burt, R 2001, *The distribution and abundance of ground-dwelling mammals in relation to time since wildfire and vegetation structure in south-eastern Australia,* Wildlife Research, vol. 28, 555-565.

Chapman, G 1969, Notes on birds of the Kosciusko high country. *Canberra Bird Notes*, vol. 1, pp. 2-6.

Churchill, S 1998, *Australian Bats*. Sydney: Reed New Holland.

Close, D 1982, *Recent records of the Oriental Plover*. South Australian Ornithologist, vol 28, pp. 205-206.

Coffin, A 2007, From roadkill to road ecology: a review of the ecological effects of roads, *Journal of Transport Geography*, vol. 15: pp. 396-406.

Compton, A & Johnson, P 1983, Observations of the Sheath-tailed Bat: Taphozous saccolaimus Temminck (Chiroptera: Emballonuridae), in the Townsville region of Queensland. *Australian Mammalogy*, vol 6, pp. 83-87.

Croydon Shire Council 2019, *Croydon Adventure Trails*. Assessed at: https://www.croydon.qld.gov.au/downloads/file/772/ imberl-adventure-trails-version3.

DCCEEW 2022a, *Protected matters search tool*, Department of Climate Change, Environment, Energy and Water (DCCEEW), Australian Government, Canberra. Assessed at: https://pmst.awe.gov.au/#/map?lng=131.52832031250003&lat=28.671310915880834&zoom=5&baseLayers=Imagery,ImageryLabels

DCCEEW 2022b, *Species Profiles and Threats Database*, Department of Climate Change, Environment, Energy and Water (DCCEEW), Australian Government, Canberra. Assessed at: https://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

DE 2013, *Matters of National Environmental Significance Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999*, Department of the Environment, Australian Government, Canberra. Accessed at: https://www.dcceew.gov.au/sites/default/files/documents/nes-guidelines_1.pdf

DE 2015a, *Conservation Advice Calidris ferruginea curlew sandpiper*. Department of the Environment. Australian Government, Canberra. Accessed at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/856-conservation-advice.pdf.

DE 2015b, *Conservation Advice Grantiella picta painted honeyeater*. Department of the Environment. Australian Government, Canberra. Accessed at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/470-conservation-advice.pdf. In effect under the EPBC Act from 08-Jul-2015.

DE 2015c, *Draft referral guideline for 14 birds listed as migratory species under the EPBC Act*, Department of the Environment. Australian Government, Canberra. Accessed at: https://www.environment.gov.au/biodiversity/threatened/publications/epbc-act-referral-guidelinesmigratory-birds

Debus, S 2012, *Masked Owl (northern subspecies) Tyto novaehollandiae kimberli Mathews, 1912,* in LK Curtis, AJ Dennis, KR McDonald, PM Kyne & SJS Debus (eds), *Queensland's threatened animals*, CSIRO Publishing, Collingwood, pp. 306-307.

DEHP 2015, *Biodiversity Planning Assessment Gulf Plains Bioregion v1.1. Fauna Expert Panel Report*, Department of Environment and Heritage, Queensland Government. Assessed at: https://www.qld.gov.au/__data/assets/pdf_file/0026/93644/bpa-gulf-plains-flora.pdf

Dennis, AJ 2012, *Bare-rumped Sheathtail Bat.* In: Curtis, L, Dennis, A, McDonald, K, Kyne, P & Debus, S (eds). *Queensland's Threatened Animals*. CSIRO Publishing.

DERM 2012, *National recovery plan for the red goshawk Erythrotriorchis radiatus*. Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra. Queensland Department of Environment and Resource Management, Brisbane. Accessed at: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-red-goshawk-erythrotriorchis-radiatus.

DES 2020, *Flora Survey Guidelines - Protected Plants.* Department of Environment and Science. Accessed at: https://www.qld.gov.au/__data/assets/pdf_file/0028/99901/gl-wl-pp-flora-survey.pdf

DES 2022a, Wildlife Online Database. Department of Environment and Science. Available at: https://apps.des.qld.gov.au/report-request/species-list/.

DES 2022b, *Remnant and pre-clearing regional ecosystems (RE mapping)*, Queensland Herbarium, Department of Environment and Science.

Dostine, P, Johnson, G, Franklin, D, Zhang, Y & Hempel, C 2001, Seasonal use of savanna landscapes by the Gouldian finch, Erythrura gouldiae, in the Yinberrie Hills area, Northern Territory, *Wildlife Research*, vol. 28, pp. 445-458.

Eyre T, Ferguson D, Smith G, Mathieson M, Venz ,M, Hogan, L, Hourigan C, Kelly, A & Rowland, J 2022, *Terrestrial Vertebrate Fauna Survey Assessment Guidelines for Queensland, Version 4.0*. Brisbane: Department of Environment and Science, Queensland Government. Accessed at: https://www.qld.gov.au/__data/assets/pdf_file/0022/68224/fauna-survey-guidelines.pdf

Farmer, A, 1993 The effects of dust on vegetation – a review. *Environmental Pollution*, vo. 79, pp. 63-75.

Frith, H, Crome, F & Brown, B 1977, Aspects of the Biology of the Japanese Snipe Gallinago hardwickii. *Australian Journal of Ecology*, vol. 2, pp. 341-368.

Garnett, S & Crowley, G 2000, *The action plan for Australian birds 2000*, Environment Australia, Canberra.

Garnett, S, Szabo, J & Dutson, G 2011, *Action Plan for Australian Birds 2010*. CSIRO.

Garnett, S 1986, Seasonal changes in the wader population in the south-east of the Gulf of Carpentaria. *Stilt*, vol 8, pp. 9--13.

Garnett, S & Crowley, G 2000, *The action plan for Australian birds 2000*, Environment Australia, Canberra.

Geering, A, Agnew L & Harding, S (eds) 2007, *Shorebirds of Australia*. Melbourne: CSIRO Publishing.

Higgins, P & S.J.J.F. Davies, (eds), 1996, *Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons*. Melbourne, Victoria: Oxford University Press

Higgins, P, Peter, J & Steele, W (eds) 2001, *Handbook of Australian, New Zealand and Antarctic birds, Volume. 5, tyrant-flycatchers to chats*, Oxford University Press, Melbourne.

Higgins, P, Peter, J & Cowling, S 2006, *Handbook of Australian, New Zealand and Antarctic Birds*. In: *Part A. Boatbill to Larks. Volume 7*. Melbourne, Victoria: Oxford University Press.

Horton, W 1975, The birds of Mount Isa. *Sunbird*, vol 6, pp 49-69.

Jaensch, R 2004, Little Curlew and other migratory shorebirds on floodplains of the Channel Country, arid inland Australia, 1999-2004. *Stilt*, vol. 46, pp. 15-18.

Lane, B 1987, *Shorebirds in Australia*, Nelson Publishers, Melbourne.

Marchant, S & Higgins, P (eds) 1993, *Handbook of Australian, New Zealand & Antarctic Birds, vol. 2*, Oxford University Press, Melbourne

Murphy, S 2002, Observations of the 'Critically Endangered' Bare-rumped Sheathtail Bat Saccolaimus saccolaimus Temminck (Chiroptera: Emballonuridae) on Cape York Peninsula, Queensland. *Australian Mammalogy*. Vol 23, pp. 185-187.

Naarding, J 1981. *Latham's Snipe (Gallinago hardwickii) in Tasmania.* Wildlife Division Technical Report. 81/2. Tasmania: National Parks and Wildlife Service.

Naarding, J 1983. *Latham's Snipe (Gallinago hardwickii) in Southern Australia*. Wildlife Division Technical Report. 83/01. Tasmania: National Parks and Wildlife Service.

Neldner, V, Wilson, B, Dillewaard, H, Ryan, T, Butler, D, McDonald, D Richter, W, Addicott, E & Appelman, C 2022, *Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland. Version 5.1. Updated March 2022*, Queensland Herbarium, Queensland Department of Environment and Science, Brisbane.

Norton, D, Hobbs, R & Atkins, L 1995, Fragmentation, disturbance, and plant distribution: mistletoes in woodland remnants in the Western Australian Wheatbelt, *Conservation Biology*, vol. 9, pp. 426-438.

Oliver, D, Chambers, M & Parker D 2003, Habitat and resource selection of the painted honeyeater (Grantiella picta) on the northern floodplains region of New South Wales, *Emu*, vol. 103, pp. 171-176.

Olsen, P & Olsen, J 1986, Distribution, Status, Movements and Breeding of the Gray Falcon Falco hypoleucos. *Emu*, vol. 86, pp. 47-50.

Olsen, P 1995, *Australian Birds of Prey*. University of NSW Press, Sydney.

Payne, R 2010, *Family Estrildidae (waxbills)*, in del Hoyo, J, Elliott, A & Christie,D (eds), *Handbook of the birds of the world, Vol. 15: weavers to New World warblers,* Lynx Edicions, Barcelona, pp. 234-377.

Pizzey, G & Knight, F 2012, *The field guide to the birds of Australia, Ninth Edition*, HarperCollins, Sydney.

Queensland Herbarium 2021, Census of the Queensland Flora, Queensland Government. Available at: https://www.data.qld.gov.au/dataset/census-of-the-queensland-flora-2021

QG 2022, *Queensland Globe*, Queensland Government, viewed 1 September 2022, https://qldglobe.information.qld.gov.au/

Reardon, T, Robson, S, Parsons, J & Inkster, T 2010, *Review of the threatened status of microchiropteran bat species on Cape York Peninsula. Executive summary.* South Australian Museum North Terrace, James Cook University, Adelaide, South Australia.

Schoenjahn, J 2013, A hot environment and one type of prey: Investigating why the Grey Falcon (*Falco hypoleucos*) is Australia's rarest falcon*. Emu*, vol. 113, pp. 19–25.

Schulz, M. & B. Thomson, 2007, *National recovery plan for the bare-rumped sheathtail bat Saccolaimus saccolaimus nudicluniatus*. Report to Department of the Environment and Heritage, Australian Government, Canberra. Accessed at: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-bare-rumped-sheathtail-bat-saccolaimus-saccolaimus-nudicluniatus.

Specht & Specht 2000, *Australian Plant Communities*, Oxford University Press, USA.

TSSC, 2015 *Conservation Advice Erythrotriorchis radiatus red goshawk*. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/942-conservation-advice-31102015.pdf.

TSSC, 2016 *Conservation Advice Erythrura gouldiae Gouldian finch*. Canberra: Department of the Environment and Energy. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/413-conservation-advice-07122016.pdf.

Watkins, D 1993 *A national plan for shorebird conservation in Australia*. RAOU Report Series. 90

Watson, D 2012, Painted Honeyeater *Grantiella picta* (Gould, 1838), in LK Curtis, AJ Dennis, KR McDonald, PM Kyne & SJS Debus (eds), *Queensland's threatened animals*, CSIRO Publishing, Collingwood, pp. 322-323.

Woinarski, J & Ward, S 2007, Ma*sked owl (north Australian mainland subspecies) Tyto novaehollandiae kimberli*, in J Woinarski, C Pavey, R Kerrigan, I Cowie & S Ward (eds), *Lost from our landscape: threatened species of the Northern Territory*, Northern Territory Department of Natural Resources, Environment and The Arts, Palmerston, pp. 194-195.

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APPENDIX A DESKTOP SEARCH RESULTS

Queensland Government

Department of Environment and Science

Environmental Reports

Biodiversity and Conservation Values

Biodiversity Planning Assessments and Aquatic Conservation Assessments

For the selected area of interest
Longitude: 142.3482 Latitude: -18.0205 with 2 kilometre radius

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or Area of Interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "Central co-ordinates" option, the resulting assessment area encompasses an area extending from 2km radius from the point of interest.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 1994). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no values have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Please direct queries about these reports to: biodiversity.planning@des.qld.gov.au

Disclaimer

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Summary Information

Tables 1 to 8 provide an overview of the AOI with respect to selected topographic and environmental values.

Table 1: Area of interest details: Longitude: 142.3482 Latitude: -18.0205

Size (ha)	1,256.55
Local Government(s)	Croydon Shire
Bioregion(s)	Gulf Plains, Einasleigh Uplands
Subregion(s)	Georgetown - Croydon, Mitchell - Gilbert Fans
Catchment(s)	Norman

The following table identifies available Biodiversity Planning Assessments (BPAs) and Aquatic Conservation Assessments (ACAs) with respect to the AOI.

Table 2: Available Biodiversity Planning and Aquatic Conservation Assessments

Assessment Type	Assessment Area and Version
Biodiversity Planning Assessment(s)	Gulf Plains v1.1, Einasleigh Uplands v1.1
Aquatic Conservation Assessment(s) (riverine)	Eastern Gulf of Carpentaria v1.1
Aquatic Conservation Assessment(s) (non-riverine)	Eastern Gulf of Carpentaria v1.1

Table 3: Remnant regional ecosystems within the AOI as per the Qld Herbarium's 'biodiversity status'

Biodiversity Status	Area (Ha)	% of AOI
Endangered	0.0	0.0
Of concern	104.86	8.34
No concern at present	1,151.69	91.66

The following table identifies the extent and proportion of the user specified area of interest (AOI) which is mapped as being of "State", "Regional" or "Local" significance via application of the Queensland Department of Environment and Science's *Biodiversity Assessment and Mapping Methodology* (BAMM).

Table 4: Summary table, biodiversity significance

Biodiversity significance	Area (Ha)	% of AOI
State Habitat for EVNT taxa	0.0	0.0
State	0.0	0.0
Regional	0.79	0.06
Local or Other Values	1,214.18	96.63

Table 5: Non-riverine wetlands intersecting the AOI

Non-riverine wetland types intersecting the area of interest	#
(No Records)	

NB. The figures presented in the table above are derived from the relevant non-riverine Aquatic Conservation Assessment(s). Later releases of wetland mapping produced via the Queensland Wetland Mapping Program may provide more recent

information in regards to wetland extent.

Table 6: Named waterways intersecting the AOI

Name	Permanency
CHRISTMAS CREEK	Non-perennial

Refer to **Map 1** for general locality information.

The following two tables identify the extent and proportion of the user specified AOI which is mapped as being of "Very High", "High", "Medium", "Low", or "Very Low" aquatic conservation value for riverine and non-riverine wetlands via application of the Queensland Department of Environment and Science's *Aquatic Biodiversity Assessment and Mapping Method* (AquaBAMM).

Table 7: Summary table, aquatic conservation significance (riverine)

Aquatic conservation significance (riverine wetlands)	Area (Ha)	% of AOI
Very High	0.0	0.0
High	1,256.55	100.0
Medium	0.0	0.0
Low	0.0	0.0
Very Low	0.0	0.0

Table 8: Summary table, aquatic conservation significance (non-riverine)

Aquatic conservation significance (non-riverine wetlands)	Area (Ha)	% of AOI
(No Records)		

Biodiversity Planning Assessments

Introduction

The Department of Environment and Science (DES) attributes biodiversity significance on a bioregional scale through a Biodiversity Planning Assessment (BPA). A BPA involves the integration of ecological criteria using the *Biodiversity assessment and Mapping Methodology* (BAMM) and is developed in two stages: 1) **diagnostic criteria**, and 2) **expert panel criteria**. The diagnostic criteria are based on existing data which is reliable and uniformly available across a bioregion, while the expert panel criteria allows for the refinement of the mapped information from the diagnostic output by incorporating local knowledge and expert opinion.

The BAMM methodology has application for identifying areas with various levels of significance solely for biodiversity reasons. These include threatened ecosystems or taxa, large tracts of habitat in good condition, ecosystem diversity, landscape context and connection, and buffers to wetlands or other types of habitat important for the maintenance of biodiversity or ecological processes. While natural resource values such as dryland salinity, soil erosion potential or land capability are not dealt with explicitly, they are included to some extent within the biodiversity status of regional ecosystems recognised by the DES.

Biodiversity Planning Assessments (BPAs) assign three levels of overall biodiversity significance.

- **State significance** - areas assessed as being significant for biodiversity at the bioregional or state scales. They also include areas assessed by other studies/processes as being significant at national or international scales. In addition, areas flagged as being of State significance due to the presence of endangered, vulnerable and/or near threatened taxa, are identified as "State Habitat for EVNT taxa".
- **Regional significance** - areas assessed as being significant for biodiversity at the subregional scale. These areas have lower significance for biodiversity than areas assessed as being of State significance.
- **Local significance and/or other values** - areas assessed as not being significant for biodiversity at state or regional scales. Local values are of significance at the local government scale.

For further information on released BPAs and a copy of the underlying methodology, go to:

http://www.qld.gov.au/environment/plants-animals/biodiversity/planning/

The GIS results can be downloaded from the Queensland Spatial Catalogue at:

http://qspatial.information.qld.gov.au/geoportal/

The following table identifies the extent and proportion of the user specified AOI which is mapped as being of "State", "Regional" or "Local" significance via application of the BAMM.

Table 9: Summary table, biodiversity significance

Biodiversity significance	Area (Ha)	% of AOI
State Habitat for EVNT taxa	0.0	0.0
State	0.0	0.0
Regional	0.79	0.06
Local or Other Values	1,214.18	96.63

Refer to **Map 2** for further information.

Diagnostic Criteria

Diagnostic criteria are based on existing data which is reliable and uniformly available across a bioregion. These criteria are diagnostic in that they are used to filter the available data and provide a "first-cut" or initial determination of biodiversity significance. This initial assessment is then combined through a second group of other essential criteria.

A description of the individual diagnostic criteria is provided in the following sections.

Criteria A. Habitat for EVNT taxa: Classifies areas according to their significance based on the presence of endangered, vulnerable and/or rare (EVNT) taxa. EVNT taxa are those scheduled under the *Nature Conservation Act 1992* and/or the

Environment Protection and Biodiversity Conservation Act 1999. It excludes highly mobile fauna taxa which are instead considered in Criterion H and brings together information on EVNT taxa using buffering of recorded sites or habitat suitability models (HSM) where available.

Criteria B. Ecosystem value: Classifies on the basis of biodiversity status of regional ecosystems, their extent in protected areas (presence of poorly conserved regional ecosystems), the presence of significant wetlands; and areas of national importance such as the presence of Threatened Ecological Communities, World Heritage areas and Ramsar sites. Ecosystem value is applied at a bioregional (**B1**) and regional (**B2**) scale.

Criteria C. Tract size: Measures the relative size of tracts of vegetation in the landscape. The size of any tract is a major indicator of ecological significance, and is also strongly correlated with the long-term viability of biodiversity values. Larger tracts are less susceptible to ecological edge effects and are more likely to sustain viable populations of native flora and fauna than smaller tracts.

Criteria D. Relative size of regional ecosystems: Classifies the relative size of each regional ecosystem unit within its bioregion (**D1**) and its subregion (**D2**). Remnant units are compared with all other occurrences with the same regional ecosystem. Large examples of a regional ecosystem are more significant than smaller examples of the same regional ecosystem because they are more representative of the biodiversity values particular to the regional ecosystem, are more resilient to the effects of disturbance, and constitute a significant proportion of the total area of the regional ecosystem.

Criteria F. Ecosystem diversity: Is an indicator of the number of regional ecosystems occurring within an area. An area with high ecosystem diversity will have many regional ecosystems and ecotones relative to other areas within the bioregion.

Criteria G. Context and connection: Represents the extent to which a remnant unit incorporates, borders or buffers areas such as significant wetlands, endangered ecosystems; and the degree to which it is connected to other vegetation.

A summary of the biodiversity status based upon the diagnostic criteria is provided in the following table.

Table 10: Summary of biodiversity significance based upon diagnostic criteria with respect to the AOI

Biodiversity significance	Description	Area (Ha)	% of AOI
Regional	Remnant contains at least 1 RE with <10 pc extent remaining or rare in subregion (B2)	0.58	0.05
Regional	Remnant contains at least one Of Concern RE (B1)	0.22	0.02
Local or Other Values	Refer to diagnostic data for additional information	1,214.18	96.63

Assessment of diagnostic criteria with respect to the AOI

The following table reflects an assessment of the individual diagnostic criteria noted above in regards to the AOI.

Table 11: Assessment of individual diagnostic criteria with respect to the AOI

Diagnostic Criteria	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
A: Habitat for EVNT Taxa							1,214.99	96.7
B1: Ecosystem Value (Bioregion)			0.22		1,200.63	95.5	14.14	1.1
B2: Ecosystem Value (Subregion)	0.58				1,200.27	95.5	14.14	1.1
C: Tract Size			1,214.99	96.7				
D1: Relative RE Size (Bioregion)							1,214.99	96.7
D2: Relative RE Size (Subregion)	0.58						1,214.41	96.6
F: Ecosystem Diversity	533.46	42.5	525.0	41.8	156.53	12.5		
G: Context and Connection	534.04	42.5	284.26	22.6	396.69	31.6		

Other Essential Criteria

Other essential criteria (also known as expert panel criteria) are based on non-uniform information sources and which may rely more upon expert opinion than on quantitative data. These criteria are used to provide a "second-cut" determination of biodiversity significance, which is then combined with the diagnostic criteria for an overall assessment of relative biodiversity significance. A summary of the biodiversity status based upon the other essential criteria is provided in the following table.

Table 12: Summary of biodiversity significance based upon other essential criteria with respect to the AOI

(No Records)

A description of each of the other essential criteria and associated assessment in regards to the AOI is provided in the following sections.

Criteria H. Essential and general habitat for priority taxa: Priority taxa are those which are at risk or of management concern, taxa of scientific interest as relictual (ancient or primitive), endemic taxa or locally significant populations (such as a flying fox camp or heronry), highly specialised taxa whose habitat requirements are complex and distributions are not well correlated with any particular regional ecosystem, taxa important for maintaining genetic diversity (such as complex spatial patterns of genetic variation, geographic range limits, highly disjunct populations), taxa critical for management or monitoring of biodiversity (functionally important or ecological indicators), or economic and culturally important taxa.

Criteria I. Special biodiversity values: areas with special biodiversity values are important because they contain multiple taxa in a unique ecological and often highly biodiverse environment. Areas with special biodiversity values can include the following:

- Ia - centres of endemism - areas where concentrations of taxa are endemic to a bioregion or subregion are found.
- Ib - wildlife refugia (Morton *et al*. 1995), for example, islands, mound springs, caves, wetlands, gorges, mountain ranges and topographic isolates, ecological refuges, refuges from exotic animals, and refuges from clearing. The latter may include large areas that are not suitable for clearing because of land suitability/capability.
- Ic - areas with concentrations of disjunct populations.
- Id - areas with concentrations of taxa at the limits of their geographic ranges.
- Ie - areas with high species richness.
- If - areas with concentrations of relictual populations (ancient and primitive taxa).
- Ig - areas containing REs with distinct variation in species composition associated with geomorphology and other environmental variables.
- Ih - an artificial waterbody or managed/manipulated wetland considered by the panel/s to be of ecological significance.
- Ii - areas with a high density of hollow-bearing trees that provide habitat for animals.
- Ij - breeding or roosting sites used by a significant number of individuals.
- Ik - climate change refuge.

The following table identifies the value and extent area of the Other Essential Criteria H and I within the AOI.

Table 13: Relative importance of expert panel criteria (H and I) used to access overall biodiversity significance with respect to the AOI

Expert Panel	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
H: Core Habitat Priority Taxa								
Ia: Centres of Endemism								
Ib: Wildlife Refugia								
Ic: Disjunct Populations								
Id: Limits of Geographic Ranges								
Ie: High Species Richness								
If: Relictual Populations								
Ig: Variation in Species Composition								

Expert Panel	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
Ih: Artificial Wetland								
Ii: Hollow Bearing Trees								
Ij: Breeding or Roosting Site								
Ik: Climate Refugia								

NB. Whilst biodiversity values associated with Criteria I may be present within the site (refer to tables 12 and 15), for the New England Tableland and Central Queensland Coast BPAs, area and % area figures associated with Criteria Ia through to Ij cannot be listed in the table above (due to slight variations in data formats between BPAs).

Criteria J. Corridors: areas identified under this criterion qualify either because they are existing vegetated corridors important for contiguity, or cleared areas that could serve this purpose if revegetated. Some examples of corridors include riparian habitats, transport corridors and "stepping stones".

Bioregional and subregional conservation corridors have been identified in the more developed bioregions of Queensland through the BPAs, using an intensive process involving expert panels. Map 3 displays the location of corridors as identified under the Statewide Corridor network. The Statewide Corridor network incorporates BPA derived corridors and for bioregions where no BPA has been assessed yet, corridors derived under other planning processes. *Note: as a result of updating and developing a statewide network, the alignment of corridors may differ slightly in some instances when compared to those used in individual BPAs.*

The functions of these corridors are:

- **Terrestrial** Bioregional corridors, in conjunction with large tracts of remnant vegetation, maintain ecological and evolutionary processes at a landscape scale, by:

  • Maintaining long term evolutionary/genetic processes that allow the natural change in distributions of species and connectivity between populations of species over long periods of time;

  • Maintaining landscape/ecosystems processes associated with geological, altitudinal and climatic gradients, to allow for ecological responses to climate change;

  • Maintaining large scale seasonal/migratory species processes and movement of fauna;

  • Maximising connectivity between large tracts/patches of remnant vegetation;

  • Identifying key areas for rehabilitation and offsets; and

- **Riparian** Bioregional Corridors also maintain and encourage connectivity of riparian and associated ecosystems.

The location of the corridors is determined by the following principles:

- Terrestrial

  • Complement riparian landscape corridors (i.e. minimise overlap and maximise connectivity);

  • Follow major watershed/catchment and/or coastal boundaries;

  • Incorporate major altitudinal/geological/climatic gradients;

  • Include and maximise connectivity between large tracts/patches of remnant vegetation;

  • Include and maximise connectivity between remnant vegetation in good condition; and

- Riparian

  • Located on the major river or creek systems within the bioregion in question.

The total extent of remnant vegetation triggered as being of "State", "Regional" or "Local" significance due to the presence of an overlying BPA derived terrestrial or riparian corridor within the AOI, is provided in the following table. For further information on how remnant vegetation is triggered due to the presence of an overlying BPA derived corridor, refer to the relevant landscape BPA expert panel report(s).

Table 14: Extent of triggered remnant vegetation due to the presence of BPA derived corridors with respect to the AOI

Biodiversity Significance	Area (Ha)	% of AOI
State	0.0	0.0
Regional	0.0	0.0
Local	0.0	0.0

NB: area figures associated with the extent of corridor triggered remnant vegetation are only available for those bioregions where a BPA has been undertaken.

Refer to **Map 3** for further information.

Threatening process/condition (Criteria K) - areas identified by experts under this criterion may be used to amend (upgrade or downgrade) biodiversity significance arising from the "first-cut" analysis. The condition of remnant vegetation is affected by threatening processes such as weeds, ferals, grazing and burning regime, selective timber harvesting/removal, salinity, soil erosion, and climate change.

Assessment of Criteria K with respect to the AOI is not currently included in the "Biodiversity and Conservation Values" report, as it has not been applied to the majority of Queensland due to data/information limitations and availability.

Special Area Decisions

Expert panel derived "Special Area Decisions" are used to assign values to Other Essential Criteria. The specific decisions which relate to the AOI in question are listed in the table below.

Table 15: Expert panel decisions for assigning levels of biodiversity significance with respect to the AOI

(No Records)

Expert panel decision descriptions:

(No Records)

Aquatic Conservation Assessments

Introduction

The Aquatic Biodiversity Assessment and Mapping Method or AquaBAMM (Clayton *et al.* 2006), was developed to assess conservation values of wetlands in queensland, and may also have application in broader geographical contexts. It is a comprehensive method that uses available data, including data resulting from expert opinion, to identify relative wetland conservation/ecological values within a specified study area (usually a catchment). The product of applying this method is an Aquatic Conservation Assessment (ACA) for the study area.

An ACA using AquaBAMM is non-social, non-economic and identifies the conservation/ecological values of wetlands at a user-defined scale. It provides a robust and objective conservation assessment using criteria, indicators and measures that are founded upon a large body of national and international literature. The criteria, each of which may have variable numbers of indicators and measures, are naturalness (aquatic), naturalness (catchment), diversity and richness, threatened species and ecosystems, priority species and ecosystems, special features, connectivity and representativeness. An ACA using AquaBAMM is a powerful decision support tool that is easily updated and simply interrogated through a geographic information system (GIS).

Where they have been conducted, ACAs can provide a source of baseline wetland conservation/ecological information to support natural resource management and planning processes. They are useful as an independent product or as an important foundation upon which a variety of additional environmental and socio-economic elements can be added and considered (i.e. an early input to broader 'triple-bottom-line' decision-making processes). An ACA can have application in:

- determining priorities for protection, regulation or rehabilitation of wetlands and other aquatic ecosystems
- on-ground investment in wetlands and other aquatic ecosystems
- contributing to impact assessment of large-scale development (e.g. dams)
- water resource and strategic regional planning prcesses

For a detailed explanation of the methodology please refer to the summary and expert panel reports relevant to the ACA utilised in this assessment. These reports can be accessed at Wetland *Info*:

http://wetlandinfo.des.qld.gov.au/wetlands/assessment/assessment-methods/aca

The GIS results can be downloaded from the Queensland Spatial Catalogue at:

http://qspatial.information.qld.gov.au/geoportal/

Explanation of Criteria

Under the AquaBAMM, eight criteria are assessed to derive an overall conservation value. Similar to the Biodiversity Assessment and Mapping Methodology, the criteria may be primarily diagnostic (quantitative) or primarily expert opinion (qualitative) in nature. The following sections provide a brief description of each of the 8 criteria.

Criteria 1. Naturalness - Aquatic: This attribute reflects the extent to which a wetland's (riverine, non-riverine, estuarine) aquatic state of naturalness is affected through relevant influencing indicators which include: presence of exotic flora and fauna; presence of aquatic communities; degree of habitat modification and degree of hydrological modification.

Criteria 2. Naturalness - Catchment: The naturalness of the terrestrial systems of a catchment can have an influence on many wetland characteristics including: natural ecological processes e.g. nutrient cycling, riparian vegetation, water chemistry, and flow. The indicators utilised to assess this criterion include: presence of exotic flora and/or fauna; riparian, catchment and flow modification.

Criteria 3. Naturalness - Diversity and Richness: This criterion is common to many ecological assessment methods and can include both physical and biological features. It includes such indicators as species richness, riparian ecosystem richness and geomorphological diversity.

Criteria 4. Threatened Species and Ecosystems: This criterion evaluates ecological rarity characteristics of a wetland. This includes both species rarity and rarity of communities / assemblages. The communities and assemblages are best represented by regional ecosystems. Species rarity is determined by NCA and EPBC status with Endangered, Vulnerable or Near-threatened species being included in the evaluation. Ecosystem rarity is determined by regional ecosystem biodiversity status i.e. Endangered, Of Concern, or Not of Concern.

Criteria 5. Priority Species and Ecosystems: Priority flora and fauna species lists are expert panel derived. These are aquatic, semi-aquatic and riparian species which exhibit at least 1 particular trait in order to be eligible for consideration. For

flora species the traits included:

- It forms significant macrophyte beds (in shallow or deep water).
- It is an important food source.
- It is important/critical habitat.
- It is implicated in spawning or reproduction for other fauna and/or flora species.
- It is at its distributional limit or is a disjunct population.
- It provides stream bank or bed stabilisation or has soil binding properties.
- It is a small population and subject to threatening processes.

Fauna species are included if they meet at least one of the following traits:

- It is endemic to the study area (>75 per cent of its distribution is in the study area/catchment).
- It has experienced, or is suspected of experiencing, a serious population decline.
- It has experienced a significant reduction in its distribution and has a naturally restricted distribution in the study area/catchment.
- It is currently a small population and threatened by loss of habitat.
- It is a significant disjunct population.
- It is a migratory species (other than birds).
- A significant proportion of the breeding population (>one per cent for waterbirds, >75 per cent other species) occurs in the waterbody (see Ramsar criterion 6 for waterbirds).
- Limit of species range.

See the individual expert panel reports for the priority species traits specific to an ACA.

Criteria 6. Special Features: Special features are areas identified by flora, fauna and ecology expert panels which exhibit characteristics beyond those identified in other criteria and which the expert panels consider to be of the highest ecological importance. Special feature traits can relate to, but are not solely restricted to geomorphic features, unique ecological processes, presence of unique or distinct habitat, presence of unique or special hydrological regimes e.g. spring-fed streams. Special features are rated on a 1 - 4 scale (4 being the highest).

Criteria 7. Connectivity: This criterion is based on the concept that appropriately connected aquatic ecosystems are healthy and resilient, with maximum potential biodiversity and delivery of ecosystem services.

Criteria 8. Representativeness: This criterion applies primarily to non-riverine assessments, evaluates the rarity and uniqueness of a wetland type in relation to specific geographic areas. Rarity is determined by the degree of wetland protection within "protected Areas" estate or within an area subject to the *Fisheries Act 1994*, *Coastal Protection and Management Act 1995*, or *Marine Parks Act 2004*. Wetland uniqueness evaluates the relative abundance and size of a wetland or wetland management group within geographic areas such as catchment and subcatchment.

Riverine Wetlands

Riverine wetlands are all wetlands and deepwater habitats within a channel. The channels are naturally or artificially created, periodically or continuously contain moving water, or connecting two bodies of standing water. AquaBAMM, when applied to riverine wetlands uses a discrete spatial unit termed subsections. A subsection can be considered as an area which encompasses discrete homogeneous stream sections in terms of their natural attributes (i.e. physical, chemical, biological and utilitarian values) and natural resources. Thus in an ACA, an aquatic conservation significance score is calculated for each subsection and applies to all streams within a subsection, rather than individual streams as such.

Please note, the area figures provided in Tables 16 and 17, are derived using the extent of riverine subsections within the AOI. Refer to **Map 5** for further information. A summary of the conservation significance of riverine wetlands within the AOI is provided in the following table.

Table 16: Overall level/s of riverine aquatic conservation significance

Aquatic conservation significance (riverine wetlands)	Area (Ha)	% of AOI
Very High	0.0	0.0

Aquatic conservation significance (riverine wetlands)	Area (Ha)	% of AOI
High	1,256.55	100.0
Medium	0.0	0.0
Low	0.0	0.0
Very Low	0.0	0.0

The individual aquatic conservation criteria ratings for riverine wetlands within the AOI are listed below.

Table 17: Level/s of riverine aquatic conservation significance based on selected criteria

Criteria	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
1. Naturalness aquatic			1,256.56	100.0				
2. Naturalness catchment					1,256.56	100.0		
3. Diversity and richness	1,139.32	90.7	117.24	9.3				
4. Threatened species and ecosystems			1,256.56	100.0				
5. Priority species and ecosystems			1,139.32	90.7				
6. Special features			1,256.56	100.0				
7. Connectivity								
8. Representative-ness								

The table below lists and describes the relevant expert panel decisions used to assign conservation significance values to riverine wetlands within the AOI.

Table 18: Expert panel decisions for assigning overall levels of riverine aquatic conservation significance

Decision number	Special feature	Catchment	Criteria/Indicator/Measure	Conservation rating (1-4)
nn_r_ec_03	Carron Forrest country	Mitchell	6.2.1, 6.4.1	3, 3

4 is the highest rating/value

Expert panel decision descriptions:

nn_r_ec_03

The Carron Forrest country contains tiny wetlands along coolibah flats. The area has value as a large interconnected aggregation rather than as individual wetlands. Overflow from the Gilbert is associated with the back swamps however on the sand surfaces, the circular wetlands are groundwater recharged. The wetland systems have significant diversity and longevity and contain very thick vegetation including melaleuca, swamp box **Lophostemon suaveolens** and spear grass. The area is also subject to flash flooding from the Gilbert River.

Non-riverine Wetlands

Non-riverine wetlands include both lacustrine and palustrine wetlands, however, do not currently incorporate estuarine, marine or subterranean wetland types. A summary of the conservation significance of non-riverine wetlands within the AOI is provided in the following table. Refer to **Map 6** for further information.

Table 19: Overall level/s of non-riverine aquatic conservation significance

Aquatic conservation significance (non-riverine wetlands)	Area (Ha)	% of AOI
(No Records)		

The following table provides an assessment of non-riverine wetlands within the AOI and associated aquatic conservation criteria values.

Table 20: Level/s of non-riverine aquatic conservation significance based on selected criteria

Criteria	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
(No Records)								

The table below lists and describes the relevant expert panel decisions used to assign conservation significance values to non-riverine wetlands within the AOI.

Table 21: Expert panel decisions for assigning overall levels of non-riverine aquatic conservation significance.

Decision number	Special feature	Catchment	Criteria/Indicator/Measure	Conservation rating (1-4)
(No Records)				

4 is the highest rating/value

Expert panel decision descriptions:

(No Records)

Threatened and Priority Species

Introduction

This chapter contains a list of threatened and priority flora and/or fauna species that have been recorded on, or within 4km of the Assessment Area.

The information presented in this chapter with respect to species presence is derived from compiled databases developed primarily for the purpose of BPAs and ACAs. Data is collated from a number of sources and is updated periodically.

It is important to note that the list of species provided in this report, may differ when compared to other reports generated from other sources such as the State government's WildNet, Herbrecs or the federal government's EPBC database for a number of reasons.

Records for threatened and priority species are filtered and checked based on a number of rules including:

- Taxonomic nomenclature - current scientific names and status,
- Location - cross-check co-ordinates with location description,
- Taxon by location - requires good knowledge of the taxon and history of the record,
- Duplicate records - identify and remove,
- Expert panels - check records and provide new records,
- Flora cultivated records excluded,
- Use precise records less than or equal to 2000m,
- Use recent records greater than or equal to 1975 animals, greater than or equal to 1950 plants.

Threatened Species

Threatened species are those species classified as "Endangered" or "Vulnerable" under the *Environment Protection and Biodiversity Conservation Act 1999* or "Endangered", "Vulnerable" or "Near threatened" under the *Nature Conservation Act 1992*.

The following threatened species have been recorded on, or within approximately 4km of the AOI.

Table 22: Threatened species recorded on, or within 4km of the AOI

(no results)

NB. Please note that the threatened species listed in this section are based upon the most recently compiled DES internal state-wide threatened species dataset. This dataset may contain additional records that were not originally available for inclusion in the relevant individual BPAs and ACAs.

**JAMBA - Japan-Australia Migratory Bird Agreement; CAMBA - China-Australia Migratory Bird Agreement; ROKAMBA - Republic of Korea-Australia Migratory Bird Agreement; CMS - Convention on the Conservation of Migratory Species*.

***I - wetland indicator species; D - wetland dependent species.*.

BPA Priority Species

A list of BPA priority species that have been recorded on, or within approximately 4km of the AOI is contained in the following table.

Table 23: Priority species recorded on, or within 4km of the AOI

(no results)

NB. Please note that the list of priority species is based on those species identified in the BPAs, however records for these species may be more recent than the originals used. furthermore, the BPA priority species databases are updated from time to time. At each update, the taxonomic details for all species are amended as necessary to reflect current taxonomic name and/or status changes.

ACA Priority Species

A list of ACA priority species used in riverine and non-riverine ACAs that have been recorded on, or within approximately 4km of the AOI are contained in the following tables.

Table 24: Priority species recorded on, or within 4 km of the AOI - riverine

Species	Common name	Back on Track rank	Identified flora/fauna
Hephaestus fuliginosus	Sooty Grunter	None	FA
Leiopotherapon unicolor	Spangled Perch	None	FA
Neosilurus hyrtlii	Hyrtl's Catfish	None	FA
Scortum ogilbyi	Gulf Grunter	None	FA

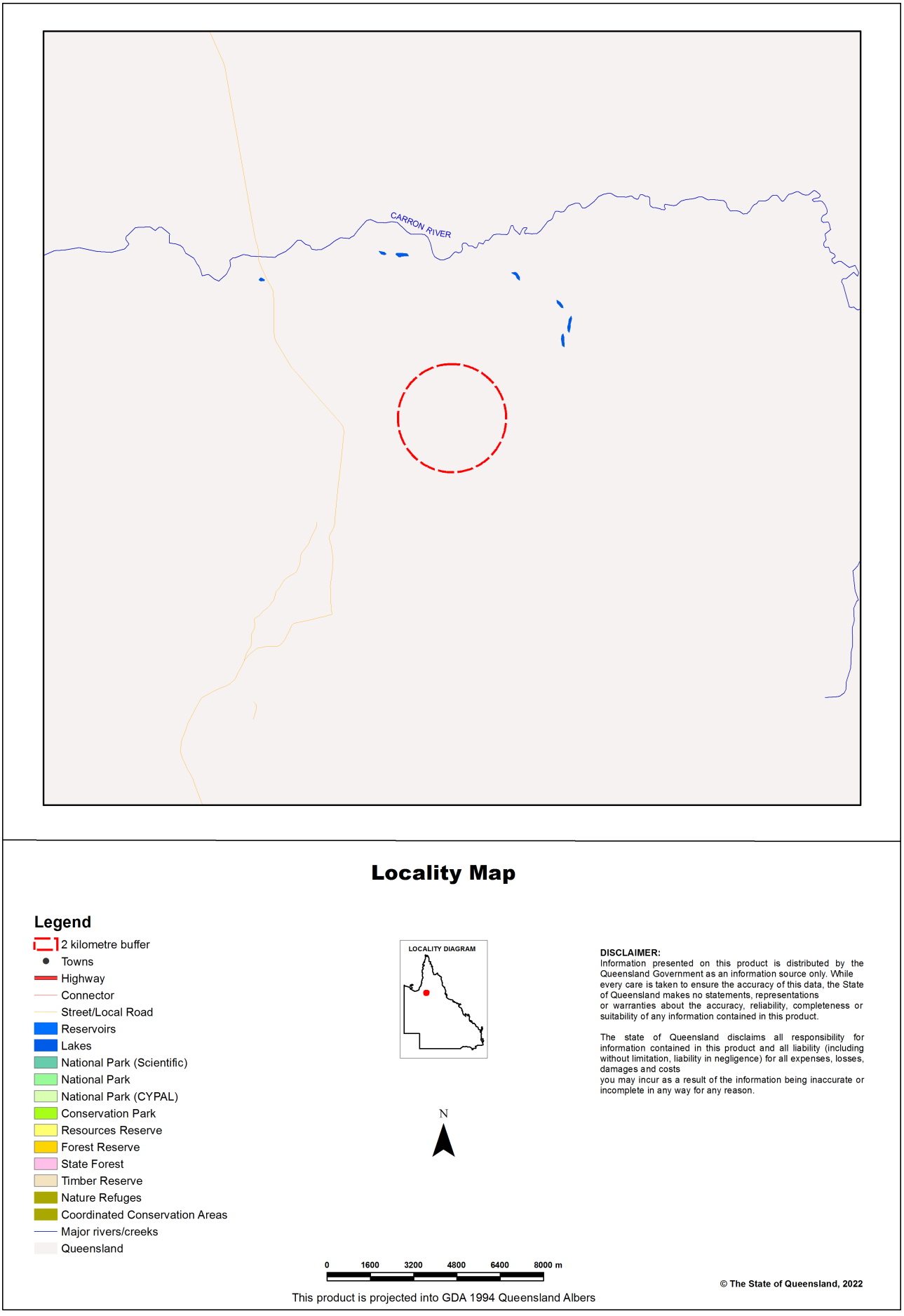
Table 25: Priority species recorded on, or within 4 km of the AOI - non-riverine

Species	Common name	Back on Track rank	Identified flora/fauna
Hephaestus fuliginosus	Sooty Grunter	None	FA
Leiopotherapon unicolor	Spangled Perch	None	FA
Neosilurus hyrtlii	Hyrtl's Catfish	None	FA
Scortum ogilbyi	Gulf Grunter	None	FA

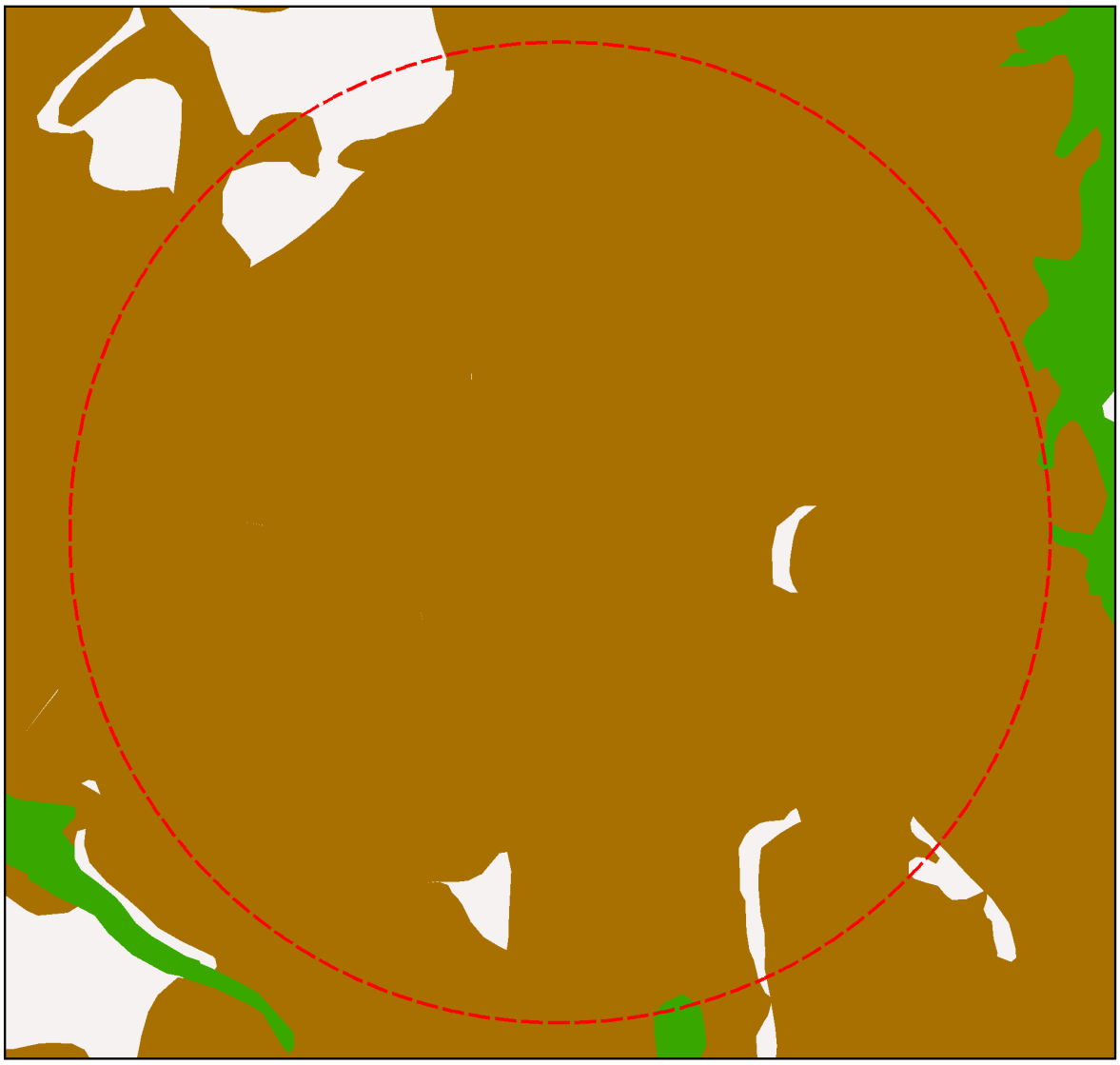
NB. Please note that the priority species records used in the above two tables are comprised of those adopted for the released individual ACAs. The ACA riverine and non-riverine priority species databases are updated from time to time to reflect new release of ACAs. At each update, the taxonomic details for all ACAs records are amended as necessary to reflect current taxonomic name and/or status changes.

Maps

Map 1 - Locality Map



Map 2 - Biodiversity Planning Assessment (BPA)



Biodiversity Planning Assessments

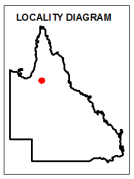
Legend

- 2 kilometre buffer
- Towns
- Roads
- Major rivers/creeks
- Queensland

Biodiversity Planning Assessment

- State Habitat for EVNT taxa
- State
- Regional
- Local or Other Values
- Non Bioregion Ecosystem

LOCALITY DIAGRAM



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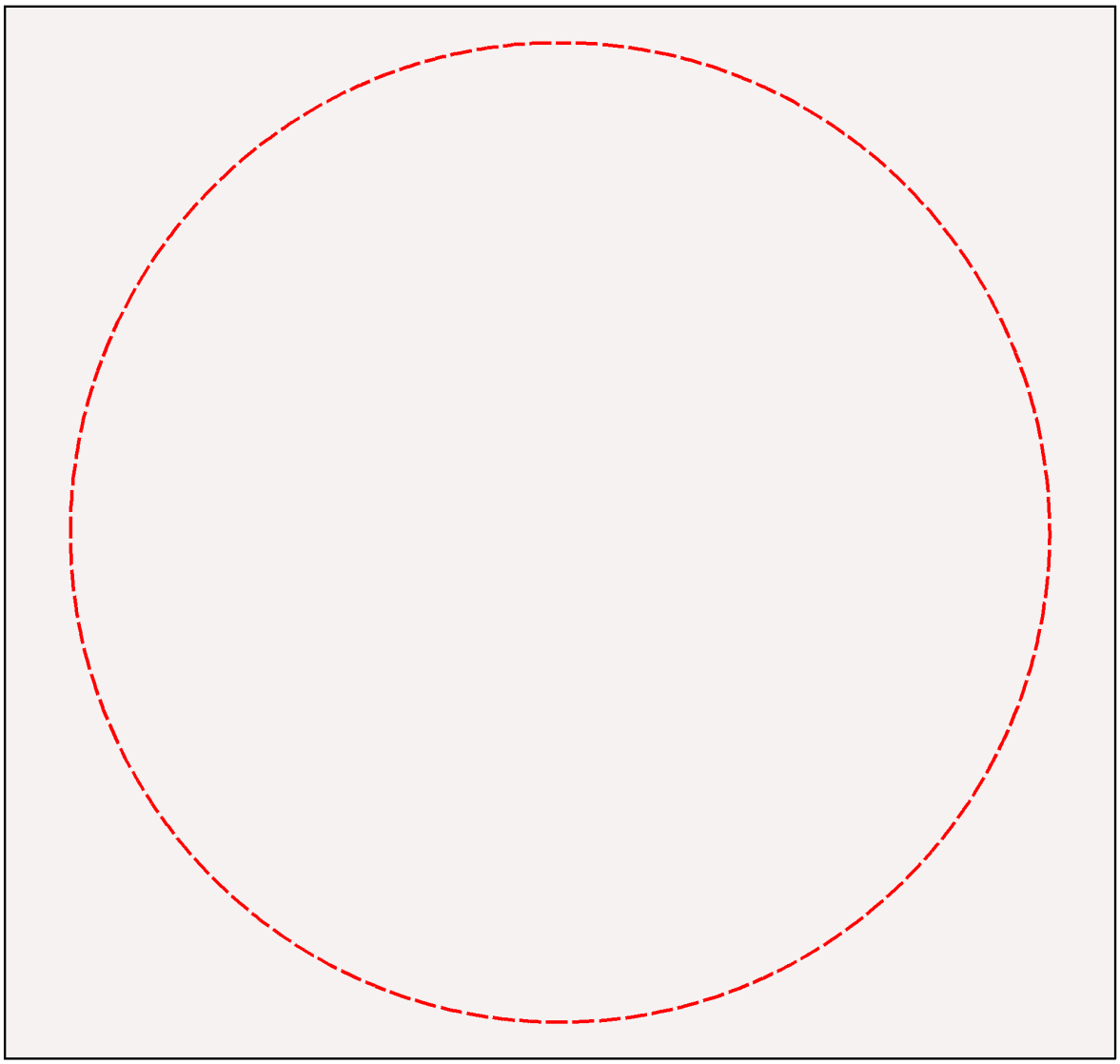
Map 3 - Corridors



Corridors

Legend

- 2 kilometre buffer
- Towns
- Roads
- Major rivers/creeks
- Queensland

Corridors

- State
- Regional

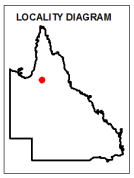
Corridor Triggered Vegetation

- State
- Regional
- Local

Core Area Vegetation

- Brigalow Belt only

LOCALITY DIAGRAM



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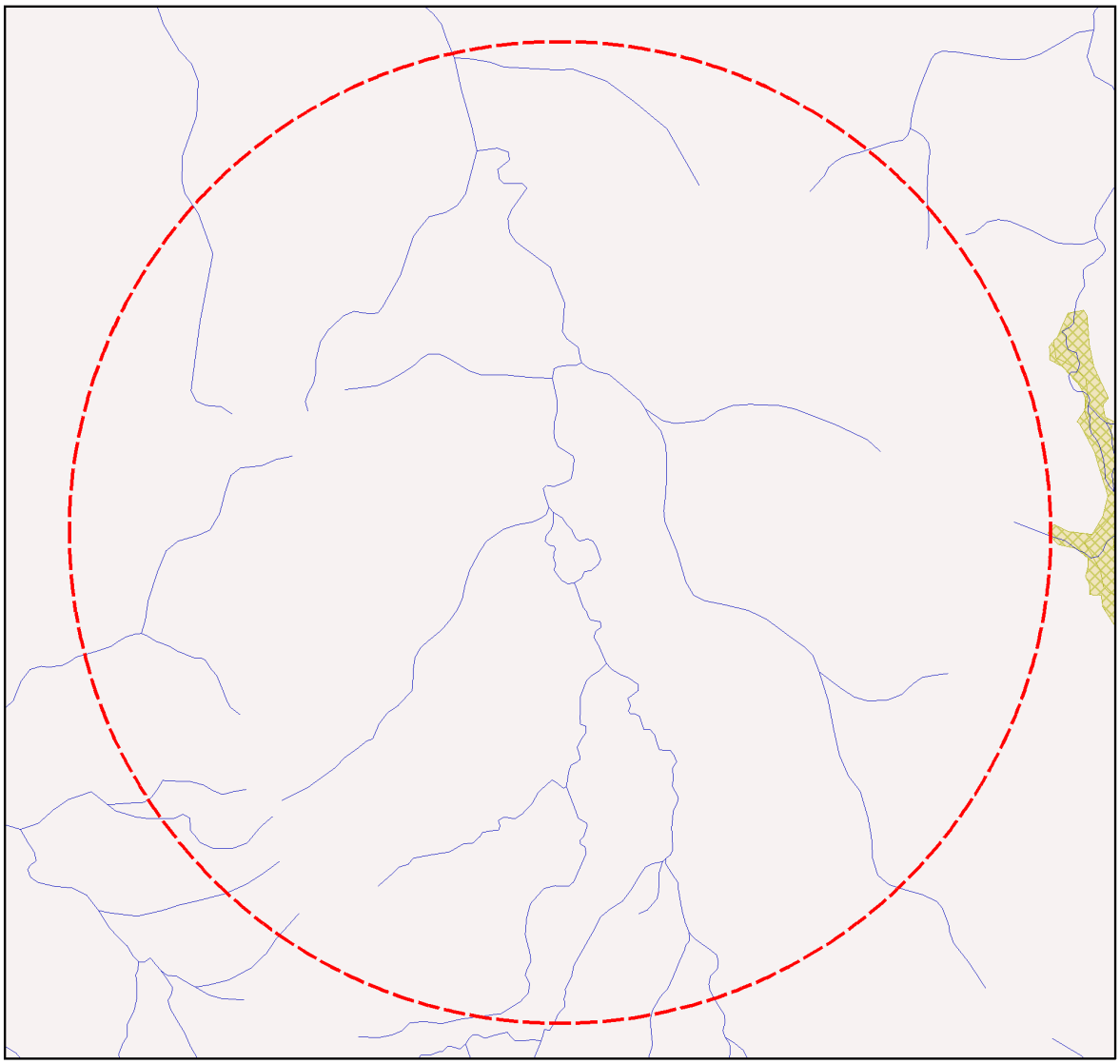
Map 4 - Wetlands and waterways



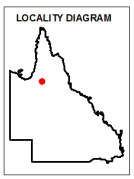
Wetlands and Waterways

Legend

- 2 kilometre buffer
- Towns
- Roads
- Springs
- Rivers/Creeks
- Directory of Important Wetlands
- Ramsar Sites - QLD
- Queensland

Wetland Type

- Marine Waterbodies
- Estuarine Waterbodies
- Riverine Waterbodies
- Lacustrine Waterbodies
- Palustrine Waterbodies
- Marine RE
- Estuarine RE
- Riverine RE
- Lacustrine RE
- Palustrine RE
- RE 51-80% wetland (mosaic units)
- RE 1-50% wetland (mosaic units)



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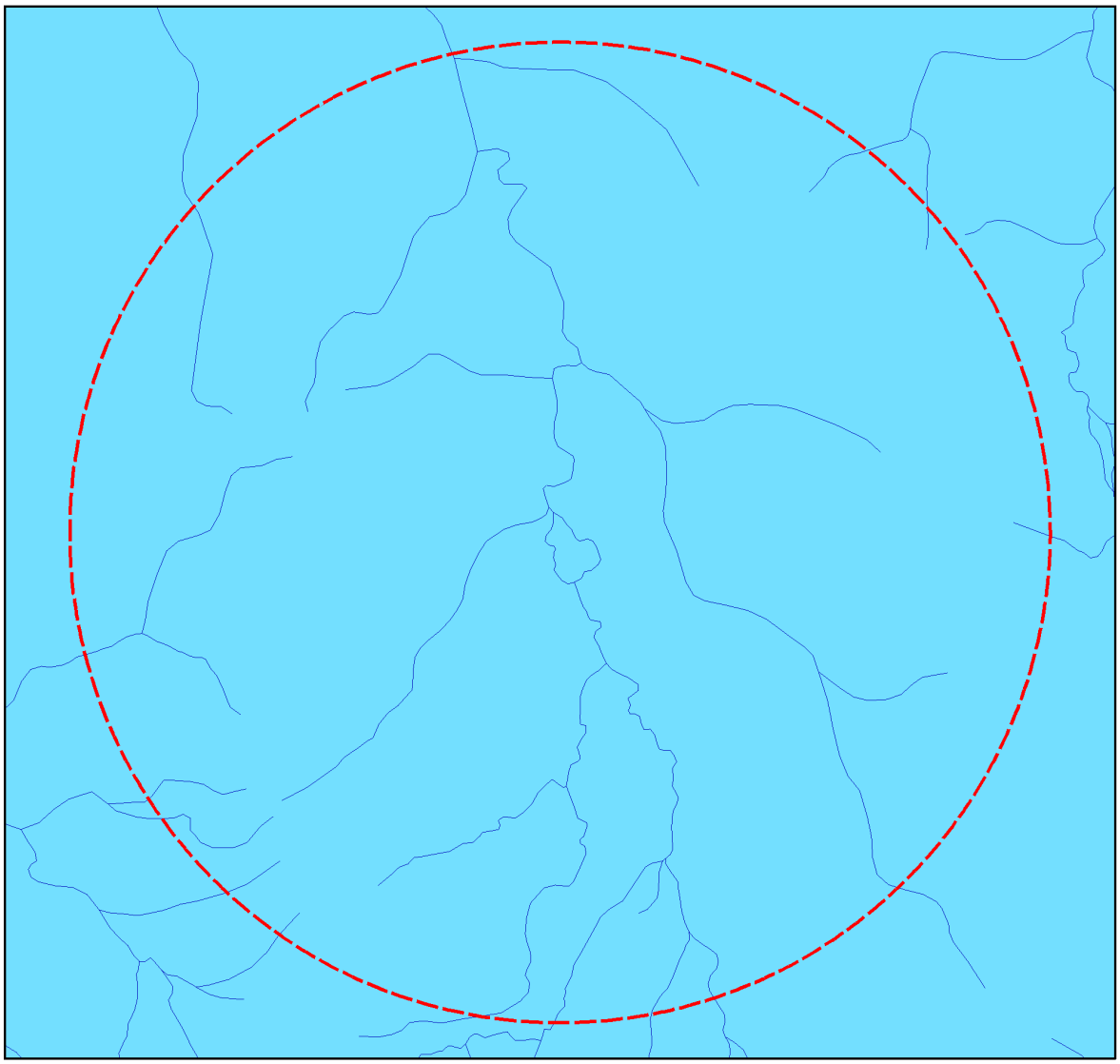
Map 5 - Aquatic Conservation Assessment (ACA) - riverine



Aquatic Conservation Assessment (ACA) - riverine

Legend

- 2 kilometre buffer
- Towns
- Roads
- Rivers/Creeks
- Queensland

ACA Riverine - Subcatchment Significance

- Very High
- High
- Medium
- Low
- Very Low

LOCALITY DIAGRAM

N

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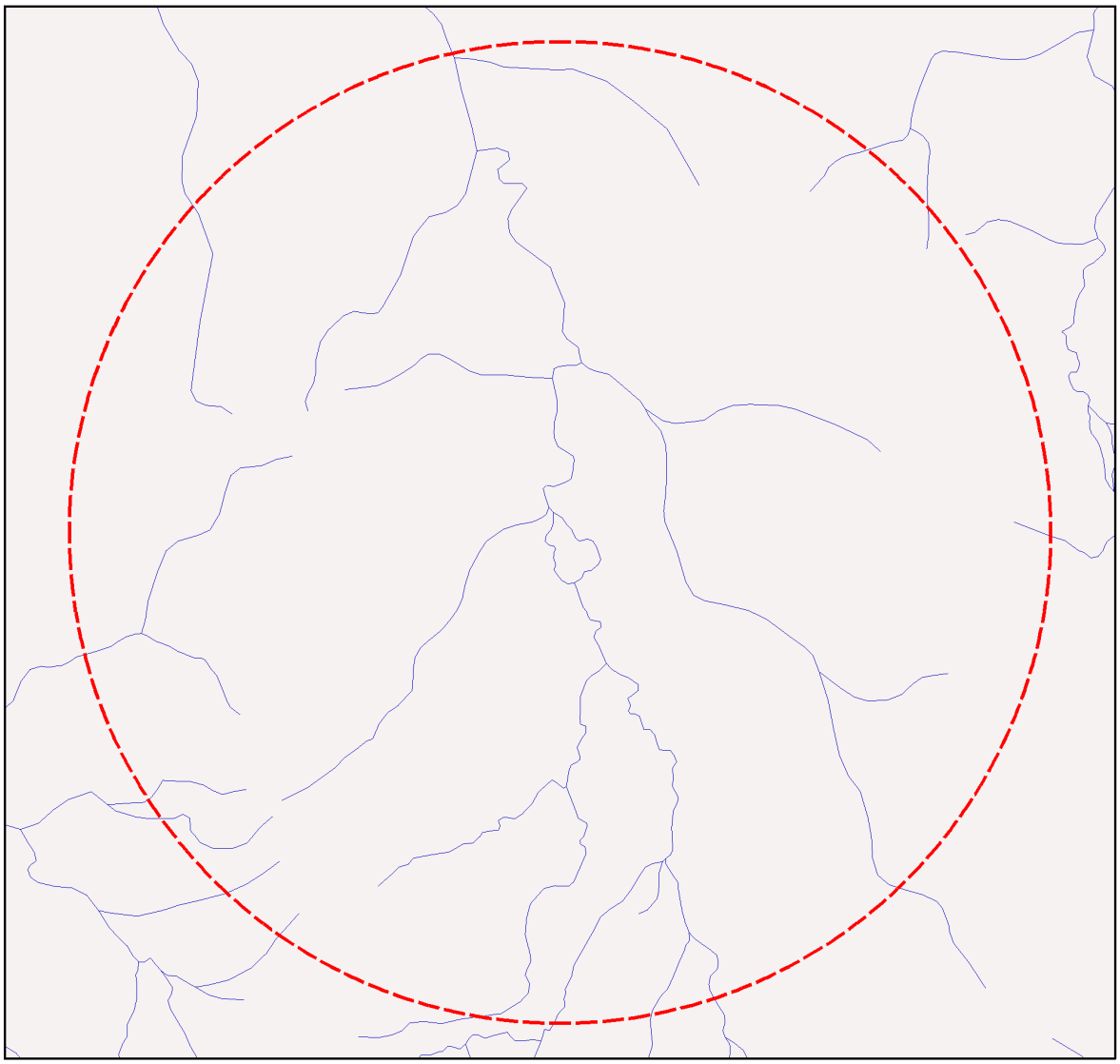
Map 6 - Aquatic Conservation Assessment (ACA) - non-riverine



Aquatic Conservation Assessment (ACA) - nonriverine

Legend

- 2 kilometre buffer
- Towns
- Roads
- Rivers/Creeks
- Queensland

ACA Non-riverine

- Very High
- High
- Medium
- Low
- Very Low

LOCALITY DIAGRAM

N

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References

Clayton, P.D., Fielder, D.F., Howell, S. and Hill, C.J. (2006) *Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool for wetlands with trial application in the Burnett River catchment.* Published by the Environmental Protection Agency, Brisbane. ISBN 1-90928-07-3. Available at

http://wetlandinfo.des.qld.gov.au/wetlands/assessment/assessment-methods/aca/

Environment and Heritage Protection 2014, *Biodiversity Assessment and Mapping Methodology.* Version 2.2. Department of Environment and Heritage Protection, Brisbane.

Morton, S. R., Short, J. and Barker, R. D. with an Appendix by G.F. Griffin and G. Pearce (1995). *Refugia for Biological Diversity in Arid and Semi-arid Australia. Biodiversity Series* , Paper No. 4, Biodiversity Unit, Environment Australia.

Sattler, P.S. and Williams, R.D. (eds) (1999). *The Conservation Status of Queensland's Bioregional Ecosystems*. Environmental Protection Agency, Brisbane.

Appendices

Appendix 1 - Source Data

Theme	Datasets
Aquatic Conservation Assessments Non-riverine*	Combination of the following datasets: Cape York Peninsula Non-riverine v1.1 Eastern Gulf of Carpentaria v1.1 Great Barrier Reef Catchment Non-riverine v1.3 Lake Eyre and Bulloo Basins v1.1 QMDB Non-riverine ACA v1.4 Southeast Queensland ACA v1.1 WBB Non-riverine ACA v1.1 Southern Gulf Catchments Non-riverine ACA v1.1
Aquatic Conservation Assessments Riverine*	Combination of the following datasets: Cape York Peninsula Riverine v1.1 Eastern Gulf of Carpentaria v1.1 Great Barrier Reef Catchment Riverine v1.1 Lake Eyre and Bulloo Basins v1.1 QMDB Riverine ACA v1.4 Southeast Queensland ACA v1.1 WBB Riverine ACA v1.1 Southern Gulf Catchments Riverine ACA v1.1
Biodiversity Planning Assessments*	Combination of the following datasets: Brigalow Belt BPA v2.1 Cape York Peninsula BPA v1.1 Central Queensland Coast BPA v1.3 Channel Country BPA v1.1 Desert Uplands BPA v1.3 Einasleigh Uplands BPA v1.1 Gulf Plains BPA v1.1 Mitchell Grass Downs BPA v1.1 Mulga Lands BPA v1.4 New England Tableland v2.3 Northwest Highlands v1.1 Southeast Queensland v4.1 Wet Tropics v1.1
Statewide BPA Corridors*	Statewide corridors v1.6
Threatened Species	An internal DES database compiled from Wildnet, Herbrecs, Corveg, the QLD Museum, as well as other incidental sources.
BPA Priority Species	An internal DES database compiled from Wildnet, Herbrecs, Corveg, the QLD Museum, as well as other incidental sources.
ACA Priority Species	An internal DES database compiled from Wildnet, Herbrecs, Corveg, the QLD Museum, as well as other incidental sources.

***These datasets are available at:**

http://dds.information.qld.gov.au/DDS

Appendix 2 - Acronyms and Abbreviations

AOI	- Area of Interest
ACA	- Aquatic Conservation Assessment
AQUABAMM	- Aquatic Biodiversity Assessment and Mapping Methodology
BAMM	- Biodiversity Assessment and Mapping Methodology
BoT	- Back on Track
BPA	- Biodiversity Planning Assessment
CAMBA	- China-Australia Migratory Bird Agreement
DES	- Department of Environment and Science
EPBC	- *Environment Protection and Biodiversity Conservation Act 1999*
EVNT	- Endangered, Vulnerable, Near Threatened
GDA94	- Geocentric Datum of Australia 1994
GIS	- Geographic Information System
JAMBA	- Japan-Australia Migratory Bird Agreement
NCA	- *Nature Conservation Act 1992*
RE	- Regional Ecosystem
REDD	- Regional Ecosystem Description Database
ROKAMBA	- Republic of Korea-Australia Migratory Bird Agreement

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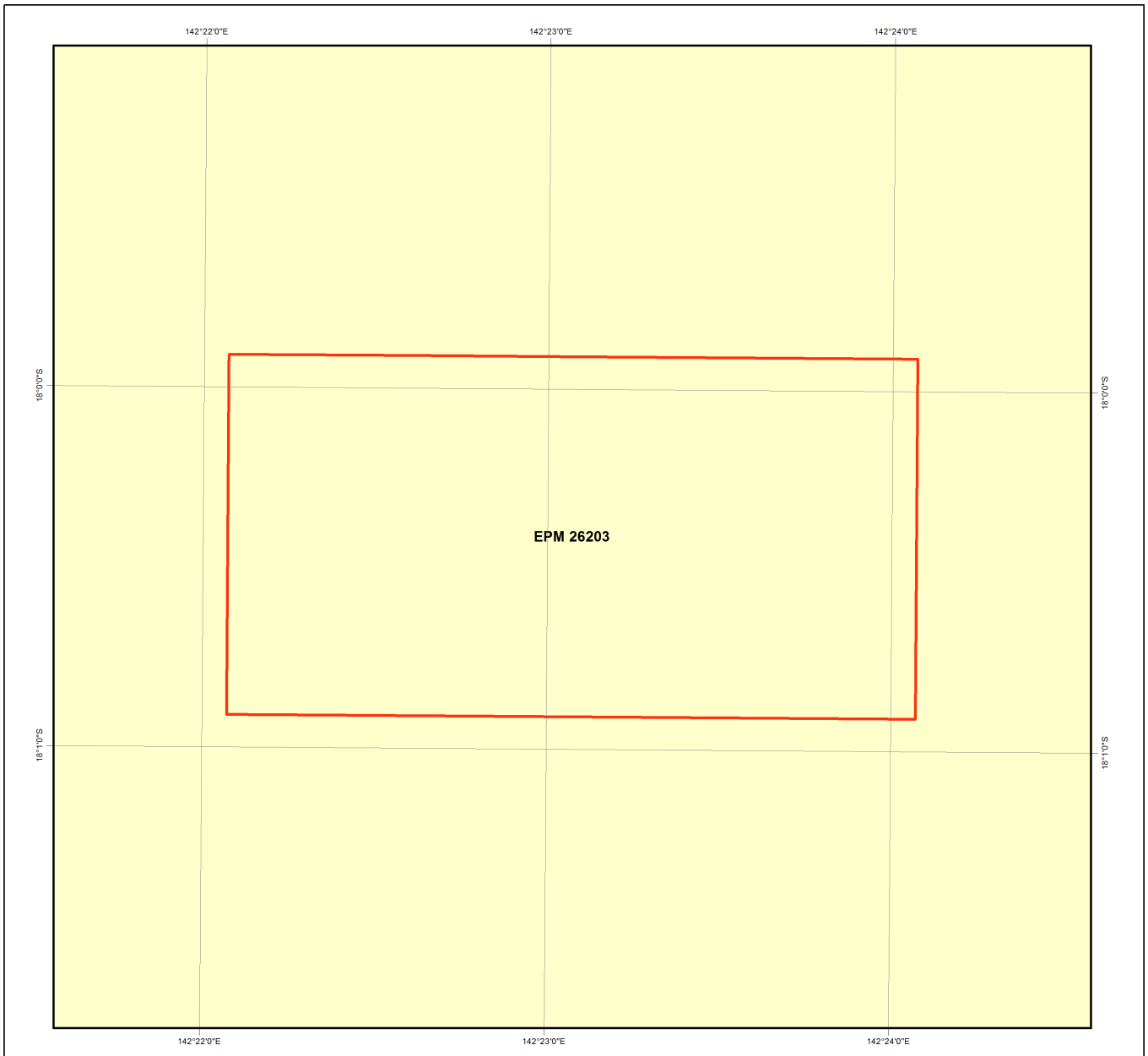


ENVIRONMENTALLY SENSITIVE AREAS - Mining Activities

Selected Exploration Permit Mineral (EPM)

CATEGORY A

- National Parks
- Conservation Parks
- Forest Reserves
- Special Wildlife Reserve
- Wet Tropics World Heritage Area
- Great Barrier Reef Marine Park Area
- Marine Parks other than General Use Zones

CATEGORY B

- Queensland Heritage Register Places
- Ramsar Sites
- Cultural Heritage Registered Areas and DLA's other than Stanbroke
- Special Forestry Areas
- Seaward Side of Highest Astronomical Tide
- Fish Habitat Areas
- Coordinated Conservation Areas
- Endangered Regional Ecosystems - regrowth and remnant (Biodiversity Status)
- General Use Zones of Marine Parks
- Marine Plants

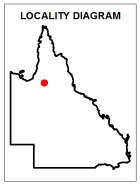
CATEGORY C

- Nature Refuges
- Resources Reserve
- State Forests
- Timber Reserves
- River Improvement Areas
- Stanbroke DLA
- Coastal Management District
- Dams and Weirs

OTHERS

- Towns
- Roads
- Repealed Wild River Nominated Waterways
- Repealed Wild River Preservation Areas
- Repealed Wild River High Preservation Areas
- Mahogany Glider Habitat
- Directory of Important Wetlands
- Queensland

LOCALITY DIAGRAM



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NOTE TO USER: Themes presented in this map are indicative only. Field survey may be required to verify the 'true' spatial extent and value. Not all environmentally sensitive areas are presented in this map. A user should refer to the particular circumstances relevant to their situation to assess the 'completeness' of themes provided.

The user should note that some boundaries and indicated values are ambient and may change over time (e.g. regional ecosystem boundaries and conservation status, watercourse mapping etc).

The user should be aware that due to multiple overlapping themes/ layers present, some themes/layers may be obscured by others. Ordering in the Legend does not accurately reflect the order by which themes/layers are displayed.

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Queensland Government

Tenure type: Exploration Permit Mineral

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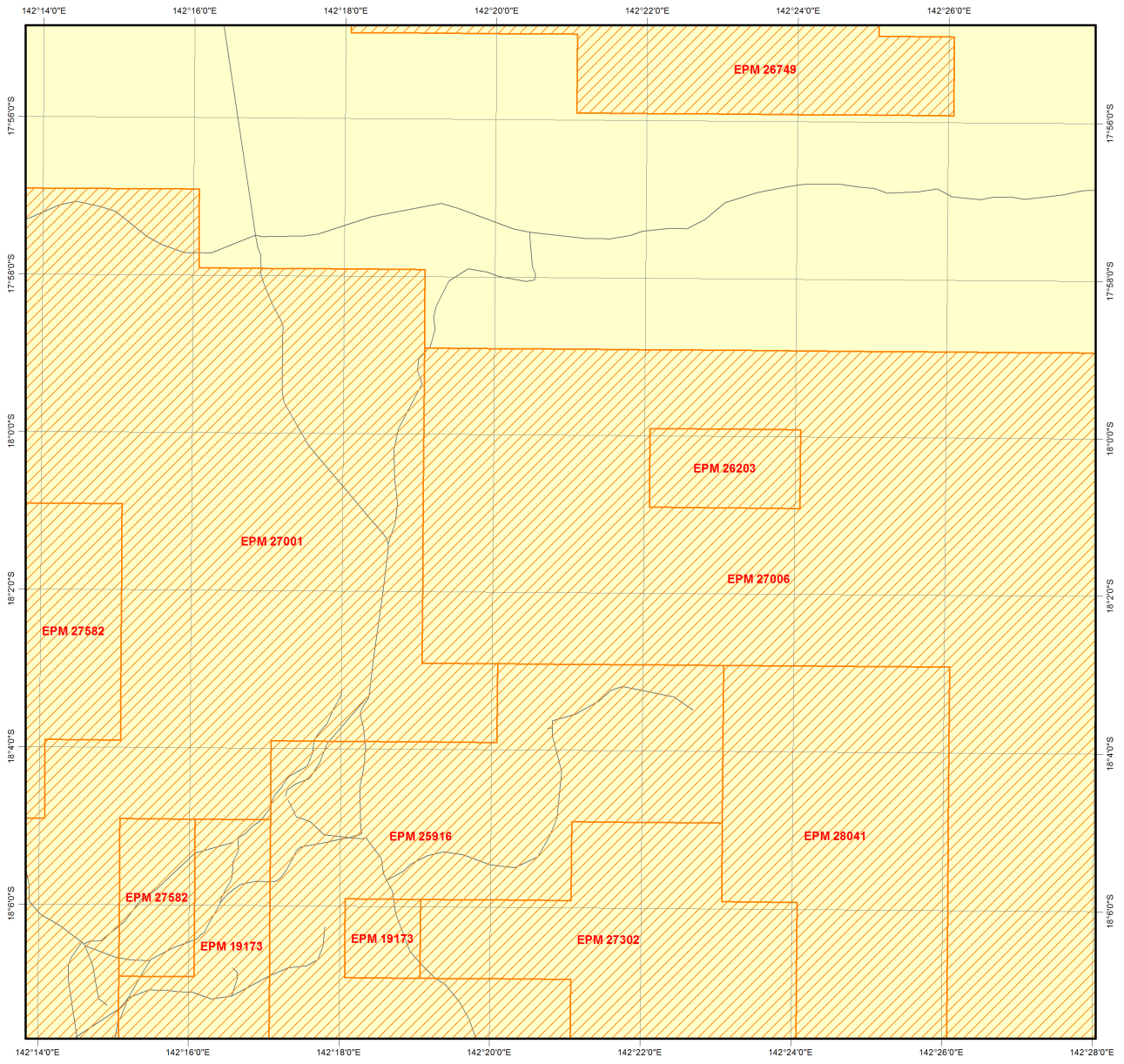


ENVIRONMENTALLY SENSITIVE AREAS - Mining Activities

- Exploration Permits Mineral

CATEGORY A

- National Parks
- Conservation Parks
- Forest Reserves
- Special Wildlife Reserve
- Wet Tropics World Heritage Area
- Great Barrier Reef Marine Park Area
- Marine Parks other than General Use Zones

CATEGORY B

- Queensland Heritage Register Places
- Ramsar Sites
- Cultural Heritage Registered Areas and DLA's other than Stanbroke
- Special Forestry Areas
- Seaward Side of Highest Astronomical Tide
- Fish Habitat Areas
- Coordinated Conservation Areas
- Endangered Regional Ecosystems - regrowth and remnant (Biodiversity Status)
- General Use Zones of Marine Parks
- Marine Plants

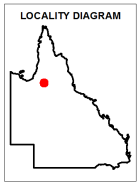
CATEGORY C

- Nature Refuges
- Resources Reserve
- State Forests
- Timber Reserves
- River Improvement Areas
- Stanbroke DLA
- Coastal Management District
- Dams and Weirs

OTHERS

- Towns
- Roads
- Repealed Wild River Nominated Waterways
- Repealed Wild River Preservation Areas
- Repealed Wild River High Preservation Areas
- Mahogany Glider Habitat
- Directory of Important Wetlands
- Queensland

LOCALITY DIAGRAM



N

0 1,300 2,600 3,900 5,200 6,500 m

This product is projected into GDA 1994 MGA Zone 54

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NOTE TO USER: Themes presented in this map are indicative only. Field survey may be required to verify the 'true' spatial extent and value. Not all environmentally sensitive areas are presented in this map. A user should refer to the particular circumstances relevant to their situation to assess the 'completeness' of themes provided.

The user should note that some boundaries and indicated values are ambient and may change over time (e.g. regional ecosystem boundaries and conservation status, watercourse mapping etc).

The user should be aware that due to multiple overlapping themes/ layers present, some themes/layers may be obscured by others. Ordering in the Legend does not accurately reflect the order by which themes/layers are displayed.

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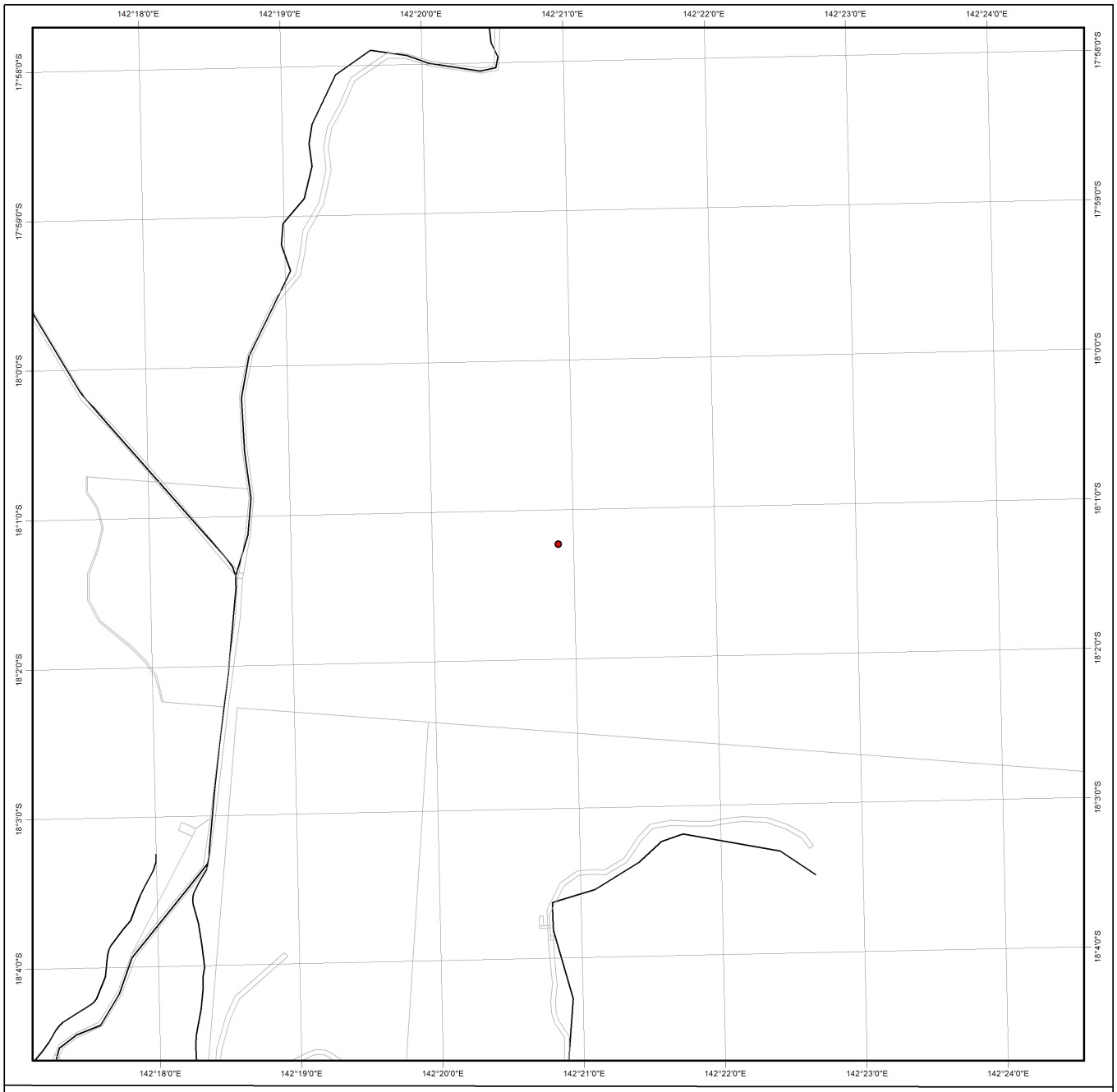
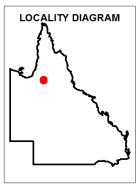
25/11/2022 08:57:41
Longitude: 142.3482 Latitude: -18.0205



Protected Plants Flora Survey Trigger Map

Legend

- Coordinates
- High risk area
- Other land parcel boundaries
- Freeways / motorways / highways
- Secondary roads / streets



N

0 480 960 1,440 1,920 2,400 m

This product is projected into:
GDA 1994 Queensland Albers

This map shows areas where particular provisions of the Nature Conservation Act 1992 apply to the clearing of protected plants.

Land parcel boundaries are provided as locational aid only.

This map is produced at a scale relevant to the size of the area selected and should be printed as A4 size in portrait orientation.

For further information or assistance with interpretation of this product, please contact the Department of Environment and Science at palm@des.qld.gov.au

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Protected plants flora survey trigger map

The protected plants flora survey trigger map identifies 'high risk areas' where threatened and near threatened plants are known to exist or are likely to exist. Under the *Nature Conservation Act 1992* (the Act) it is an offence to clear protected plants that are 'in the wild' unless you are authorised or the clearing is exempt, for more information see section 89 of the Act.

Please see the Department of Environment and Science webpage on the clearing of protected plants for information on what exemptions may apply in your circumstances, whether you may need to undertake a flora survey, and whether you may need a protected plants clearing permit.

Updates to the data informing the flora survey trigger map

The flora survey trigger map will be reviewed, and updated if necessary, at least every 12 months to ensure the map reflects the most up-to-date and accurate data available.

Species information

Please note that flora survey trigger maps do not identify species associated with 'high risk areas'. While some species information may be publicly available, for example via the Queensland Spatial Catalogue, the Department of Environment and Science does not provide species information on request. Regardless of whether species information is available for a particular high risk area, clearing plants in a high risk area may require a flora survey and/or clearing permit. Please see the Department of Environment and Science webpage on the clearing of protected plants for more information.

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Department of Environment and Science

Environmental Reports

Matters of State Environmental Significance

For the selected area of interest
Longitude: 142.3482 Latitude: -18.0205 with 2 kilometre radius

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or area of interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "central coordinates" option, the resulting assessment area encompasses an area extending for a 2km radius from the point of interest.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 1994). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no values have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Please direct queries about these reports to: Planning.Support@des.qld.gov.au

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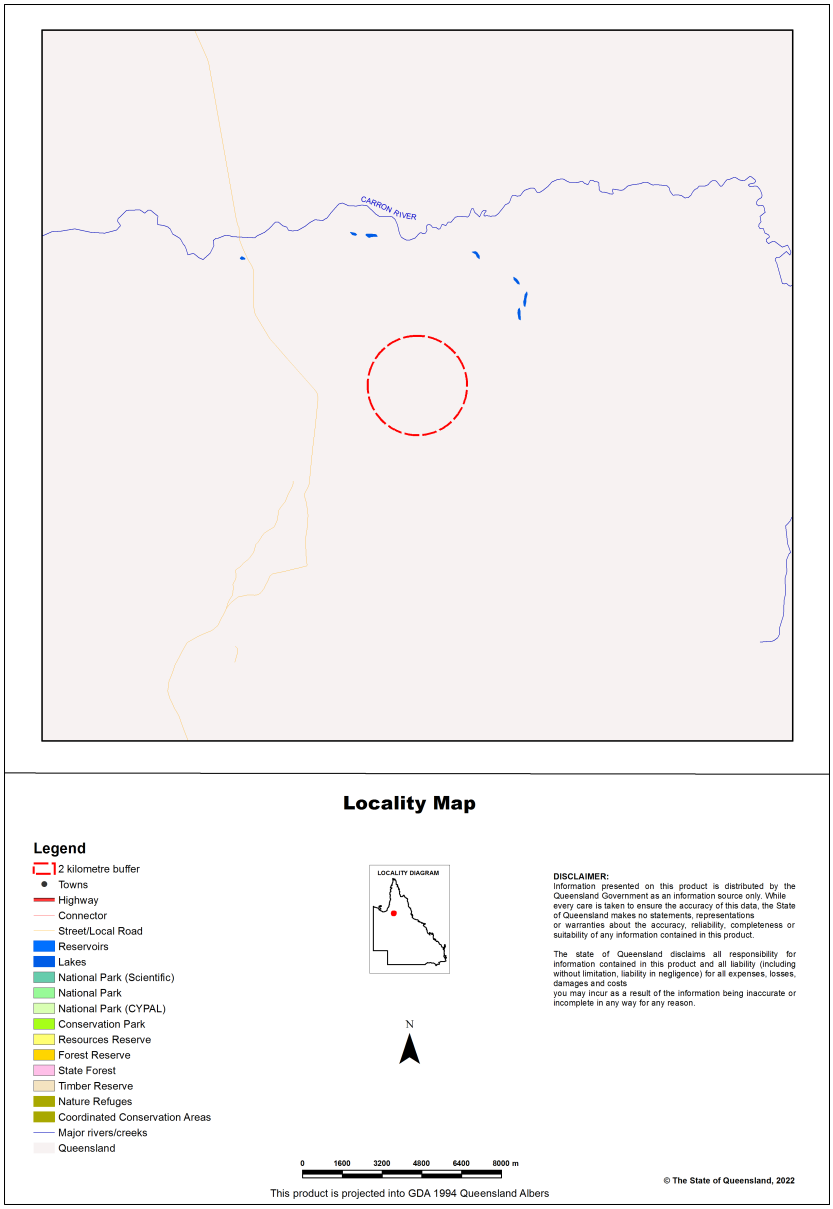
Assessment Area Details

The following table provides an overview of the area of interest (AOI) with respect to selected topographic and environmental values.

Table 1: Summary table, details for AOI Longitude: 142.3482 Latitude: -18.0205

Size (ha)	1,256.55
Local Government(s)	Croydon Shire
Bioregion(s)	Gulf Plains, Einasleigh Uplands
Subregion(s)	Georgetown - Croydon, Mitchell - Gilbert Fans
Catchment(s)	Norman



Matters of State Environmental Significance (MSES)

MSES Categories

Queensland's State Planning Policy (SPP) includes a biodiversity State interest that states:

'The sustainable, long-term conservation of biodiversity is supported. Significant impacts on matters of national or state environmental significance are avoided, or where this cannot be reasonably achieved; impacts are minimised and residual impacts offset.'

The MSES mapping product is a guide to assist planning and development assessment decision-making. Its primary purpose is to support implementation of the SPP biodiversity policy. While it supports the SPP, the mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations. Similarly, the SPP biodiversity policy does not override or replace specific requirements of other Acts or regulations.

The SPP defines matters of state environmental significance as:

- Protected areas (including all classes of protected area except coordinated conservation areas) under the *Nature Conservation Act 1992* ;

- Marine parks and land within a 'marine national park', 'conservation park', 'scientific research', 'preservation' or 'buffer' zone under the *Marine Parks Act 2004* ;

- Areas within declared fish habitat areas that are management A areas or management B areas under the Fisheries Regulation 2008;

- Threatened wildlife under the *Nature Conservation Act 1992* and special least concern animals under the Nature Conservation (Wildlife) Regulation 2006;

- Regulated vegetation under the *Vegetation Management Act 1999* that is:

    • Category B areas on the regulated vegetation management map, that are 'endangered' or 'of concern' regional ecosystems;

    • Category C areas on the regulated vegetation management map that are 'endangered' or 'of concern' regional ecosystems;

    • Category R areas on the regulated vegetation management map;

    • Regional ecosystems that intersect with watercourses identified on the vegetation management watercourse and drainage feature map;

    • Regional ecosystems that intersect with wetlands identified on the vegetation management wetlands map;

- Strategic Environmental Areas under the *Regional Planning Interests Act 2014* ;

- Wetlands in a wetland protection area of wetlands of high ecological significance shown on the Map of Queensland Wetland Environmental Values under the Environment Protection Regulation 2019;

- Wetlands and watercourses in high ecological value waters defined in the Environmental Protection (Water) Policy 2009, schedule 2;

- Legally secured offset areas.

MSES Values Present

The MSES values that are present in the area of interest are summarised in the table below:

Table 2: Summary of MSES present within the AOI

1a Protected Areas- estates	0.0 ha	0.0 %
1b Protected Areas- nature refuges	0.0 ha	0.0 %
1c Protected Areas- special wildlife reserves	0.0 ha	0.0 %
2 State Marine Parks- highly protected zones	0.0 ha	0.0 %
3 Fish habitat areas (A and B areas)	0.0 ha	0.0 %
4 Strategic Environmental Areas (SEA)	0.0 ha	0.0 %
5 High Ecological Significance wetlands on the map of Referable Wetlands	0.0 ha	0.0 %
6a High Ecological Value (HEV) wetlands	0.0 ha	0.0 %
6b High Ecological Value (HEV) waterways	0.0 km	Not applicable
7a Threatened (endangered or vulnerable) wildlife	0.0 ha	0.0 %
7b Special least concern animals	0.0 ha	0.0 %
7c i Koala habitat area - core (SEQ)	0.0 ha	0.0 %
7c ii Koala habitat area - locally refined (SEQ)	0.0 ha	0.0 %
7d Sea turtle nesting areas	0.0 km	Not applicable
8a Regulated Vegetation - Endangered/Of concern in Category B (remnant)	0.0 ha	0.0 %
8b Regulated Vegetation - Endangered/Of concern in Category C (regrowth)	0.0 ha	0.0 %
8c Regulated Vegetation - Category R (GBR riverine regrowth)	0.0 ha	0.0 %
8d Regulated Vegetation - Essential habitat	0.0 ha	0.0 %
8e Regulated Vegetation - intersecting a watercourse	22.0 km	Not applicable
8f Regulated Vegetation - within 100m of a Vegetation Management Wetland	0.0 ha	0.0 %
9a Legally secured offset areas- offset register areas	0.0 ha	0.0 %
9b Legally secured offset areas- vegetation offsets through a Property Map of Assessable Vegetation	0.0 ha	0.0 %

Additional Information with Respect to MSES Values Present

MSES - State Conservation Areas

1a. Protected Areas - estates

(no results)

1b. Protected Areas - nature refuges

(no results)

1c. Protected Areas - special wildlife reserves

(no results)

2. State Marine Parks - highly protected zones

(no results)

3. Fish habitat areas (A and B areas)

(no results)

Refer to **Map 1 - MSES - State Conservation Areas** for an overview of the relevant MSES.

MSES - Wetlands and Waterways

4. Strategic Environmental Areas (SEA)

(no results)

5. High Ecological Significance wetlands on the Map of Queensland Wetland Environmental Values

(no results)

6a. Wetlands in High Ecological Value (HEV) waters

(no results)

6b. Waterways in High Ecological Value (HEV) waters

(no results)

Refer to **Map 2 - MSES - Wetlands and Waterways** for an overview of the relevant MSES.

MSES - Species

7a. Threatened (endangered or vulnerable) wildlife

Not applicable

7b. Special least concern animals

Not applicable

7c i. Koala habitat area - core (SEQ)

Not applicable

7c ii. Koala habitat area - locally refined (SEQ)

Not applicable

7d. Wildlife habitat (sea turtle nesting areas)

Not applicable

Threatened (endangered or vulnerable) wildlife habitat suitability models

Species	Common name	NCA status	Presence
Boronia keysii		V	None
Calyptorhynchus lathami	Glossy black cockatoo	V	None
Casuarius casuarius johnsonii	Sthn population cassowary	E	None
Crinia tinnula	Wallum froglet	V	None
Denisonia maculata	Ornamental snake	V	None
Litoria freycineti	Wallum rocketfrog	V	None
Litoria olongburensis	Wallum sedgefrog	V	None
Macadamia integrifolia		V	None
Macadamia ternifolia		V	None
Macadamia tetraphylla		V	None
Melaleuca irbyana		E	None
Petaurus gracilis	Mahogany Glider	E	None
Petrogale persephone	Proserpine rock-wallaby	E	None
Pezoporus wallicus wallicus	Eastern ground parrot	V	None
Phascolarctos cinereus	Koala - outside SEQ*	V	None
Taudactylus pleione	Kroombit tinkerfrog	E	None
Xeromys myoides	Water Mouse	V	None

**For koala model, this includes areas outside SEQ. Check 7c SEQ koala habitat for presence/absence.*

Threatened (endangered or vulnerable) wildlife species records

(no results)

Special least concern animal species records

(no results)

Shorebird habitat (critically endangered/endangered/vulnerable)

Not applicable

Shorebird habitat (special least concern)

Not applicable

**Nature Conservation Act 1992 (NCA) Status- Endangered (E), Vulnerable (V) or Special Least Concern Animal (SL). Environment Protection and Biodiversity Conservation Act 1999 (EPBC) status: Critically Endangered (CE) Endangered (E), Vulnerable (V)*

Migratory status (M) - China and Australia Migratory Bird Agreement (C), Japan and Australia Migratory Bird Agreement (J), Republic of Korea and Australia Migratory Bird Agreement (R), Bonn Migratory Convention (B), Eastern Flyway (E)

To request a species list for an area, or search for a species profile, access Wildlife Online at:

https://www.qld.gov.au/environment/plants-animals/species-list/

Refer to **Map 3a - MSES - Species - Threatened (endangered or vulnerable) wildlife and special least concern animals, Map 3b - MSES - Species - Koala habitat area (SEQ)** and **Map 3c - MSES - Wildlife habitat (sea turtle nesting areas)** for an overview of the relevant MSES.

MSES - Regulated Vegetation

For further information relating to regional ecosystems in general, go to:

https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/

For a more detailed description of a particular regional ecosystem, access the regional ecosystem search page at:

https://environment.ehp.qld.gov.au/regional-ecosystems/

8a. Regulated Vegetation - Endangered/Of concern in Category B (remnant)

Not applicable

8b. Regulated Vegetation - Endangered/Of concern in Category C (regrowth)

Not applicable

8c. Regulated Vegetation - Category R (GBR riverine regrowth)

Not applicable

8d. Regulated Vegetation - Essential habitat

Not applicable

8e. Regulated Vegetation - intersecting a watercourse**

A vegetation management watercourse is mapped as present

8f. Regulated Vegetation - within 100m of a Vegetation Management wetland

Not applicable

Refer to **Map 4 - MSES - Regulated Vegetation** for an overview of the relevant MSES.

MSES - Offsets

9a. Legally secured offset areas - offset register areas

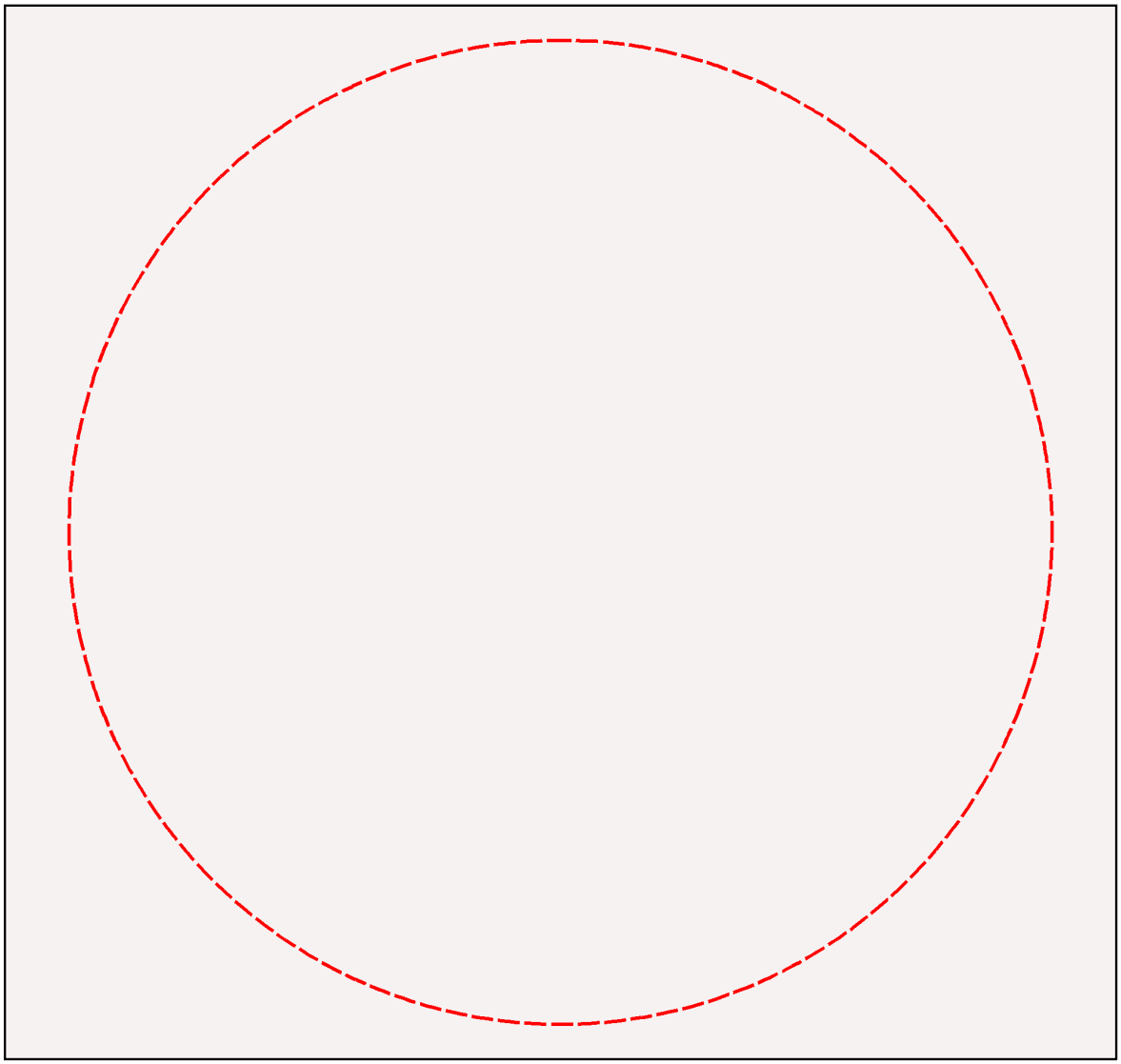
(no results)

9b. Legally secured offset areas - vegetation offsets through a Property Map of Assessable Vegetation

(no results)

Refer to **Map 5 - MSES - Offset Areas** for an overview of the relevant MSES.

Map 1 - MSES - State Conservation Areas

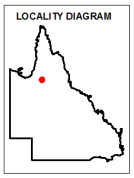


MSES - State Conservation Areas

Area of Interest

- 2 kilometre buffer
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Protected area (estates, nature refuges, special wildlife reserves)
- Declared fish habitat area (A and B areas)
- Marine park (highly protected)

LOCALITY DIAGRAM



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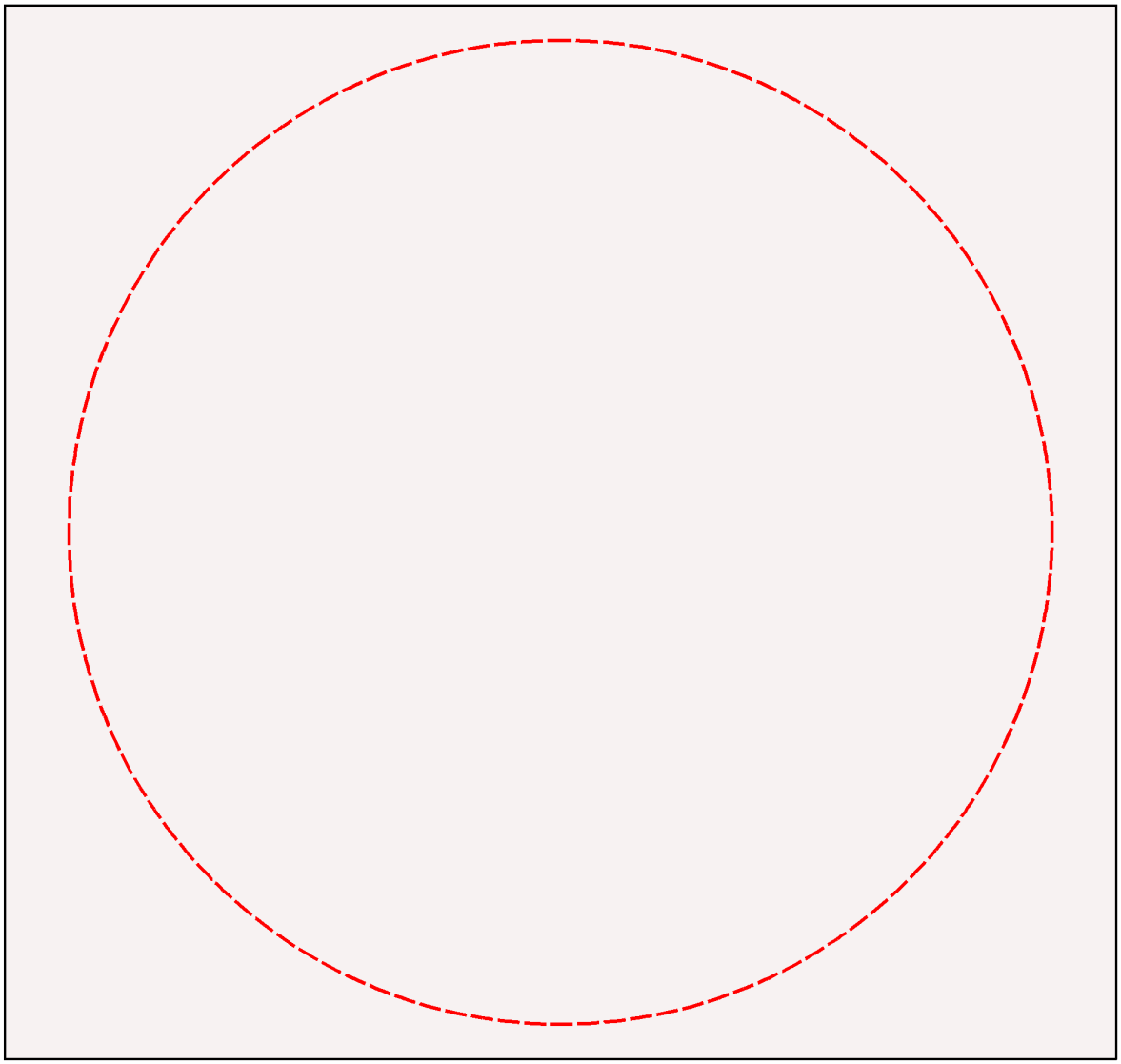
Map 2 - MSES - Wetlands and Waterways

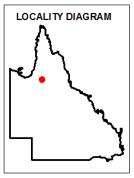


MSES - Wetlands and Waterways

Area of Interest

- 2 kilometre buffer
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Declared high ecological value waters (watercourse)
- Strategic environmental area (designated precinct)
- Declared high ecological value waters (wetland)
- High ecological significance wetlands

LOCALITY DIAGRAM



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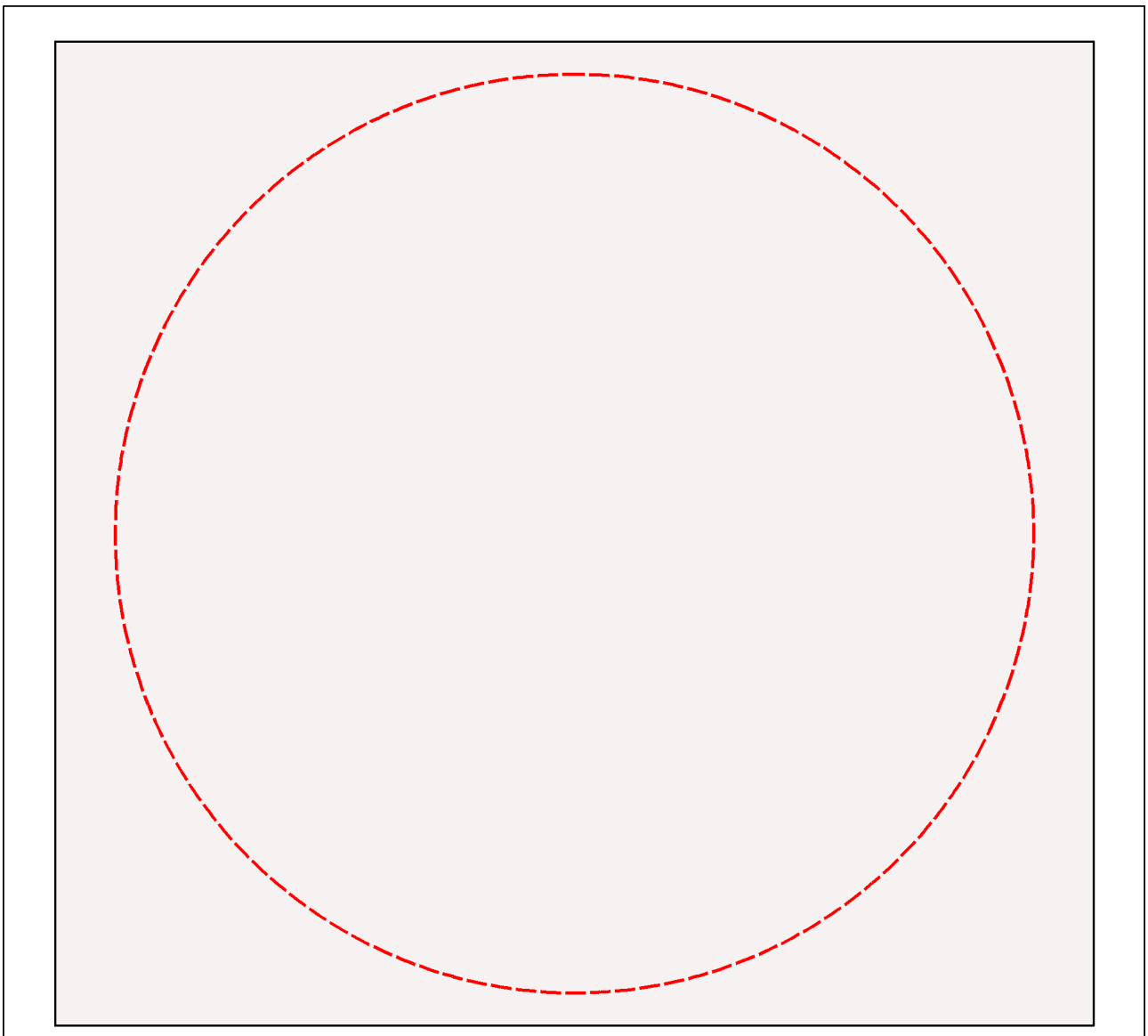
Map 3a - MSES - Species - Threatened (endangered or vulnerable) wildlife and special least concern animals

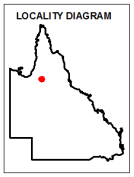


MSES - Species
Threatened (endangered or vulnerable) wildlife and special least concern animals

Area of Interest

- 2 kilometre buffer
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Wildlife habitat (special least concern)
- Wildlife habitat (endangered or vulnerable)

LOCALITY DIAGRAM



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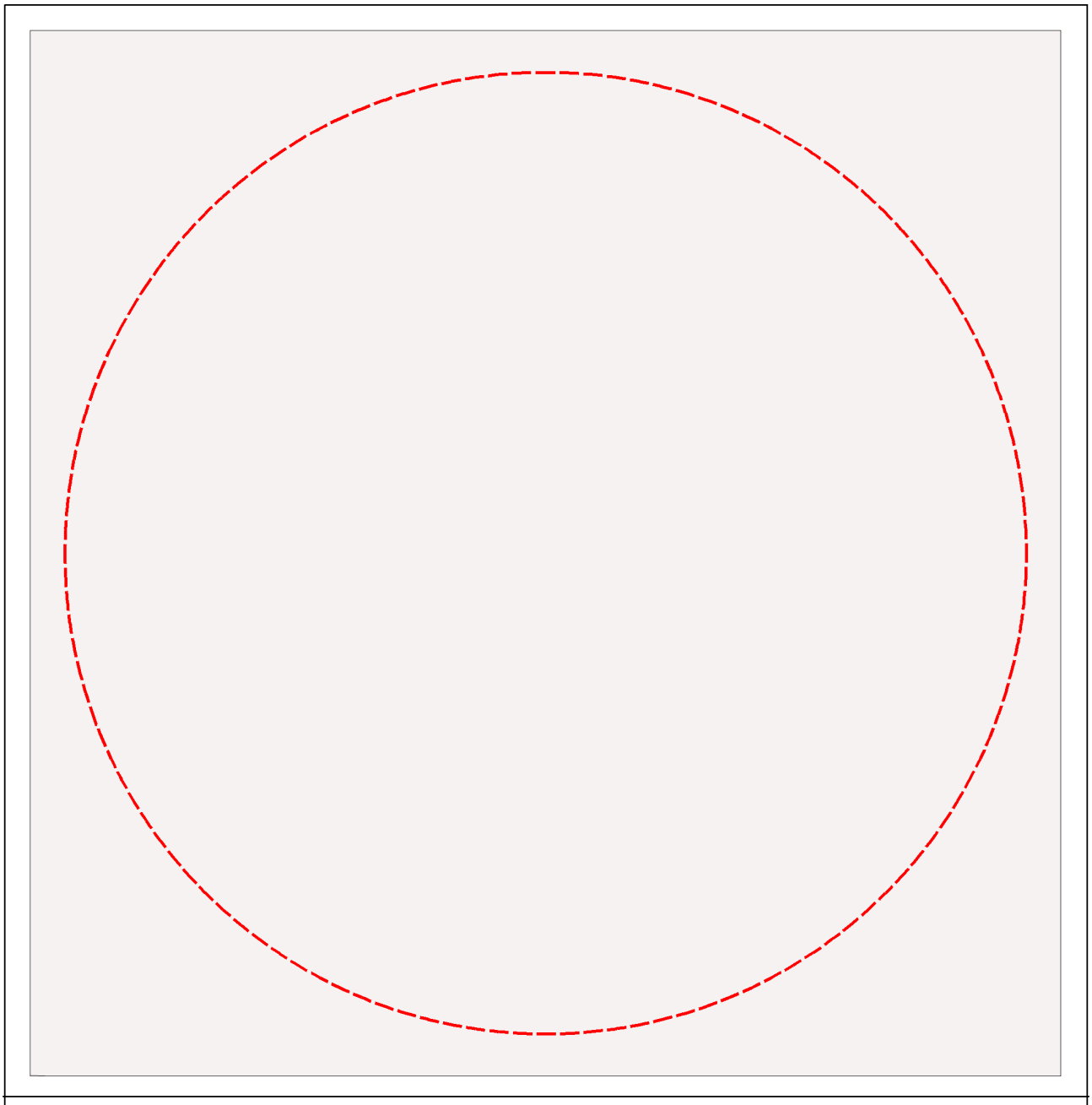
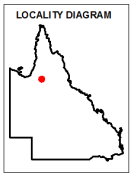
Map 3b - MSES - Species - Koala habitat area (SEQ)



MSES - Species
Koala habitat area (SEQ)

Area of Interest
- 2 kilometre buffer
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Koala habitat area (core)
- Koala habitat area (locally refined)

LOCALITY DIAGRAM



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The represented layers for SEQ 'koala habitat area-core' and 'koala habitat area- locally refined' in MSES are sourced directly from the regulatory mapping under the Nature Conservation (Koala) Conservation Plan 2017. Whilst every effort is made to ensure the information remains current, there may be delays between updating versions. Please refer to the original mapping for the most recent version. See https://environment.des.qld.gov.au/wildlife/animals/living-with/koalas/mapping

The koala habitat mapping within South East Queensland uses regional ecosystem linework compiled at a scale varying from 1:25,000 to 1:100,000. Linework should be used as a guide only. The positional accuracy of regional ecosystem data mapped at a scale of 1:100,000 is +/- 100 metres.

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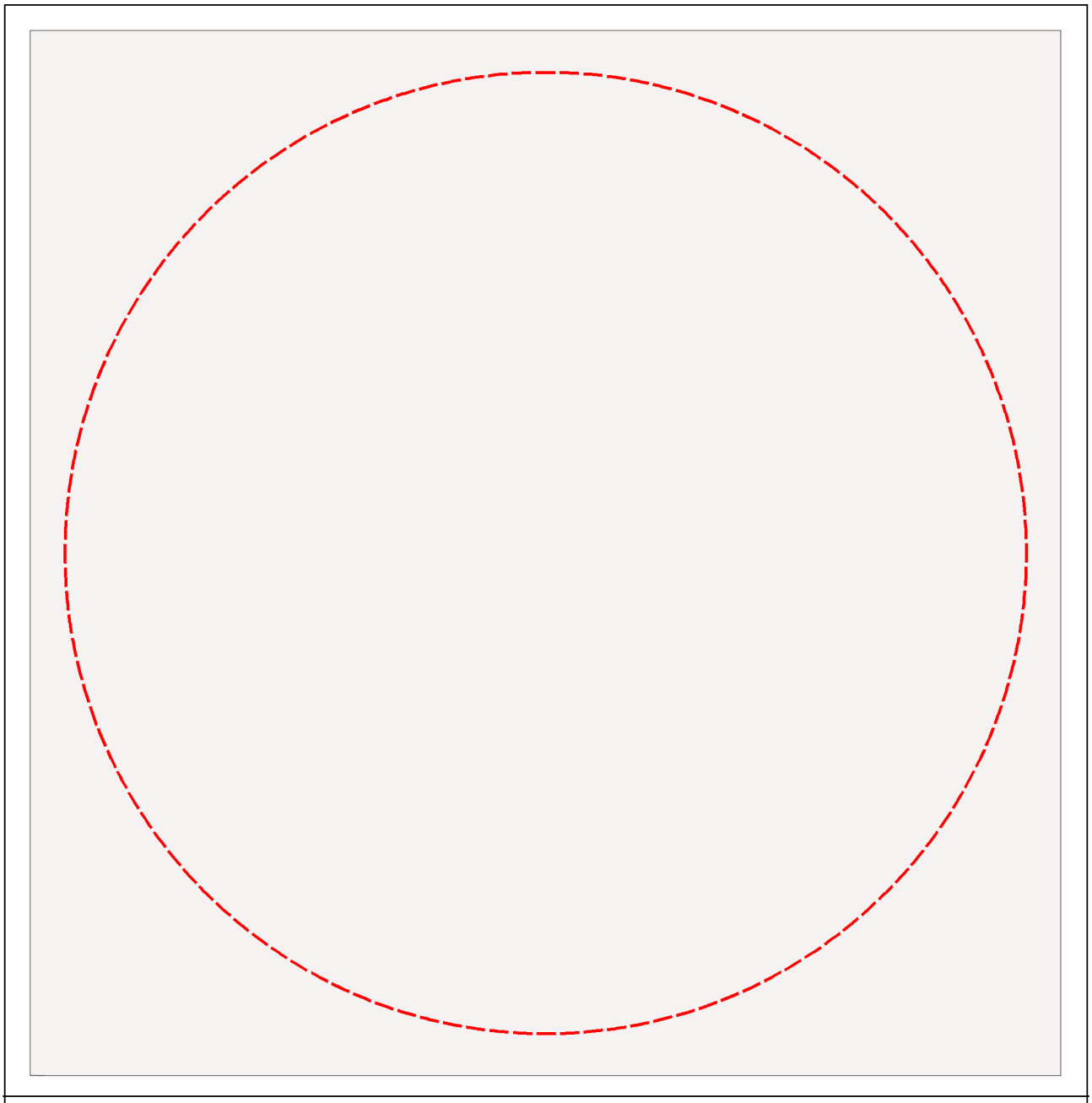
0 220 440 660 880 1,100 m

This product is projected into GDA 1994 Queensland Albers

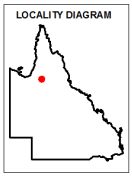
Map 3c - MSES - Wildlife habitat (sea turtle nesting areas)



MSES - Wildlife habitat (sea turtle nesting areas)

Area of Interest
- 2 kilometre buffer
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Wildlife habitat (sea turtle nesting areas)

LOCALITY DIAGRAM



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MSES mapping of sea turtle nesting areas identifies beaches where the recorded number of turtle nests are over 1% of the turtle species or genetic stock. The linework is also deliberately extended along nearby rocky coastlines and headlands to recognise that significant numbers of nesting adults and hatchlings can become disoriented by light pollution from development on rocky coastlines and headlands while navigating offshore from nesting beaches.

0 220 440 660 880 1,100 m

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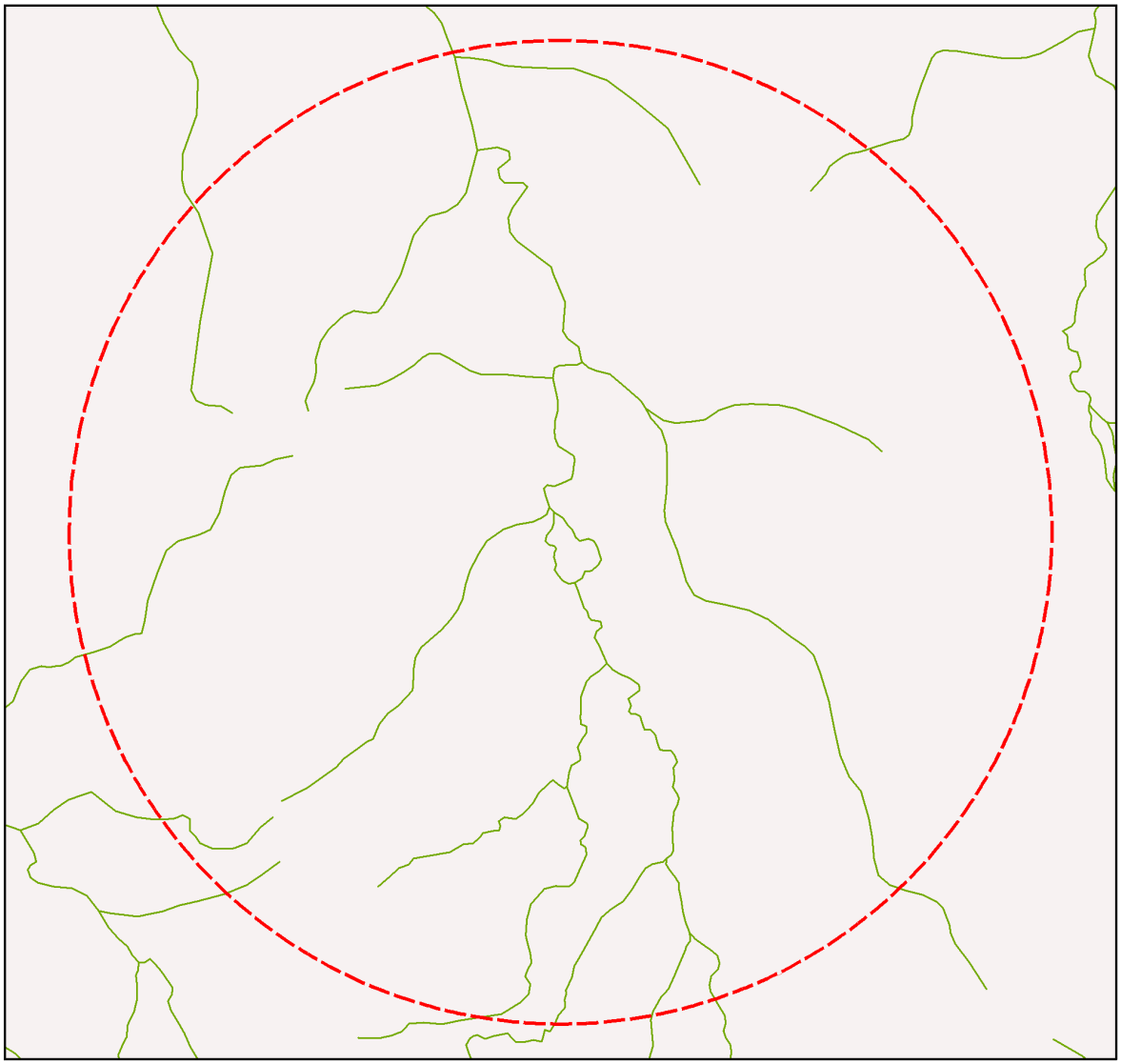
Map 4 - MSES - Regulated Vegetation

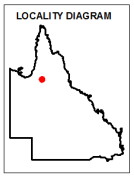


MSES - Regulated Vegetation

Area of Interest

- 2 kilometre buffer
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Regulated vegetation (intersecting a watercourse)
- Regulated vegetation (100m from wetland)
- Regulated vegetation (category B - endangered or of concern)
- Regulated vegetation (category C - endangered or of concern)
- Regulated vegetation (category R - GBR riverine)
- Regulated vegetation (essential habitat)

LOCALITY DIAGRAM



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0 240 480 720 960 1200 m

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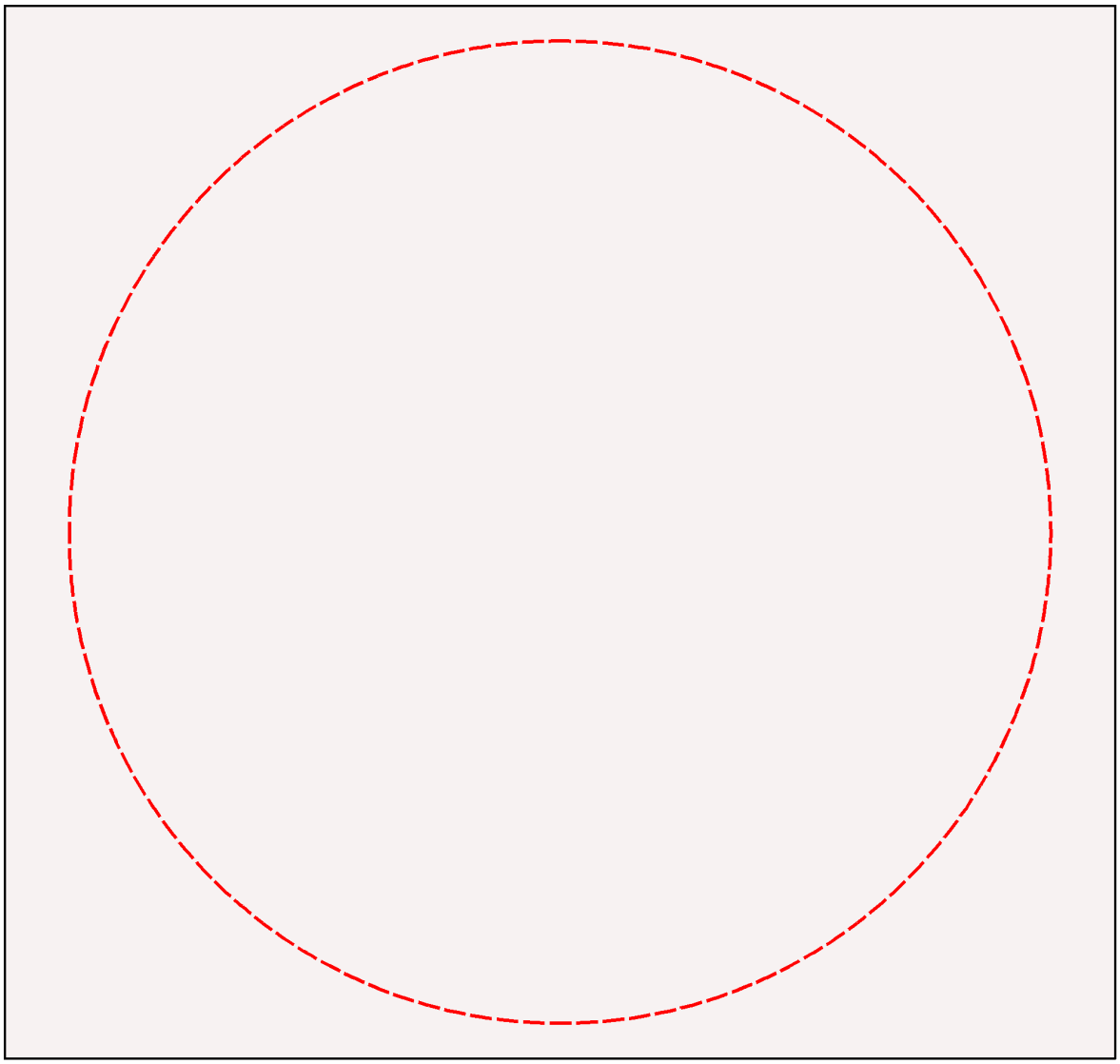
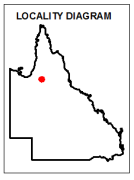
Map 5 - MSES - Offset Areas



MSES - Offsets

Area of Interest

- 2 kilometre buffer
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Legally secured offset area (offset register)
- Legally secured offset area (vegetation offsets)



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Appendices

Appendix 1 - Matters of State Environmental Significance (MSES) methodology

MSES mapping is a regional-scale representation of the definition for MSES under the State Planning Policy (SPP). The compiled MSES mapping product is a guide to assist planning and development assessment decision-making. Its primary purpose is to support implementation of the SPP biodiversity policy. While it supports the SPP, the mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations. Similarly, the SPP biodiversity policy does not override or replace specific requirements of other Acts or regulations.

The Queensland Government's "Method for mapping - matters of state environmental significance for use in land use planning and development assessment" can be downloaded from:

http://www.ehp.qld.gov.au/land/natural-resource/method-mapping-mses.html .

Appendix 2 - Source Data

The datasets listed below are available on request from:

http://qldspatial.information.qld.gov.au/catalogue/custom/index.page

- Matters of State environmental significance

Note: MSES mapping is not based on new or unique data. The primary mapping product draws data from a number of underlying environment databases and geo-referenced information sources. MSES mapping is a versioned product that is updated generally on a twice-yearly basis to incorporate the changes to underlying data sources. Several components of MSES mapping made for the current version may differ from the current underlying data sources. To ensure accuracy, or proper representation of MSES values, it is strongly recommended that users refer to the underlying data sources and review the current definition of MSES in the State Planning Policy, before applying the MSES mapping.

Individual MSES layers can be attributed to the following source data available at QSpatial:

MSES layers	**current QSpatial data (http://qspatial.information.qld.gov.au)**
Protected Areas-Estates, Nature Refuges, Special Wildlife Reserves	- Protected areas of Queensland - Nature Refuges - Queensland - Special Wildlife Reserves- Queensland
Marine Park-Highly Protected Zones	Moreton Bay marine park zoning 2008
Fish Habitat Areas	Queensland fish habitat areas
Strategic Environmental Areas-designated	Regional Planning Interests Act - Strategic Environmental Areas
HES wetlands	Map of Queensland Wetland Environmental Values
Wetlands in HEV waters	HEV waters: - EPP Water intent for waters Source Wetlands: - Queensland Wetland Mapping (Current version 5) Source Watercourses: - Vegetation management watercourse and drainage feature map (1:100000 and 1:250000)
Wildlife habitat (threatened and special least concern)	- WildNet database species records - habitat suitability models (various) - SEQ koala habitat areas under the Koala Conservation Plan 2019 - Sea Turtle Nesting Areas records
VMA regulated regional ecosystems	Vegetation management regional ecosystem and remnant map
VMA Essential Habitat	Vegetation management - essential habitat map
VMA Wetlands	Vegetation management wetlands map
Legally secured offsets	Vegetation Management Act property maps of assessable vegetation. For offset register data-contact DES
Regulated Vegetation Map	Vegetation management - regulated vegetation management map

Appendix 3 - Acronyms and Abbreviations

AOI	- Area of Interest
DES	- Department of Environment and Science
EP Act	- *Environmental Protection Act 1994*
EPP	- Environmental Protection Policy
GDA94	- Geocentric Datum of Australia 1994
GEM	- General Environmental Matters
GIS	- Geographic Information System
MSES	- Matters of State Environmental Significance
NCA	- *Nature Conservation Act 1992*
RE	- Regional Ecosystem
SPP	- State Planning Policy
VMA	- *Vegetation Management Act 1999*

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 25-Nov-2022

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	9
Listed Migratory Species:	13

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	18
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	None
Regional Forest Agreements:	None
Nationally Important Wetlands:	None
EPBC Act Referrals:	1
Key Ecological Features (Marine):	None
Biologically Important Areas:	None
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Listed Threatened Species			[Resource Information]
Status of Conservation Dependent and Extinct are not MNES under the EPBC Act. Number is the current name ID.			
Scientific Name	Threatened Category	Presence Text	Buffer Status
BIRD			
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat may occur within area	In feature area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat likely to occur within area	In feature area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat may occur within area	In feature area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area	In feature area
Tyto novaehollandiae kimberli Masked Owl (northern) [26048]	Vulnerable	Species or species habitat may occur within area	In feature area
MAMMAL			
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat may occur within area	In feature area
Saccolaimus saccolaimus nudicluniatus Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889]	Vulnerable	Species or species habitat may occur within area	In buffer area only

Scientific Name	Threatened Category	Presence Text	Buffer Status
SHARK			
Pristis pristis			
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area	In feature area

Listed Migratory Species [Resource Information]

Scientific Name	Threatened Category	Presence Text	Buffer Status
Migratory Marine Birds			
Apus pacificus			
Fork-tailed Swift [678]		Species or species habitat likely to occur within area	In feature area
Migratory Marine Species			
Pristis pristis			
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area	In feature area
Migratory Terrestrial Species			
Cuculus optatus			
Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area	In feature area
Hirundo rustica			
Barn Swallow [662]		Species or species habitat may occur within area	In feature area
Motacilla cinerea			
Grey Wagtail [642]		Species or species habitat may occur within area	In feature area
Motacilla flava			
Yellow Wagtail [644]		Species or species habitat may occur within area	In feature area
Migratory Wetlands Species			
Actitis hypoleucos			
Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area
Calidris acuminata			
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area	In feature area
Calidris ferruginea			
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
[Calidris melanotos](#)			
Pectoral Sandpiper [858]		Species or species habitat may occur within area	In feature area
[Charadrius veredus](#)			
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area	In feature area
[Gallinago hardwickii](#)			
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area	In feature area
[Glareola maldivarum](#)			
Oriental Pratincole [840]		Species or species habitat may occur within area	In feature area

Other Matters Protected by the EPBC Act

Listed Marine Species			[Resource Information]
Scientific Name	Threatened Category	Presence Text	Buffer Status
Bird			
[Actitis hypoleucos](#)			
Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area
[Anseranas semipalmata](#)			
Magpie Goose [978]		Species or species habitat may occur within area overfly marine area	In feature area
[Apus pacificus](#)			
Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area	In feature area
[Bubulcus ibis as Ardea ibis](#)			
Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area	In feature area
[Calidris acuminata](#)			
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area	In feature area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area	In feature area
Chalcites osculans as Chrysococcyx osculans Black-eared Cuckoo [83425]		Species or species habitat may occur within area overfly marine area	In feature area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area overfly marine area	In feature area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area overfly marine area	In feature area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area overfly marine area	In feature area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area	In feature area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area overfly marine area	In feature area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
[Motacilla cinerea](#) Grey Wagtail [642]		Species or species habitat may occur within area overfly marine area	In feature area
[Motacilla flava](#) Yellow Wagtail [644]		Species or species habitat may occur within area overfly marine area	In feature area
[Rostratula australis as Rostratula benghalensis (sensu lato)](#) Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area overfly marine area	In feature area
Reptile			
[Crocodylus johnstoni](#) Freshwater Crocodile, Johnston's Crocodile, Johnstone's Crocodile [1773]		Species or species habitat may occur within area	In feature area

Extra Information

EPBC Act Referrals				[Resource Information]
Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Not controlled action				
[Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia](#)	2015/7522	Not Controlled Action	Completed	In feature area

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact us page.

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Queensland Government

Department of Environment and Science

Environmental Reports

Regional Ecosystems

Biodiversity Status

For the selected area of interest
Longitude: 142.3482 Latitude: -18.0205 with 2 kilometre radius

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or area of interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "central coordinates" option, the resulting assessment area encompasses an area extending for a 2km radius from the input coordinates.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 1994). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no matters of interest have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Important Note to User

Information presented in this report is based upon the Queensland Herbarium's Regional Ecosystem framework. The Biodiversity Status has been used to depict the extent of "Endangered", "Of Concern" and "No Concern at Present" regional ecosystems in all cases, rather than the classes used for the purposes of the *Vegetation Management Act 1999* (VMA). Mapping and figures presented in this document reflect the Queensland Herbarium's Remnant and Pre-clearing Regional Ecosystem Datasets, and not the certified mapping used for the purpose of the VMA.

For matters relevant to vegetation management under the VMA, please refer to the Department of Resources website https://www.resources.qld.gov.au/

Please direct queries about these reports to: Queensland.Herbarium@qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of the information provided in this report, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness, or suitability, for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which the user may incur as a consequence of the information being inaccurate or incomplete in any way and for any reason.

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Summary Information

The following table provides an overview of the AOI with respect to selected topographic and environmental themes. Refer to **Map 1** for locality information.

Table 1: Area of interest details: Longitude: 142.3482 Latitude: -18.0205 with 2 kilometre radius

Size (ha)	1,256.55
Local Government(s)	Croydon Shire
Bioregion(s)	Gulf Plains, Einasleigh Uplands
Subregion(s)	Georgetown - Croydon, Mitchell - Gilbert Fans
Catchment(s)	Norman

The table below summarizes the extent of remnant vegetation classed as "Endangered", "Of concern" and "No concern at present" regional ecosystems classified by Biodiversity Status within the area of interest (AOI).

Table 2: Summary table, biodiversity status of regional ecosystems within the AOI

Biodiversity Status	Area (Ha)	% of AOI
Endangered	0.0	0.0
Of concern	104.86	8.34
No concern at present	1,151.69	91.66
Total remnant vegetation	1,256.55	100.0

Refer to **Map 2** for further information.

Regional Ecosystems

1. Introduction

Regional ecosystems are vegetation communities in a bioregion that are consistently associated with particular combinations of geology, landform and soil (Sattler and Williams 1999). Descriptions of Queensland's Regional ecosystems are available online from the Regional Ecosystem Description Database (REDD). Descriptions are compiled from a broad range of information sources including vegetation, land system and geology survey and mapping and detailed vegetation site data. The regional ecosystem classification and descriptions are reviewed as new information becomes available. A number of vegetation communities may form a single regional ecosystem and are usually distinguished by differences in dominant species, frequently in the shrub or ground layers and are denoted by a letter following the regional ecosystem code (e.g. a, b, c). Vegetation communities and regional ecosystems are amalgamated into a higher level classification of broad vegetation groups (BVGs).

A published methodology for survey and mapping of regional ecosystems across Queensland (Neldner et al 2020) provides further details on regional ecosystem concepts and terminology.

This report provides information on the type, status, and extent of vegetation communities, regional ecosystems and broad vegetation groups present within a user specified area of interest. Please note, for the purpose of this report, the Biodiversity Status is used. This report has not been developed for application of the *Vegetation Management Act 1999* (VMA). Additionally, information generated in this report has been derived from the Queensland Herbarium's Regional Ecosystem Mapping, and not the regulated mapping certified for the purposes of the VMA. If your interest/matter relates to regional ecosystems and the VMA, users should refer to the Department of Resources website.

https://www.resources.qld.gov.au/

With respect to the Queensland Biodiversity Status,

"Endangered" regional ecosystems are described as those where:

- remnant vegetation is less than 10 per cent of its pre-clearing extent across the bioregion; or 10-30% of its pre-clearing extent remains and the remnant vegetation is less than 10,000 hectares, or
- less than 10 per cent of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss*, or
- 10-30 per cent of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss and the remnant vegetation is less than 10,000 hectares; or
- it is a rare** regional ecosystem subject to a threatening process.***

"Of concern" regional ecosystems are described as those where:

- the degradation criteria listed above for 'Endangered' regional ecosystems are not met and,
- remnant vegetation is 10-30 per cent of its pre-clearing extent across the bioregion; or more than 20 per cent of its pre-clearing extent remains and the remnant extent is less than 10,000 hectares, or
- 10-30 percent of its pre-clearing extent remains unaffected by moderate degradation and/or biodiversity loss.****

and "No concern at present" regional ecosystems are described as those where:

- remnant vegetation is over 30 per cent of its pre-clearing extent across the bioregion, and the remnant area is greater than 10,000 hectares, and
- the degradation criteria listed above for 'Endangered' or 'Of concern' regional ecosystems are not met.

**Severe degradation and/or biodiversity loss is defined as: floristic and/or faunal diversity is greatly reduced but unlikely to recover within the next 50 years even with the removal of threatening processes; or soil surface is severely degraded, for example, by loss of A horizon, surface expression of salinity; surface compaction, loss of organic matter or sheet erosion.*

***Rare regional ecosystem: pre-clearing extent (1000 ha); or patch size (100 ha and of limited total extent across its range).*

****Threatening processes are those that are reducing or will reduce the biodiversity and ecological integrity of a regional ecosystem. For example, clearing, weed invasion, fragmentation, inappropriate fire regime or grazing pressure, or infrastructure development.*

*****Moderate degradation and/or biodiversity loss is defined as: floristic and/or faunal diversity is greatly reduced but unlikely to recover within the next 20 years even with the removal of threatening processes; or soil surface is moderately degraded.*

2. Remnant Regional Ecosystems

The following table identifies the remnant regional ecosystems and vegetation communities mapped within the AOI and provides their short descriptions, Biodiversity Status, and remnant extent within the selected AOI. Please note, where heterogeneous vegetated patches (mixed patches of remnant vegetation mapped as containing multiple regional ecosystems) occur within the AOI, they have been split and listed as individual regional ecosystems (or vegetation communities where present) for the purposes of the table below. In such instances, associated area figures have been generated based upon the estimated proportion of each regional ecosystem (or vegetation community) predicted to be present within the larger mixed patch.

Table 3: Remnant regional ecosystems, description and status within the AOI

Regional Ecosystem	Short Description	BD Status	Area (Ha)	% of AOI
2.3.26a	Eucalyptus camaldulensis +/- Melaleuca spp. woodland fringing sandy, seasonal channels	Of concern	104.84	8.34
2.3.29a	Melaleuca viridiflora +/- M. citrolens, M. stenostachya low woodland in depressions and broad valleys on solodised soils in the east	No concern at present	314.4	25.02
2.5.9	Eucalyptus microneura woodland on plains and plateaus on earths, podsolics and skeletal soils	No concern at present	0.35	0.03
9.12.27	Eucalyptus melanophloia and/or E. shirleyi +/- Corymbia erythrophloia low open woodland on igneous rocks	No concern at present	121.9	9.7
9.12.33a	Eucalyptus microneura +/- Corymbia pocillum low open woodland on igneous rocks	No concern at present	548.69	43.67
9.12.33c	Eucalyptus microneura +/- Corymbia pocillum low open woodland on igneous rocks	No concern at present	31.62	2.52
9.12.37	Acacia shirleyi +/- Corymbia pocillum +/- Eucalyptus microneura woodland on igneous rocks	No concern at present	0.23	0.02
9.3.24	Melaleuca viridiflora and/or M. citrolens low woodland +/- Corymbia spp. emergents on alluvial deposits	No concern at present	20.32	1.62
9.3.26	Mixed grassland to open grassland including Eragrostis sp., Aristida sp., Enneapogon sp., Iseilema sp., Chloris sp. or Dichanthium sp. on non-basalt derived alluvial deposits	Of concern	0.02	less than 0.01
9.5.10c	Eucalyptus microneura +/- Terminalia spp. low woodland on sand sheets	No concern at present	99.9	7.95
9.5.13a	Melaleuca citrolens and/or Macropteranthes montana low woodland with Eucalyptus spp. emergents on Tertiary sand sheets	No concern at present	14.29	1.14

Refer to **Map 2** for further information. **Map 3** also provides a visual estimate of the distribution of regional ecosystems present before clearing.

Table 4 provides further information in regards to the remnant regional ecosystems present within the AOI. Specifically, the extent of remnant vegetation remaining within the bioregion, the 1:1,000,000 broad vegetation group (BVG) classification, whether the regional ecosystem is identified as a wetland, and extent of representation in Queensland's Protected Area Estate. For a description of the vegetation communities within the AOI and classified according to the 1:1,000,000 BVG, refer to **Table 6**.

Table 4: Remnant regional ecosystems within the AOI, additional information

Regional Ecosystem	Remnant Extent	BVG (1 Million)	Wetland	Representation in protected estate
2.3.26a	Pre-clearing 236000 ha; Remnant 2019 235000 ha	16a	Riverine	Low
2.3.29a	Pre-clearing 1061000 ha; Remnant 2019 1060000 ha	21a	Not a Wetland	High
2.5.9	Pre-clearing 315000 ha; Remnant 2019 311000 ha	18d	Not a Wetland	Low
9.12.27	Pre-clearing 411000 ha; Remnant 2019 410000 ha	13a	Not a Wetland	Medium
9.12.33a	Pre-clearing 278000 ha; Remnant 2019 277000 ha	13b	Not a Wetland	High
9.12.33c	Pre-clearing 278000 ha; Remnant 2019 277000 ha	13b	Not a Wetland	High
9.12.37	Pre-clearing 25000 ha; Remnant 2019 25000 ha	24a	Not a Wetland	Low
9.3.24	Pre-clearing 25000 ha; Remnant 2019 25000 ha	21a	Not a Wetland	High
9.3.26	Pre-clearing 23000 ha; Remnant 2019 22000 ha	32a	Contains Palustrine	Medium
9.5.10c	Pre-clearing 94000 ha; Remnant 2019 93000 ha	18d	Not a Wetland	Medium
9.5.13a	Pre-clearing 31000 ha; Remnant 2019 31000 ha	21b	Not a Wetland	High

Representation in Protected Area Estate: High greater than 10% of pre-clearing extent is represented; Medium 4 - 10% is represented; Low less than 4% is represented, No representation.

The distribution of mapped wetland systems within the area of interest is displayed in **Map 6**.

The following table lists known special values associated with a regional ecosystem type.

Table 5: Remnant regional ecosystems within the AOI, special values

Regional Ecosystem	Special Values
2.3.26a	Significant provincial refuges for fauna. Includes areas of permanent water with high habitat values for aquatic and other species. 2.3.26a: Significant provincial refuges for fauna. Includes areas of permanent water with high habitat values for aquatic and other species. 2.3.26b: Provincial refuge for flora and fauna. 2.3.26d: Significant provincial refuges for fauna. Includes permanent, spring-fed water with high habitat values for aquatic and other species. 2.3.26e: Provincial refuge for flora and fauna. 2.3.26f: Provincial refuge for flora and fauna. 2.3.26x1a: Significant provincial refuges for fauna. Includes permanent, spring-fed water with high habitat values for aquatic and other species. 2.3.26x1b: Significant provincial refuges for fauna. Includes permanent, spring-fed water with high habitat values for aquatic and other species. 2.3.26x1c: Provincial refuge for flora and fauna. 2.3.26x1d: Provincial refuge for flora and fauna. 2.3.26x2: Supports plant growth well into the dry season. Provincial refuge for flora and fauna.

Regional Ecosystem	Special Values
2.3.29a	Provides wetland habitat for a flora and fauna. 2.3.29a: Potential habitat for the golden-shouldered parrot (Psephotus chrysopterygius). 2.3.29b: Provides wetland habitat for a flora and fauna. 2.3.29c: Potential habitat for the golden-shouldered parrot (Psephotus chrysopterygius).
2.5.9	Potential habitat for NCA listed species: Solanum carduiforme
9.12.27	Potential habitat for NCA listed species: Eriocaulon carsonii subsp. orientale, Euphorbia carissoides, Macropteranthes montana, Solanum angustum
9.12.33a	None
9.12.33c	None
9.12.37	None
9.3.24	Potential habitat for NCA listed species: Hardenbergia sp. (Mt Mulligan J.R.Clarkson 5775)
9.3.26	Significant habitat particularly for herbivores such as macropods and arboreal mammals
9.5.10c	None
9.5.13a	Habitat for the vulnerable plant species Macropteranthes montana.

3. Remnant Regional Ecosystems by Broad Vegetation Group

BVGs are a higher-level grouping of vegetation communities. Queensland encompasses a wide variety of landscapes across temperate, wet and dry tropics and semi-arid climatic zones. BVGs provide an overview of vegetation communities across the state or a bioregion and allow comparison with other states. There are three levels of BVGs which reflect the approximate scale at which they are designed to be used: the 1:5,000,000 (national), 1:2,000,000 (state) and 1:1,000,000 (regional) scales.

A comprehensive description of BVGs is available at:

https://publications.qld.gov.au/dataset/redd/resource/

The following table provides a description of the 1:1,000,000 BVGs present and their associated extent within the AOI.

Table 6: Broad vegetation groups (1 million) within the AOI

BVG (1 Million)	Description	Area (Ha)	% of AOI
13a	Woodlands and open woodlands dominated by ironbarks such Eucalyptus cullenii (Cullen's ironbark), E. staigeriana (lemon-scented ironbark) or E. melanophloia (silver-leaved ironbark) and bloodwoods such as Corymbia stockeri subsp. peninsularis, C. clarksoniana (grey bloodwood) or C. leichhardtii (rustyjacket). (land zones 11, 12, 7, 5) (EIU, CYP, GUP)	121.9	9.7
13b	Woodlands to open woodlands dominated by Eucalyptus microneura (Gilbert River box) on shallow soils on rolling hills. (land zones 12, 11, 9) (EIU, GUP)	580.31	46.18

BVG (1 Million)	Description	Area (Ha)	% of AOI
16a	Open forest and woodlands dominated by Eucalyptus camaldulensis (river red gum) (or E. tereticornis (blue gum)) and/or E. coolabah (coolabah) (or E. microtheca (coolabah)) fringing drainage lines. Associated species may include Melaleuca spp., Corymbia tessellaris (carbeen), Angophora spp., Casuarina cunninghamiana (riveroak). Does not include alluvial areas dominated by herb and grasslands or alluvial plains that are not flooded. (land zone 3) (MGD, BRB, GUP, CHC, MUL, DEU, EIU, NWH, SEQ, [NET, WET]) (All bioregions except CYP and CQC)	104.84	8.34
18d	Woodlands to low open woodlands dominated by Eucalyptus microneura (Gilbert River box) sometimes with Corymbia spp. (land zones 5, 10, 3, 12) (GUP, EIU)	100.25	7.98
21a	Low woodlands and low open woodlands dominated by Melaleuca viridiflora (coarse-leaved paperbark) on depositional plains. (land zones 3, 5, 11, [10]) (GUP, CYP, BRB, CQC, EIU, WET, SEQ)	334.71	26.64
21b	Low open woodlands and tall shrublands of Melaleuca citrolens or M. stenostachya or other Melaleuca spp. (land zones 5, 3, 7, 10, 11, 12) (GUP, CYP, EIU, DEU, BRB, [SEQ])	14.29	1.14
24a	Low woodlands to tall shrublands dominated by Acacia spp. on residuals. Species include A. shirleyi (lancewood), A. catenulata (bendee), A. microsperma (bowyakka), A. clivicola, A. sibirica, A. rhodoxylon (rosewood) and A. leptostachya (Townsville wattle). (land zones 7, 10, 5, 12, 11, [9, 3]) (MUL, CHC, BRB, GUP, EIU, MGD, DEU, NWH, [CYP])	0.23	0.02
32a	Closed tussock grasslands dominated by Themeda arguens, Dichanthium sericeum (Queensland bluegrass) or Panicum spp., Eriachne spp., Fimbristylis spp., Aristida spp. or Imperata cylindrica (blady grass) on marine and alluvial plains. (land zones 3, [5]) (GUP, CYP, [BRB,EIU, WET, CQC])	0.02	less than 0.01

Refer to **Map 4** for further information. **Map 5** also provides a representation of the distribution of vegetation communities as per the 1:5,000,000 BVG believed to be present prior to European settlement.

4. Technical and BioCondition Benchmark Descriptions

Technical descriptions provide a detailed description of the full range in structure and floristic composition of regional ecosystems (e.g. 11.3.1) and their component vegetation communities (e.g. 11.3.1a, 11.3.1b). See:

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/technical-descriptions/

The descriptions are compiled using site survey data from the Queensland Herbarium's CORVEG database. Distribution maps, representative images (if available) and the pre-clearing and remnant extent (hectares) of each vegetation community derived from the regional ecosystem mapping data are included. The technical descriptions should be used in conjunction with the fields from the regional ecosystem description database (REDD) for a full description of the regional ecosystem.

Technical descriptions include data on canopy height, canopy cover and native plant species composition of the predominant layer, which are attributes relevant to assessment of the remnant status of vegetation under the *Vegetation Management Act 1999*. However, as technical descriptions reflect the full range in structure and floristic composition across the climatic, natural disturbance and geographic range of the regional ecosystem, local reference sites should be used for remnant assessment where possible (Neldner et al. 2020 (PDF))* section 3.3 of:

https://publications.qld.gov.au/dataset/redd/resource/

The technical descriptions are subject to review and are updated as additional data becomes available.

When conducting a BioCondition assessment, these technical descriptions should be used in conjunction with BioCondition benchmarks for the specific regional ecosystem, or component vegetation community.

http://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks/

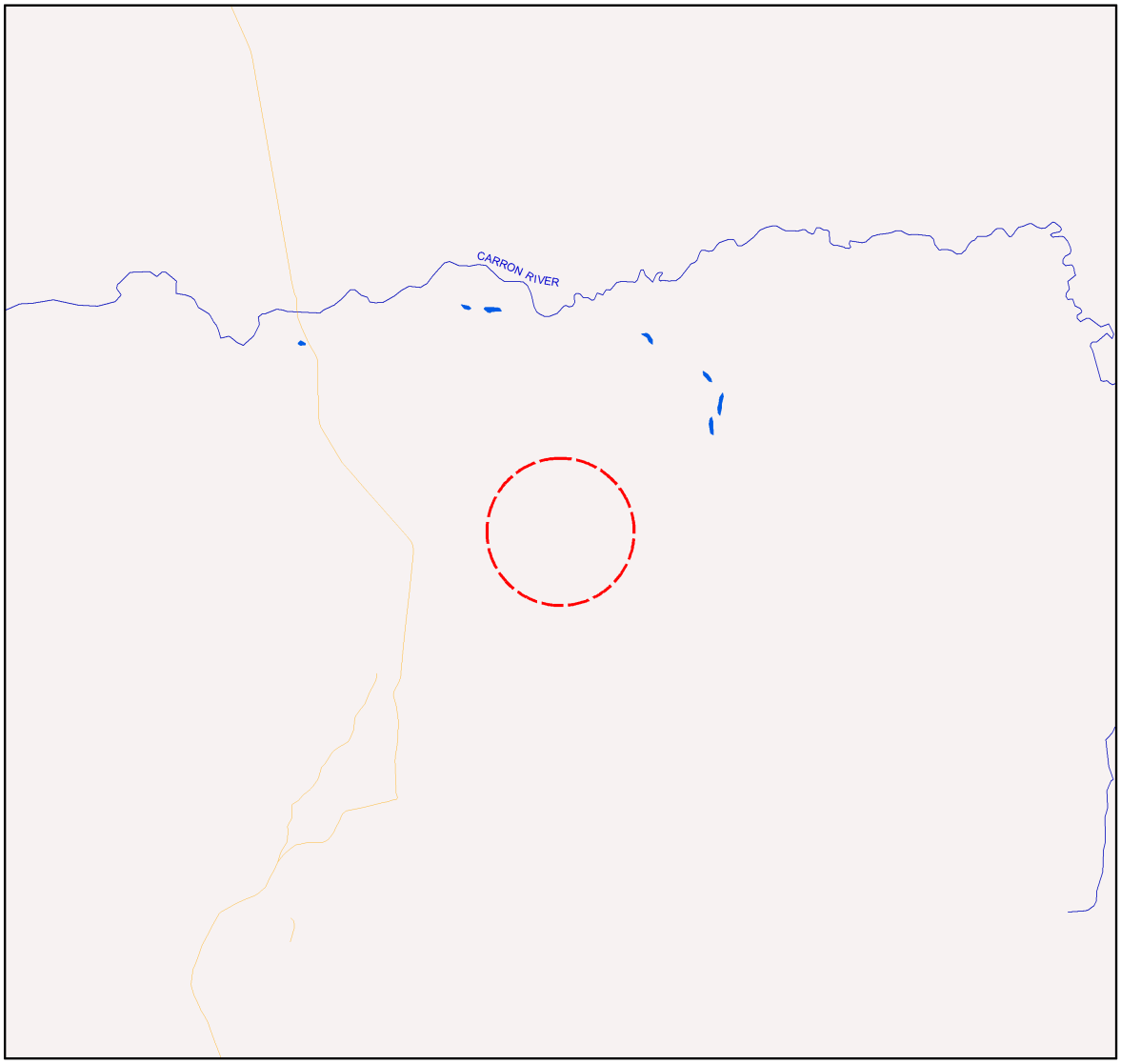
Benchmarks are based on a combination of quantitative and qualitative information and should be used as a guide only. Benchmarks are specific to one regional ecosystem vegetation community, however, the natural variability in structure and floristic composition under a range of climatic and natural disturbance regimes has been considered throughout the geographic extent of the regional ecosystem. Local reference sites should be used for this spatial and temporal (seasonal and annual) variability.

Table 7: List of remnant regional ecosystems within the AOI for which technical and biocondition benchmark descriptions are available

Regional ecosystems mapped as within the AOI	Technical Descriptions	Biocondition Benchmarks
2.3.26a	Not currently available	Not currently available
2.3.29a	Not currently available	Not currently available
2.5.9	Not currently available	Not currently available
9.12.27	Available	Not currently available
9.12.33a	Available	Not currently available
9.12.33c	Available	Not currently available
9.12.37	Available	Not currently available
9.3.24	Available	Not currently available
9.3.26	Not currently available	Not currently available
9.5.10c	Not currently available	Not currently available
9.5.13a	Available	Not currently available

Maps

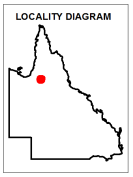
Map 1 - Location



Locality Map

Legend

- 2 kilometre buffer
- Towns
- Highway
- Connector
- Street/Local Road
- Reservoirs
- Lakes
- National Park (Scientific)
- National Park
- National Park (CYPAL)
- Conservation Park
- Resources Reserve
- Forest Reserve
- State Forest
- Timber Reserve
- Nature Refuges
- Coordinated Conservation Areas
- Major rivers/creeks
- Queensland



N

0 1600 3200 4800 6400 8000 m

This product is projected into GDA 1994 Queensland Albers

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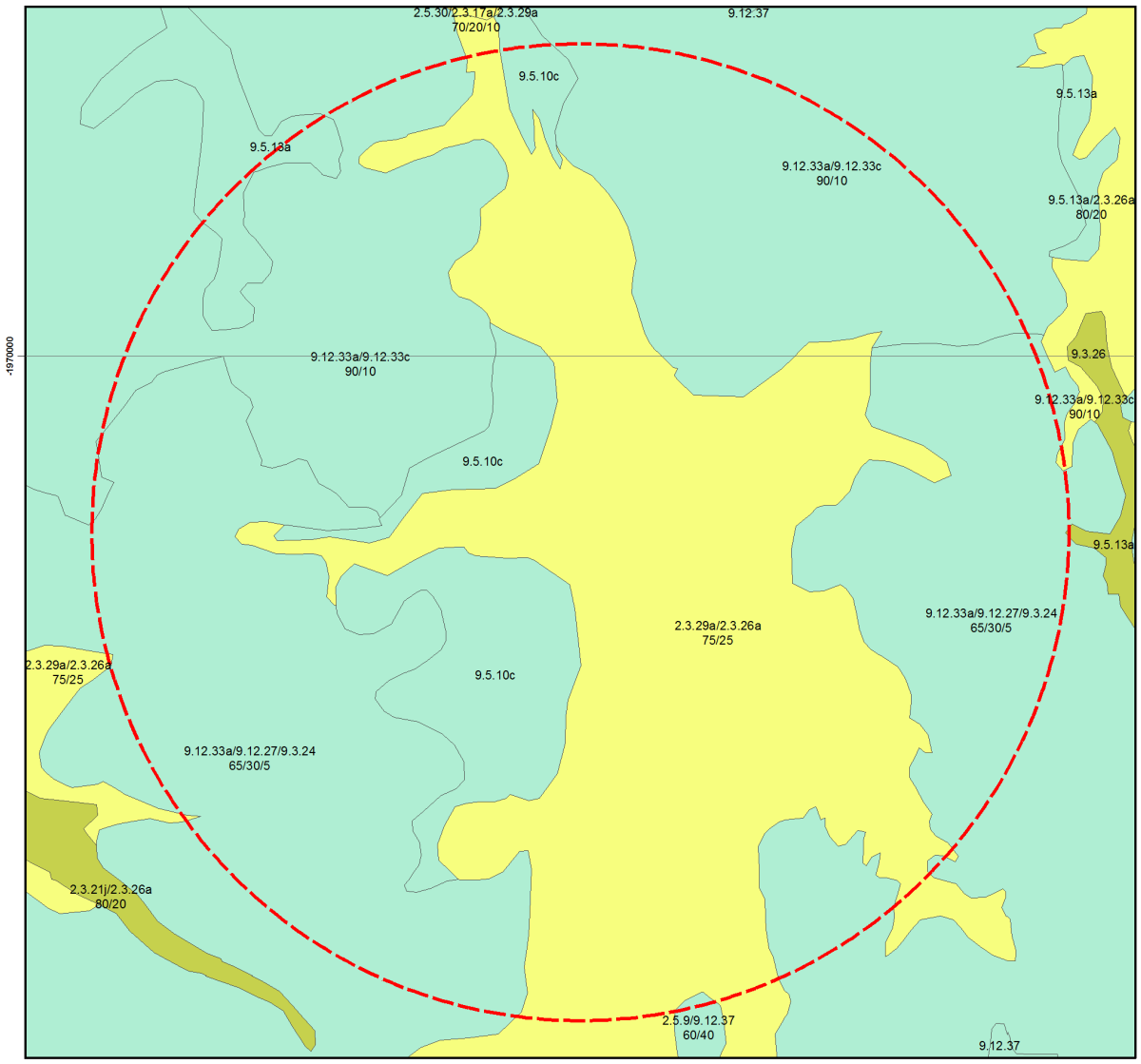
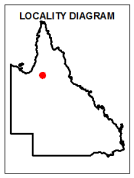
Map 2 - Remnant 2019 regional ecosystems



Remnant 2019 Regional Ecosystems

Biodiversity Status

- 2 kilometre buffer
- Endangered - Dominant vegetation
- Endangered - Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-dominant
- No concern at present
- Non-remnant vegetation, cultivated or built environment
- Plantation
- Water
- Cadastral Boundaries



N

0 0.25 0.5 0.75 1 km

This product is projected into GDA 1994 Queensland Albers

Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.

Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.

The polygons are labelled by regional ecosystem (RE); where more than one RE occurs, the percentage of each is labelled. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".

Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

Remnant woody vegetation is defined as vegetation that has not been cleared or vegetation that has been cleared but where the dominant canopy has >70% of the height and >50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy.

Non-remnant vegetation includes regrowth and disturbed native vegetation.

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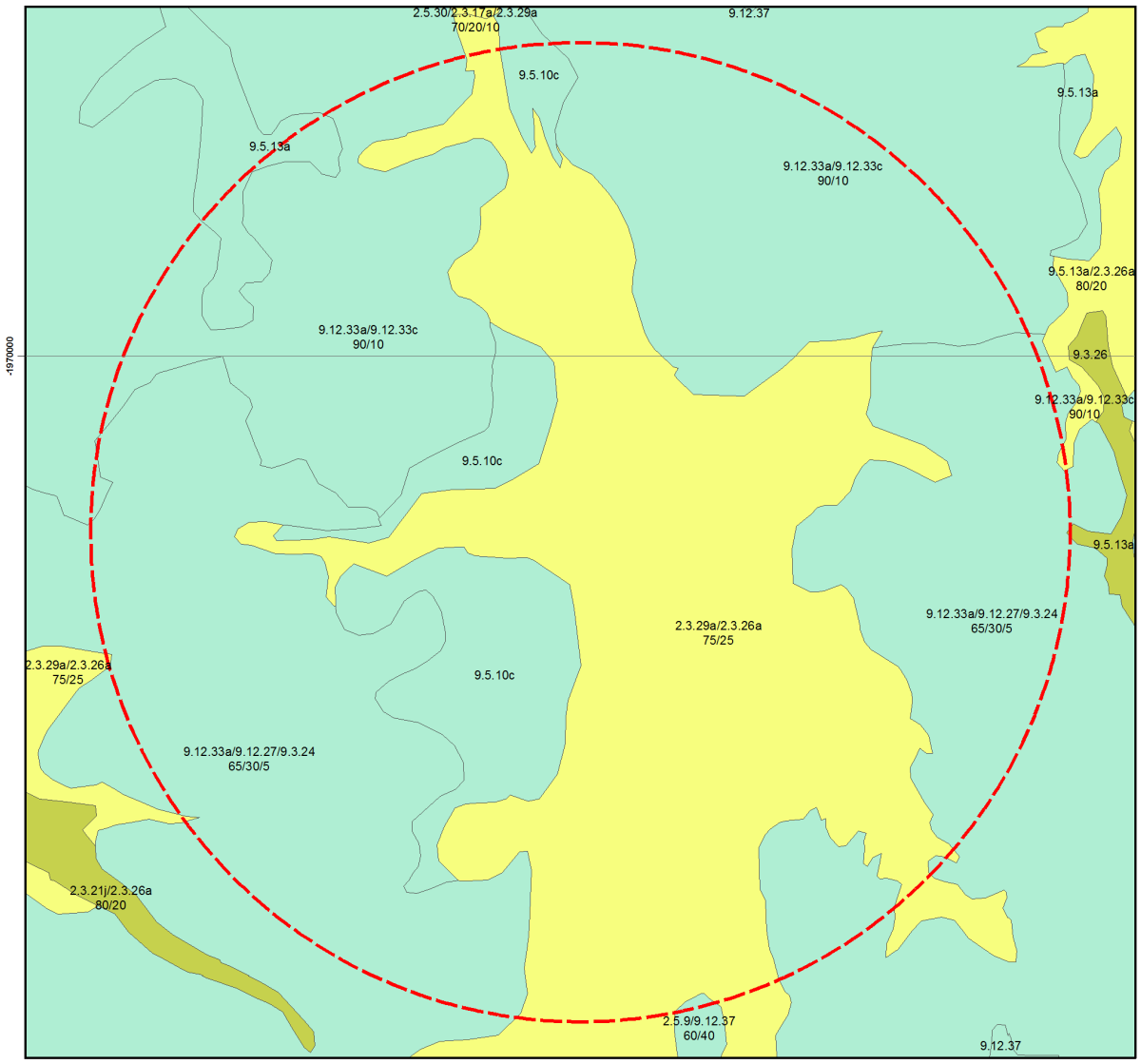
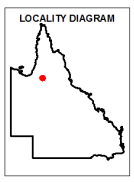
Map 3 - Pre-clearing regional ecosystems



Pre-clearing Regional Ecosystems

Biodiversity Status

- 2 kilometre buffer
- Endangered - Dominant vegetation
- Endangered - Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-dominant
- No concern at present
- Water
- Cadastral Boundaries



N

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Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

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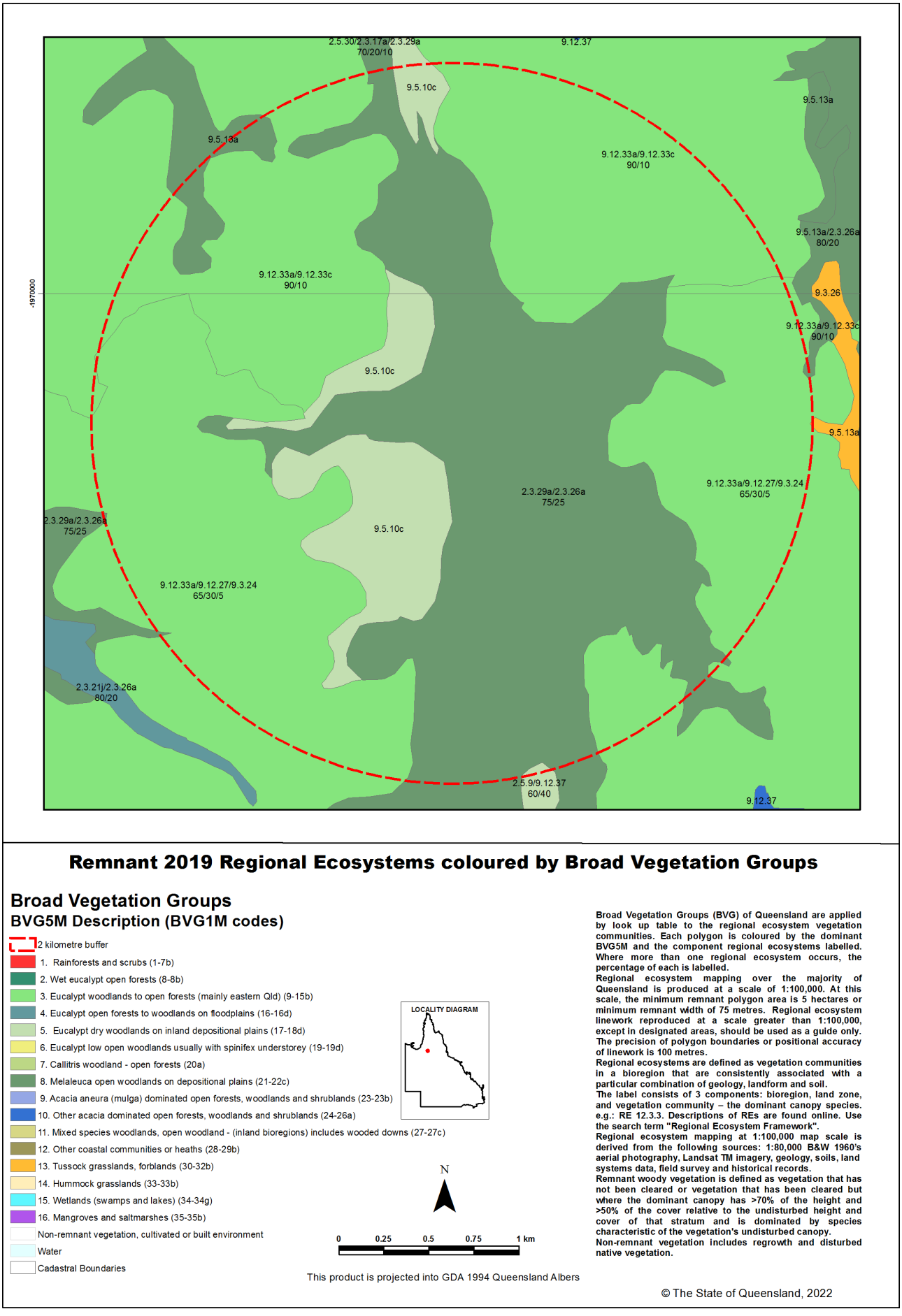
Map 4 - Remnant 2019 regional ecosystems by BVG (5M)



Remnant 2019 Regional Ecosystems coloured by Broad Vegetation Groups

Broad Vegetation Groups
BVG5M Description (BVG1M codes)

- 2 kilometre buffer
- 1. Rainforests and scrubs (1-7b)
- 2. Wet eucalypt open forests (8-8b)
- 3. Eucalypt woodlands to open forests (mainly eastern Qld) (9-15b)
- 4. Eucalypt open forests to woodlands on floodplains (16-16d)
- 5. Eucalypt dry woodlands on inland depositional plains (17-18d)
- 6. Eucalypt low open woodlands usually with spinifex understorey (19-19d)
- 7. Callitris woodland - open forests (20a)
- 8. Melaleuca open woodlands on depositional plains (21-22c)
- 9. Acacia aneura (mulga) dominated open forests, woodlands and shrublands (23-23b)
- 10. Other acacia dominated open forests, woodlands and shrublands (24-26a)
- 11. Mixed species woodlands, open woodland - (inland bioregions) includes wooded downs (27-27c)
- 12. Other coastal communities or heaths (28-29b)
- 13. Tussock grasslands, forblands (30-32b)
- 14. Hummock grasslands (33-33b)
- 15. Wetlands (swamps and lakes) (34-34g)
- 16. Mangroves and saltmarshes (35-35b)
- Non-remnant vegetation, cultivated or built environment
- Water
- Cadastral Boundaries

N

0 0.25 0.5 0.75 1 km

This product is projected into GDA 1994 Queensland Albers

Broad Vegetation Groups (BVG) of Queensland are applied by look up table to the regional ecosystem vegetation communities. Each polygon is coloured by the dominant BVG5M and the component regional ecosystems labelled. Where more than one regional ecosystem occurs, the percentage of each is labelled.
Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.
The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.
Remnant woody vegetation is defined as vegetation that has not been cleared or vegetation that has been cleared but where the dominant canopy has >70% of the height and >50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy.
Non-remnant vegetation includes regrowth and disturbed native vegetation.

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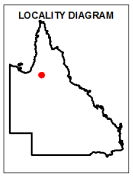
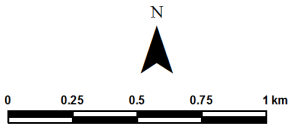
Map 5 - Pre-clearing regional ecosystems by BVG (5M)

Pre-clearing Regional Ecosystems coloured by Broad Vegetation Groups

Broad Vegetation Groups
BVG5M Description (BVG1M codes)

- 2 kilometre buffer
- 1. Rainforests and scrubs (1-7b)
- 2. Wet eucalypt open forests (8-8b)
- 3. Eucalypt woodlands to open forests (mainly eastern Qld) (9-15b)
- 4. Eucalypt open forests to woodlands on floodplains (16-16d)
- 5. Eucalypt dry woodlands on inland depositional plains (17-18d)
- 6. Eucalypt low open woodlands usually with spinifex understorey (19-19d)
- 7. Callitris woodland - open forests (20a)
- 8. Melaleuca open woodlands on depositional plains (21-22c)
- 9. Acacia aneura (mulga) dominated open forests, woodlands and shrublands (23-23b)
- 10. Other acacia dominated open forests, woodlands and shrublands (24-26a)
- 11. Mixed species woodlands, open woodland - (inland bioregions) includes wooded downs (27-27c)
- 12. Other coastal communities or heaths (28-29b)
- 13. Tussock grasslands, forblands (30-32b)
- 14. Hummock grasslands (33-33b)
- 15. Wetlands (swamps and lakes) (34-34g)
- 16. Mangroves and saltmarshes (35-35b)
- Water
- Cadastral Boundaries





This product is projected into GDA 1994 Queensland Albers

Broad Vegetation Groups (BVG) of Queensland are applied by look up table to the regional ecosystem vegetation communities. Each polygon is coloured by the dominant BVG5M and the component regional ecosystems labelled. Where more than one regional ecosystem occurs, the percentage of each is labelled.
Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.
The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

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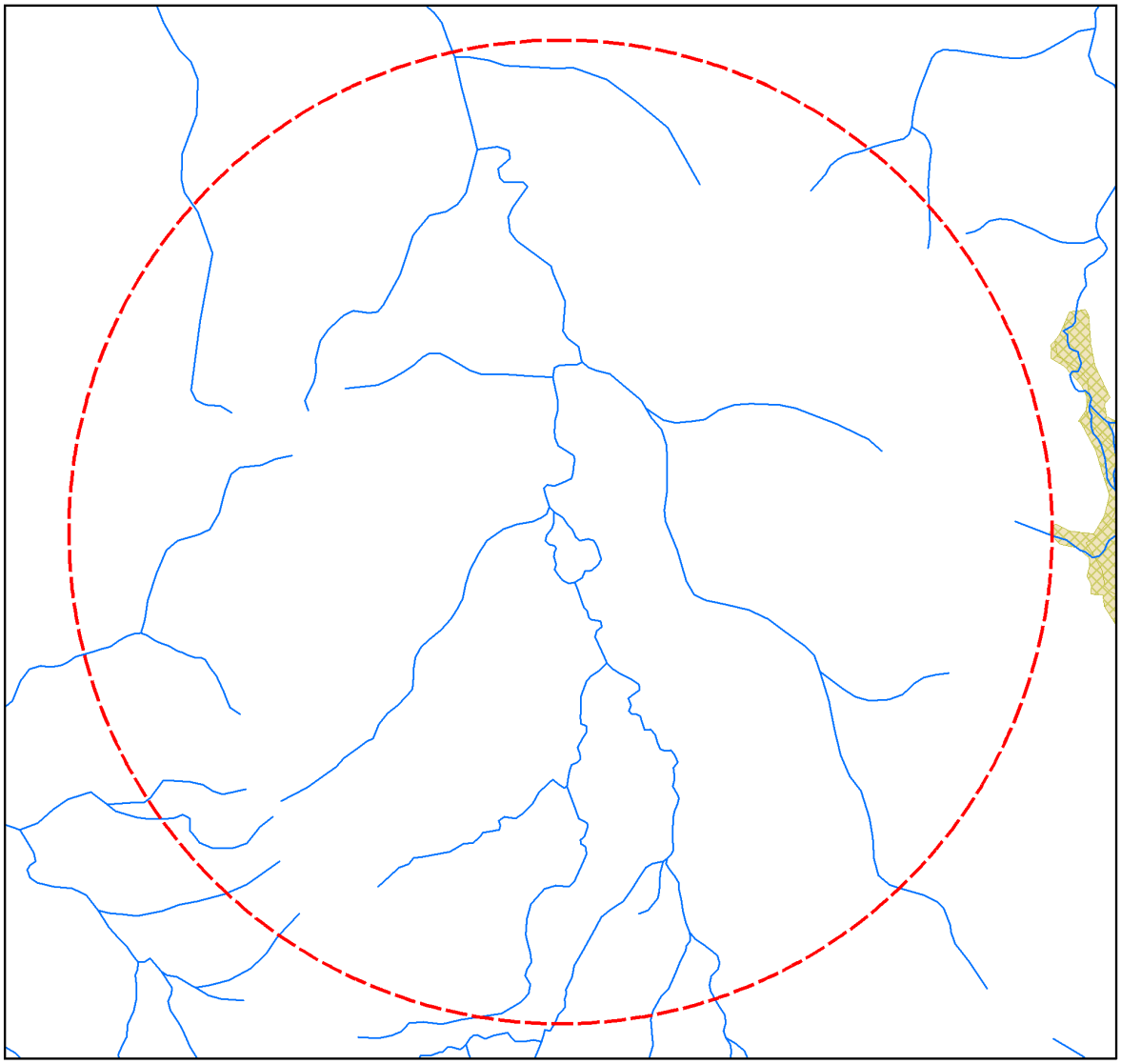
Map 6 - Wetlands and waterways



Queensland Wetland Data

Legend

- 2 kilometre buffer
- Towns

Queensland Wetland Data

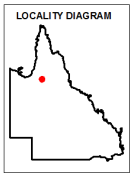
- Riverine Drainage Lines
- Springs

Wetland System - Water Bodies

- Marine Waterbodies
- Estuarine Waterbodies
- Riverine Waterbodies
- Lacustrine Waterbodies
- Palustrine Waterbodies

Wetland System - Regional Ecosystems

- Marine RE
- Estuarine RE
- Riverine RE
- Lacustrine RE
- Palustrine RE
- RE 51-80% wetland (mosaic units)
- RE 1-50% wetland (mosaic units)



N

0 240 480 720 960 1200 m

Accuracy information: The positional accuracy of wetland data mapped at a scale of 1:100,000 is +/-100m with a minimum polygon size of 5ha or 75m wide for linear features, except for areas along the east coa st which are mapped at the 1:50,000 scale with a positional accuracy of +/-50m, with a minimum polygon size of 1ha or 35m wide for linear features. Wetlands smaller than 1ha are not delineated on the wetland data. Consideration of the effects of mapped scale is necessary when interpret ing data at a larger scale, e.g. 1:25,000. For property assessment, digital linework should be used as a guide only. The extent of wetlands depicted on this map is based on rectified 2013 Landsat ETM+ imagery supplied by Statewide Landcover and Trees Study (SLATS), Department of Environment and Science. The extent of water bodies is based on the maximum extent of inundation derived from available Landsat imagery up to and including the 2013 imagery.

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This product is projected into GDA 1994 Queensland Albers

Links and Other Information Sources

The Department of Environment and Science's Website -

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/

provides further information on the regional ecosystem framework, including access to links to the Regional Ecosystem Database, Broad Vegetation Group Definitions, Regional Ecosystem and Land zone descriptions.

Descriptions of the broad vegetation groups of Queensland can be downloaded from:

https://publications.qld.gov.au/dataset/redd/resource/

The methodology for mapping regional ecosystems can be downloaded from:

https://publications.qld.gov.au/dataset/redd/resource/

Technical descriptions for regional ecosystems can be obtained from:

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/technical-descriptions/

Benchmarks can be obtained from:

http://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks/

For further information associated with the remnant regional ecosystem dataset used by this report, refer to the metadata associated with the Biodiversity status of pre-clearing and Remnant Regional Ecosystems of Queensland dataset (version listed in **Appendix 1**) which is available through the Queensland Government Information System portal,

http://dds.information.qld.gov.au/dds/

The Queensland Globe is a mapping and data application. As an interactive online tool, Queensland Globe allows you to view and explore Queensland maps, imagery (including up-to-date satellite images) and other spatial data, including regional ecosystem mapping. To further view and explore regional ecosystems over an area of interest, access the Biota Globe (a component of the Queensland Globe). The Queensland Globe can be accessed via the following link:

https://qldglobe.information.qld.gov.au/

References

Neldner, V.J., Niehus, R.E., Wilson, B.A., McDonald, W.J.F., Ford, A.J. and Accad, A. (2019). The Vegetation of Queensland. Descriptions of Broad Vegetation Groups. Version 4.0. Queensland Herbarium, Department of Environment and Science.

(https://publications.qld.gov.au/dataset/redd/resource/78209e74-c7f2-4589-90c1-c33188359086)

Neldner, V.J., Wilson, B.A., Dillewaard, H.A., Ryan, T.S., Butler, D.W., McDonald, W.J.F, Addicott, E.P. and Appelman, C.N. (2020). Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland. Version 5.1. Updated March 2020. Queensland Herbarium, Queensland Department of Environment and Science, Brisbane.

(https://publications.qld.gov.au/dataset/redd/resource/6dee78ab-c12c-4692-9842-b7257c2511e4)

Sattler, P.S. and Williams, R.D. (eds) (1999). *The Conservation Status of Queensland's Bioregional Ecosystems*. Environmental Protection Agency, Brisbane.

Appendices

Appendix 1 - Source Data

The dataset listed below is available for download from:

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/download/

- Regional Ecosystem Description Database

The datasets listed below are available for download from:

http://dds.information.qld.gov.au/dds/

- Biodiversity status of pre-clearing and 2019 remnant regional ecosystems of Queensland
- Pre-clearing Vegetation Communities and Regional Ecosystems of Queensland
- Queensland Wetland Data Version - Wetland lines
- Queensland Wetland Data Version - Wetland points
- Queensland Wetland Data Version - Wetland areas

Appendix 2 - Acronyms and Abbreviations

AOI	- Area of Interest
GDA94	- Geocentric Datum of Australia 1994
GIS	- Geographic Information System
RE	- Regional Ecosystem
REDD	- Regional Ecosystem Description Database
VMA	- *Vegetation Management Act 1999*

Queensland Government

WildNet species list

Search Criteria: Species List for a Specified Point
Species: All
Type: All
Queensland status: All
Records: Confirmed
Date: Since 1980
Latitude: -18.0205
Longitude: 142.3482
Distance: 50
Email: orobertson@epicenvironmental.com.au
Date submitted: Friday 25 Nov 2022 08:43:34
Date extracted: Friday 25 Nov 2022 08:50:03

The number of records retrieved = 938

Disclaimer
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Information about your Species lists request is logged for quality assurance, user support and product enhancement purposes only.
The information provided should be appropriately acknowledged as being derived from WildNet database when it is used. As the WildNet Program is still in a process of collating and vetting data, it is possible the information given is not complete. Go to the WildNet database webpage (https://www.qld.gov.au/environment/plants-animals/species-information/wildnet) to find out more about WildNet and where to access other WildNet information products approved for publication. Feedback about WildNet species lists should be emailed to wildlife.online@des.qld.gov.au.

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	amphibians	Bufonidae	*Rhinella marina*	cane toad	Y			34
animals	amphibians	Hylidae	*Cyclorana brevipes*	superb collared frog		C		12
animals	amphibians	Hylidae	*Cyclorana novaehollandiae*	eastern snapping frog		C		34
animals	amphibians	Hylidae	*Litoria caerulea*	common green treefrog		C		9
animals	amphibians	Hylidae	*Litoria electrica*	buzzing treefrog		C		19
animals	amphibians	Hylidae	*Litoria inermis*	bumpy rocketfrog		C		9
animals	amphibians	Hylidae	*Litoria pallida*	pallid rocketfrog		C		37
animals	amphibians	Hylidae	*Litoria rothii*	northern laughing treefrog		C		21
animals	amphibians	Hylidae	*Litoria rubella*	ruddy treefrog		C		23
animals	amphibians	Limnodynastidae	*Notaden melanoscaphus*	brown shovelfoot		C		5
animals	amphibians	Limnodynastidae	*Platyplectrum ornatum*	ornate burrowing frog		C		2
animals	amphibians	Myobatrachidae	*Crinia deserticola*	chirping froglet		C		8
animals	amphibians	Myobatrachidae	*Uperoleia lithomoda*	stonemason gungan		C		32
animals	amphibians	Myobatrachidae	*Uperoleia littlejohni*	Einasleigh gungan		C		10
animals	birds	Acanthizidae	*Gerygone olivacea*	white-throated gerygone		C		8
animals	birds	Accipitridae	*Accipiter cirrocephalus*	collared sparrowhawk		C		1
animals	birds	Accipitridae	*Accipiter fasciatus*	brown goshawk		C		2
animals	birds	Accipitridae	*Accipiter novaehollandiae*	grey goshawk		C		1
animals	birds	Accipitridae	*Aquila audax*	wedge-tailed eagle		C		8
animals	birds	Accipitridae	*Haliaeetus leucogaster*	white-bellied sea-eagle		C		2
animals	birds	Accipitridae	*Haliastur sphenurus*	whistling kite		C		17
animals	birds	Accipitridae	*Hamirostra melanosternon*	black-breasted buzzard		C		3
animals	birds	Accipitridae	*Milvus migrans*	black kite		C		23
animals	birds	Aegothelidae	*Aegotheles cristatus*	Australian owlet-nightjar		C		3
animals	birds	Alaudidae	*Mirafra javanica*	Horsfield's bushlark		C		1/1
animals	birds	Alcedinidae	*Ceyx azureus*	azure kingfisher		C		1
animals	birds	Anatidae	*Anas gracilis*	grey teal		C		7
animals	birds	Anatidae	*Anas superciliosa*	Pacific black duck		C		5
animals	birds	Anatidae	*Aythya australis*	hardhead		C		6
animals	birds	Anatidae	*Chenonetta jubata*	Australian wood duck		C		2
animals	birds	Anatidae	*Cygnus atratus*	black swan		C		1
animals	birds	Anatidae	*Dendrocygna eytoni*	plumed whistling-duck		C		1
animals	birds	Anatidae	*Malacorhynchus membranaceus*	pink-eared duck		C		1
animals	birds	Anatidae	*Nettapus pulchellus*	green pygmy-goose		C		8
animals	birds	Anhingidae	*Anhinga novaehollandiae*	Australasian darter		C		15
animals	birds	Ardeidae	*Ardea alba modesta*	eastern great egret		C		2
animals	birds	Ardeidae	*Ardea intermedia*	intermediate egret		C		1
animals	birds	Ardeidae	*Ardea pacifica*	white-necked heron		C		5
animals	birds	Ardeidae	*Egretta garzetta*	little egret		C		1
animals	birds	Ardeidae	*Egretta novaehollandiae*	white-faced heron		C		4
animals	birds	Ardeidae	*Ixobrychus flavicollis*	black bittern		C		1
animals	birds	Ardeidae	*Nycticorax caledonicus*	nankeen night-heron		C		5
animals	birds	Artamidae	*Artamus cinereus*	black-faced woodswallow		C		8/2
animals	birds	Artamidae	*Artamus minor*	little woodswallow		C		1
animals	birds	Artamidae	*Artamus personatus*	masked woodswallow		C		1
animals	birds	Artamidae	*Artamus superciliosus*	white-browed woodswallow		C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Artamidae	*Cracticus nigrogularis*	pied butcherbird		C		15
animals	birds	Artamidae	*Cracticus torquatus*	grey butcherbird		C		1
animals	birds	Artamidae	*Gymnorhina tibicen*	Australian magpie		C		26
animals	birds	Burhinidae	*Burhinus grallarius*	bush stone-curlew		C		5
animals	birds	Cacatuidae	*Cacatua galerita*	sulphur-crested cockatoo		C		6
animals	birds	Cacatuidae	*Cacatua sanguinea*	little corella		C		1
animals	birds	Cacatuidae	*Calyptorhynchus banksii*	red-tailed black-cockatoo		C		5
animals	birds	Cacatuidae	*Calyptorhynchus banksii banksii*	red-tailed black-cockatoo (Cape York & Eastern Aust)		C		3
animals	birds	Cacatuidae	*Eolophus roseicapilla*	galah		C		25
animals	birds	Cacatuidae	*Nymphicus hollandicus*	cockatiel		C		2
animals	birds	Campephagidae	*Coracina maxima*	ground cuckoo-shrike		C		1
animals	birds	Campephagidae	*Coracina novaehollandiae*	black-faced cuckoo-shrike		C		9
animals	birds	Campephagidae	*Coracina papuensis*	white-bellied cuckoo-shrike		C		3
animals	birds	Campephagidae	*Lalage tricolor*	white-winged triller		C		3
animals	birds	Casuariidae	*Dromaius novaehollandiae*	emu		C		2
animals	birds	Charadriidae	*Elseyornis melanops*	black-fronted dotterel		C		5
animals	birds	Charadriidae	*Erythrogonys cinctus*	red-kneed dotterel		C		2
animals	birds	Charadriidae	*Vanellus miles*	masked lapwing		C		6
animals	birds	Charadriidae	*Vanellus miles miles*	masked lapwing (northern subspecies)		C		10
animals	birds	Ciconiidae	*Ephippiorhynchus asiaticus*	black-necked stork		C		4
animals	birds	Climacteridae	*Climacteris picumnus*	brown treecreeper		C		1
animals	birds	Columbidae	*Geopelia cuneata*	diamond dove		C		8
animals	birds	Columbidae	*Geopelia humeralis*	bar-shouldered dove		C		7
animals	birds	Columbidae	*Geopelia placida*	peaceful dove		C		32
animals	birds	Columbidae	*Geophaps plumifera*	spinifex pigeon		C		4
animals	birds	Columbidae	*Geophaps scripta*	squatter pigeon		C		32
animals	birds	Columbidae	*Geophaps scripta peninsulae*	squatter pigeon (northern subspecies)		C		3
animals	birds	Columbidae	*Ocyphaps lophotes*	crested pigeon		C		14
animals	birds	Columbidae	*Phaps chalcoptera*	common bronzewing		C		4
animals	birds	Coraciidae	*Eurystomus orientalis*	dollarbird		C		4
animals	birds	Corcoracidae	*Struthidea cinerea*	apostlebird		C		53
animals	birds	Corvidae	*Corvus coronoides*	Australian raven		C		1
animals	birds	Corvidae	*Corvus orru*	Torresian crow		C		31
animals	birds	Cuculidae	*Cacomantis pallidus*	pallid cuckoo		C		1
animals	birds	Cuculidae	*Cacomantis variolosus*	brush cuckoo		C		1
animals	birds	Cuculidae	*Centropus phasianinus*	pheasant coucal		C		9
animals	birds	Cuculidae	*Chalcites minutillus russatus*	Gould's bronze-cuckoo		C		1
animals	birds	Cuculidae	*Eudynamys orientalis*	eastern koel		C		3
animals	birds	Dicruridae	*Dicrurus bracteatus*	spangled drongo		C		1
animals	birds	Estrildidae	*Chloebia gouldiae*	Gouldian finch		E	E	3
animals	birds	Estrildidae	*Poephila cincta*	black-throated finch		C		8/1
animals	birds	Estrildidae	*Poephila cincta atropygialis*	black-throated finch (black-rumped subspecies)		C		4
animals	birds	Estrildidae	*Poephila personata*	masked finch		C		2
animals	birds	Estrildidae	*Taeniopygia bichenovii*	double-barred finch		C		18

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Falconidae	*Falco berigora*	brown falcon		C		4
animals	birds	Falconidae	*Falco cenchroides*	nankeen kestrel		C		1
animals	birds	Falconidae	*Falco peregrinus macropus*	Australian peregrine falcon		C		3
animals	birds	Gruidae	*Antigone antigone*	sarus crane		C		1
animals	birds	Gruidae	*Antigone rubicunda*	brolga		C		6
animals	birds	Halcyonidae	*Dacelo leachii*	blue-winged kookaburra		C		19
animals	birds	Halcyonidae	*Todiramphus macleayii*	forest kingfisher		C		4
animals	birds	Halcyonidae	*Todiramphus sanctus*	sacred kingfisher		C		2
animals	birds	Hirundinidae	*Petrochelidon ariel*	fairy martin		C		1
animals	birds	Hirundinidae	*Petrochelidon nigricans*	tree martin		C		1
animals	birds	Jacanidae	*Irediparra gallinacea*	comb-crested jacana		C		2
animals	birds	Maluridae	*Malurus assimilis*	purple-backed fairy-wren		C		1
animals	birds	Maluridae	*Malurus melanocephalus*	red-backed fairy-wren		C		3/1
animals	birds	Megaluridae	*Cincloramphus mathewsi*	rufous songlark		C		9
animals	birds	Meliphagidae	*Cissomela pectoralis*	banded honeyeater		C		2
animals	birds	Meliphagidae	*Conopophila rufogularis*	rufous-throated honeyeater		C		8
animals	birds	Meliphagidae	*Entomyzon cyanotis*	blue-faced honeyeater		C		16
animals	birds	Meliphagidae	*Grantiella picta*	painted honeyeater		V	V	1
animals	birds	Meliphagidae	*Lichmera indistincta*	brown honeyeater		C		10
animals	birds	Meliphagidae	*Manorina flavigula*	yellow-throated miner		C		1
animals	birds	Meliphagidae	*Melithreptus albogularis*	white-throated honeyeater		C		7
animals	birds	Meliphagidae	*Philemon argenticeps*	silver-crowned friarbird		C		1
animals	birds	Meliphagidae	*Philemon citreogularis*	little friarbird		C		11
animals	birds	Meliphagidae	*Philemon corniculatus*	noisy friarbird		C		1
animals	birds	Meliphagidae	*Ptilotula flavescens*	yellow-tinted honeyeater		C		8/2
animals	birds	Meliphagidae	*Ptilotula plumula*	grey-fronted honeyeater		C		3
animals	birds	Meliphagidae	*Stomiopera flava*	yellow honeyeater		C		7
animals	birds	Meropidae	*Merops ornatus*	rainbow bee-eater		C		17
animals	birds	Monarchidae	*Grallina cyanoleuca*	magpie-lark		C		46
animals	birds	Monarchidae	*Myiagra inquieta*	restless flycatcher		C		10/3
animals	birds	Nectariniidae	*Dicaeum hirundinaceum*	mistletoebird		C		3
animals	birds	Neosittidae	*Daphoenositta chrysoptera*	varied sittella		C		1
animals	birds	Oriolidae	*Oriolus sagittatus*	olive-backed oriole		C		3
animals	birds	Otididae	*Ardeotis australis*	Australian bustard		C		5
animals	birds	Pachycephalidae	*Colluricincla harmonica*	grey shrike-thrush		C		2
animals	birds	Pachycephalidae	*Pachycephala rufiventris*	rufous whistler		C		6
animals	birds	Pardalotidae	*Pardalotus rubricatus*	red-browed pardalote		C		2
animals	birds	Pardalotidae	*Pardalotus striatus*	striated pardalote		C		14
animals	birds	Pelecanidae	*Pelecanus conspicillatus*	Australian pelican		C		4
animals	birds	Phalacrocoracidae	*Microcarbo melanoleucos*	little pied cormorant		C		5
animals	birds	Phalacrocoracidae	*Phalacrocorax sulcirostris*	little black cormorant		C		3
animals	birds	Phasianidae	*Synoicus ypsilophorus*	brown quail		C		5
animals	birds	Podargidae	*Podargus strigoides*	tawny frogmouth		C		3
animals	birds	Podicipedidae	*Tachybaptus novaehollandiae*	Australasian grebe		C		9
animals	birds	Pomatostomidae	*Pomatostomus temporalis*	grey-crowned babbler		C		27/3
animals	birds	Psittacidae	*Aprosmictus erythropterus*	red-winged parrot		C		11

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Psittacidae	*Melopsittacus undulatus*	budgerigar		C		6
animals	birds	Psittacidae	*Platycercus adscitus*	pale-headed rosella		C		18/2
animals	birds	Psittacidae	*Psitteuteles versicolor*	varied lorikeet		C		3
animals	birds	Psittacidae	*Trichoglossus moluccanus*	rainbow lorikeet		C		6/2
animals	birds	Ptilonorhynchidae	*Chlamydera nuchalis*	great bowerbird		C		10
animals	birds	Rallidae	*Fulica atra*	Eurasian coot		C		4
animals	birds	Rallidae	*Tribonyx ventralis*	black-tailed native-hen		C		1
animals	birds	Recurvirostridae	*Himantopus himantopus*	black-winged stilt		C		1
animals	birds	Rhipiduridae	*Rhipidura albiscapa*	grey fantail		C		3
animals	birds	Rhipiduridae	*Rhipidura leucophrys*	willie wagtail		C		23
animals	birds	Strigidae	*Ninox boobook*	southern boobook		C		3
animals	birds	Threskiornithidae	*Platalea regia*	royal spoonbill		C		4
animals	birds	Threskiornithidae	*Threskiornis molucca*	Australian white ibis		C		3
animals	birds	Threskiornithidae	*Threskiornis spinicollis*	straw-necked ibis		C		12
animals	birds	Turnicidae	*Turnix pyrrhothorax*	red-chested button-quail		C		1
animals	mammals	Bovidae	*Bos sp.*	cattle	Y			6
animals	mammals	Canidae	*Canis familiaris*	dog	Y			3
animals	mammals	Canidae	*Canis familiaris (dingo)*	dingo				4
animals	mammals	Equidae	*Equus caballus*	horse	Y			1
animals	mammals	Felidae	*Felis catus*	cat	Y			11
animals	mammals	Macropodidae	*Macropus giganteus*	eastern grey kangaroo		C		1
animals	mammals	Macropodidae	*Notamacropus agilis*	agile wallaby		C		40
animals	mammals	Macropodidae	*Onychogalea unguifera*	northern nailtail wallaby		C		13
animals	mammals	Macropodidae	*Osphranter antilopinus*	antilopine wallaroo		C		4
animals	mammals	Macropodidae	*Osphranter robustus*	common wallaroo		C		19
animals	mammals	Macropodidae	*Osphranter rufus*	red kangaroo		C		3
animals	mammals	Macropodidae	*Petrogale assimilis*	allied rock-wallaby		C		7/6
animals	mammals	Macropodidae	*Wallabia bicolor*	swamp wallaby		C		1
animals	mammals	Muridae	*Pseudomys delicatulus*	delicate mouse		C		2
animals	mammals	Muridae	*Rattus sordidus*	canefield rat		C		1
animals	mammals	Phalangeridae	*Trichosurus vulpecula*	common brushtail possum		C		8
animals	mammals	Pteropodidae	*Pteropus scapulatus*	little red flying-fox		C		2
animals	mammals	Suidae	*Sus scrofa*	pig	Y			13
animals	mammals	Tachyglossidae	*Tachyglossus aculeatus*	short-beaked echidna		SL		1
animals	ray-finned fishes	Ambassidae	*Ambassis macleayi*	Macleay's glassfish				1
animals	ray-finned fishes	Ambassidae	*Ambassis sp.*					1
animals	ray-finned fishes	Apogonidae	*Glossamia aprion*	mouth almighty				3
animals	ray-finned fishes	Atherinidae	*Craterocephalus stercusmuscarum*	flyspecked hardyhead				1
animals	ray-finned fishes	Belonidae	*Strongylura krefftii*	freshwater longtom				4
animals	ray-finned fishes	Clupeidae	*Nematalosa erebi*	bony bream				1
animals	ray-finned fishes	Eleotridae	*Oxyeleotris lineolata*	sleepy cod				4
animals	ray-finned fishes	Eleotridae	*Oxyeleotris selheimi*	blackbanded gudgeon				1
animals	ray-finned fishes	Melanotaeniidae	*Melanotaenia splendida inornata*	checkered rainbowfish				3
animals	ray-finned fishes	Plotosidae	*Neosilurus ater*	black catfish				3
animals	ray-finned fishes	Terapontidae	*Amniataba percoides*	barred grunter				4
animals	ray-finned fishes	Terapontidae	*Hephaestus fuliginosus*	sooty grunter				4

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	ray-finned fishes	Terapontidae	*Leiopotherapon unicolor*	spangled perch				4
animals	ray-finned fishes	Terapontidae	*Scortum ogilbyi*	Gulf grunter				4
animals	ray-finned fishes	Toxotidae	*Toxotes chatareus*	sevenspot archerfish				4
animals	reptiles	Agamidae	*Chlamydosaurus kingii*	frilled lizard		C		2
animals	reptiles	Agamidae	*Diporiphora australis*	tommy roundhead		C		5/2
animals	reptiles	Agamidae	*Diporiphora nobbi*	nobbi		C		2/2
animals	reptiles	Agamidae	*Tropicagama temporalis*	swamplands lashtail		C		3
animals	reptiles	Boidae	*Antaresia childreni*	children's python		C		2
animals	reptiles	Boidae	*Antaresia maculosa*	spotted python		C		2
animals	reptiles	Boidae	*Aspidites melanocephalus*	black-headed python		C		5
animals	reptiles	Colubridae	*Dendrelaphis punctulatus*	green tree snake		C		1
animals	reptiles	Crocodylidae	*Crocodylus johnstoni*	Australian freshwater crocodile		C		4
animals	reptiles	Diplodactylidae	*Amalosia rhombifer*	zig-zag gecko		C		5
animals	reptiles	Diplodactylidae	*Oedura argentea*	silver-eyed velvet gecko		C		1
animals	reptiles	Diplodactylidae	*Oedura monilis sensu lato*	ocellated velvet gecko		C		1
animals	reptiles	Elapidae	*Demansia vestigiata*	lesser black whipsnake		C		3
animals	reptiles	Gekkonidae	*Gehyra einasleighensis*	Einasleigh rock dtella		C		3
animals	reptiles	Gekkonidae	*Gehyra sp.*			C		3/2
animals	reptiles	Gekkonidae	*Heteronotia binoei*	Bynoe's gecko		C		13
animals	reptiles	Pygopodidae	*Lialis burtonis*	Burton's legless lizard		C		2
animals	reptiles	Scincidae	*Carlia munda*	shaded-litter rainbow-skink		C		1
animals	reptiles	Varanidae	*Varanus gouldii*	sand monitor		C		1
animals	reptiles	Varanidae	*Varanus panoptes*	yellow-spotted monitor		C		21
animals	reptiles	Varanidae	*Varanus storri*	Storr's monitor		C		1
animals	uncertain	Indeterminate	*Indeterminate*	Unknown or Code Pending				1
fungi	Agaricomycetes	Thelephoraceae	*Thelephora*					1/1
plants	land plants	Acanthaceae	*Dicliptera armata*			C		3/3
plants	land plants	Acanthaceae	*Hygrophila angustifolia*			C		2/2
plants	land plants	Acanthaceae	*Nelsonia campestris*			C		10/3
plants	land plants	Acanthaceae	*Pseuderanthemum variabile*	pastel flower		C		2/2
plants	land plants	Acanthaceae	*Rostellularia adscendens*			C		1/1
plants	land plants	Aizoaceae	*Trianthema*					2/2
plants	land plants	Aizoaceae	*Trianthema rhynchocalyptra*			C		3/3
plants	land plants	Aizoaceae	*Trianthema triquetra*	red spinach		C		7/7
plants	land plants	Alismataceae	*Caldesia oligococca*			SL		4/3
plants	land plants	Amaranthaceae	*Achyranthes aspera*			C		2/2
plants	land plants	Amaranthaceae	*Alternanthera*					1/1
plants	land plants	Amaranthaceae	*Alternanthera angustifolia*			C		2/2
plants	land plants	Amaranthaceae	*Alternanthera denticulata var. denticulata*			C		1/1
plants	land plants	Amaranthaceae	*Alternanthera denticulata var. micrantha*			C		1/1
plants	land plants	Amaranthaceae	*Alternanthera pungens*	khaki weed	Y			1/1
plants	land plants	Amaranthaceae	*Amaranthus viridis*	green amaranth	Y			1/1
plants	land plants	Amaranthaceae	*Gomphrena arida*			C		1/1
plants	land plants	Amaranthaceae	*Gomphrena flaccida*			C		7/7
plants	land plants	Amaranthaceae	*Gomphrena lanata*			C		2/2
plants	land plants	Amaranthaceae	*Gomphrena leptophylla*			C		3/3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	land plants	Amaranthaceae	*Ptilotus fusiformis*			C		12/12
plants	land plants	Apocynaceae	*Calotropis procera*		Y			1/1
plants	land plants	Apocynaceae	*Carissa lanceolata*			C		3/3
plants	land plants	Apocynaceae	*Catharanthus roseus*	pink periwinkle	Y			1/1
plants	land plants	Apocynaceae	*Cryptostegia grandiflora*	rubber vine	Y			1/1
plants	land plants	Apocynaceae	*Leichhardtia viridiflora subsp. tropica*			C		2/2
plants	land plants	Araceae	*Lemna aequinoctialis*	common duckweed		C		2/1
plants	land plants	Araliaceae	*Trachymene bivestita var. bivestita*			C		1/1
plants	land plants	Aristolochiaceae	*Aristolochia pubera var. pubera*			C		2/2
plants	land plants	Asteraceae	*Acanthospermum hispidum*	star burr	Y			2/2
plants	land plants	Asteraceae	*Ageratum conyzoides*	billygoat weed	Y			1/1
plants	land plants	Asteraceae	*Ageratum houstonianum*	blue billygoat weed	Y			3
plants	land plants	Asteraceae	*Allopterigeron filifolius*			C		3/3
plants	land plants	Asteraceae	*Bidens pilosa*		Y			1/1
plants	land plants	Asteraceae	*Blumea diffusa*			C		1/1
plants	land plants	Asteraceae	*Blumea saxatilis*			C		7/5
plants	land plants	Asteraceae	*Emilia sonchifolia*		Y			1
plants	land plants	Asteraceae	*Emilia sonchifolia var. sonchifolia*		Y			3/3
plants	land plants	Asteraceae	*Iotasperma australiense*			C		1/1
plants	land plants	Asteraceae	*Pterocaulon ciliosum*			C		1/1
plants	land plants	Asteraceae	*Pterocaulon serrulatum var. serrulatum*			C		1/1
plants	land plants	Asteraceae	*Sphaeromorphaea littoralis*			C		4/4
plants	land plants	Asteraceae	*Streptoglossa odora*			C		2/2
plants	land plants	Asteraceae	*Synedrella nodiflora*		Y			1/1
plants	land plants	Asteraceae	*Xanthium occidentale*		Y			1/1
plants	land plants	Bignoniaceae	*Dolichandrone alternifolia*			C		1/1
plants	land plants	Blechnaceae	*Blechnum orientale*			SL		2/1
plants	land plants	Boraginaceae	*Ehretia saligna*			C		1/1
plants	land plants	Boraginaceae	*Heliotropium consimile*			C		1/1
plants	land plants	Boraginaceae	*Heliotropium cunninghamii*			C		6/6
plants	land plants	Boraginaceae	*Heliotropium foliatum*			C		3/3
plants	land plants	Boraginaceae	*Heliotropium peninsulare*			C		5/5
plants	land plants	Byblidaceae	*Byblis liniflora*			SL		2/2
plants	land plants	Byttneriaceae	*Melochia corchorifolia*			C		5/5
plants	land plants	Byttneriaceae	*Waltheria indica*			C		8/7
plants	land plants	Campanulaceae	*Lobelia dioica*			SL		1/1
plants	land plants	Cannabaceae	*Trema tomentosa var. aspera*			C		1/1
plants	land plants	Caryophyllaceae	*Polycarpaea breviflora*			C		1/1
plants	land plants	Caryophyllaceae	*Polycarpaea corymbosa*			C		1/1
plants	land plants	Caryophyllaceae	*Polycarpaea corymbosa var. corymbosa*			C		1/1
plants	land plants	Caryophyllaceae	*Polycarpaea spirostylis subsp. compacta*			C		1/1
plants	land plants	Caryophyllaceae	*Polycarpaea spirostylis subsp. glabra*			C		2/2
plants	land plants	Caryophyllaceae	*Polycarpaea spirostylis subsp. spirostylis*			C		2/2
plants	land plants	Centrolepidaceae	*Centrolepis*					1/1
plants	land plants	Centrolepidaceae	*Centrolepis exserta*			C		2/2
plants	land plants	Chenopodiaceae	*Dysphania carinata*			C		1/1

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plants	land plants	Chenopodiaceae	*Salsola australis*			C		1/1
plants	land plants	Chrysobalanaceae	*Parinari nonda*			C		3/2
plants	land plants	Cleomaceae	*Areocleome oxalidea*			C		7/7
plants	land plants	Cleomaceae	*Arivela tetrandra*			C		3/3
plants	land plants	Cleomaceae	*Arivela viscosa*			C		2/2
plants	land plants	Cleomaceae	*Gynandropsis gynandra*		Y			1/1
plants	land plants	Cochlospermaceae	*Cochlospermum gregorii*			C		2/2
plants	land plants	Combretaceae	*Terminalia*					1
plants	land plants	Combretaceae	*Terminalia aridicola subsp. chillagoensis*			C		2/2
plants	land plants	Combretaceae	*Terminalia hadleyana subsp. carpentariae*			C		1/1
plants	land plants	Combretaceae	*Terminalia platyphylla*			C		2/2
plants	land plants	Combretaceae	*Terminalia platyptera*			C		6/6
plants	land plants	Combretaceae	*Terminalia subacroptera*			C		2/2
plants	land plants	Commelinaceae	*Cartonema parviflorum*			C		3/3
plants	land plants	Commelinaceae	*Cartonema spicatum*			C		3/3
plants	land plants	Commelinaceae	*Commelina agrostophylla*			C		8/7
plants	land plants	Commelinaceae	*Commelina diffusa*			C		1/1
plants	land plants	Commelinaceae	*Commelina lanceolata*			C		1/1
plants	land plants	Commelinaceae	*Cyanotis axillaris*			C		1/1
plants	land plants	Commelinaceae	*Murdannia graminea*	murdannia		C		6/6
plants	land plants	Convolvulaceae	*Bonamia*					2/2
plants	land plants	Convolvulaceae	*Bonamia linearis*			C		3/3
plants	land plants	Convolvulaceae	*Bonamia longipilosa*			C		6/6
plants	land plants	Convolvulaceae	*Bonamia media*			C		11/11
plants	land plants	Convolvulaceae	*Bonamia multiflora*			C		7/7
plants	land plants	Convolvulaceae	*Bonamia sp. (Croydon K.R.McDonald KRM4000)*			C		4/4
plants	land plants	Convolvulaceae	*Cuscuta chinensis*			C		1/1
plants	land plants	Convolvulaceae	*Evolvulus alsinoides*			C		1/1
plants	land plants	Convolvulaceae	*Evolvulus alsinoides var. decumbens*			C		7/7
plants	land plants	Convolvulaceae	*Ipomoea brassii*			C		3/3
plants	land plants	Convolvulaceae	*Ipomoea carnea subsp. fistulosa*		Y			1/1
plants	land plants	Convolvulaceae	*Ipomoea eriocarpa*			C		2/2
plants	land plants	Convolvulaceae	*Ipomoea plebeia*	bellvine		C		1/1
plants	land plants	Convolvulaceae	*Ipomoea polymorpha*			C		6/6
plants	land plants	Convolvulaceae	*Ipomoea racemigera*			C		2/2
plants	land plants	Convolvulaceae	*Jacquemontia browniana*			C		1/1
plants	land plants	Convolvulaceae	*Jacquemontia paniculata*			C		2/2
plants	land plants	Convolvulaceae	*Jacquemontia sp. (Fairview R.W.Johnson 4026)*			C		2/2
plants	land plants	Convolvulaceae	*Polymeria*					3/3
plants	land plants	Convolvulaceae	*Polymeria ambigua*			C		3/3
plants	land plants	Convolvulaceae	*Polymeria lanata*			C		1/1
plants	land plants	Convolvulaceae	*Polymeria sp. (Chillagoe K.R.McDonald KRM328)*			C		1/1
plants	land plants	Convolvulaceae	*Polymeria subhirsuta*			C		4/4
plants	land plants	Convolvulaceae	*Xenostegia tridentata*			C		3/3
plants	land plants	Cucurbitaceae	*Citrullus amarus*		Y			1/1
plants	land plants	Cucurbitaceae	*Cucumis melo*			C		7/7

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plants	land plants	Cyperaceae	*Abildgaardia macrantha*			C		1/1
plants	land plants	Cyperaceae	*Abildgaardia odontocarpa*			C		6/6
plants	land plants	Cyperaceae	*Abildgaardia ovata*			C		1/1
plants	land plants	Cyperaceae	*Abildgaardia oxystachya*			C		8/8
plants	land plants	Cyperaceae	*Abildgaardia pachyptera*			C		4/4
plants	land plants	Cyperaceae	*Abildgaardia schoenoides*			C		1/1
plants	land plants	Cyperaceae	*Bulbostylis barbata*			C		7/7
plants	land plants	Cyperaceae	*Cyperus aquatilis*			C		4/4
plants	land plants	Cyperaceae	*Cyperus blakeanus*			C		1/1
plants	land plants	Cyperaceae	*Cyperus breviculmis*			C		1/1
plants	land plants	Cyperaceae	*Cyperus brevifolius*	Mullumbimby couch	Y			6/1
plants	land plants	Cyperaceae	*Cyperus carinatus*			C		3/3
plants	land plants	Cyperaceae	*Cyperus compressus*		Y			3/3
plants	land plants	Cyperaceae	*Cyperus conicus var. conicus*			C		8/8
plants	land plants	Cyperaceae	*Cyperus cristulatus*			C		4/3
plants	land plants	Cyperaceae	*Cyperus difformis*	rice sedge		C		3/2
plants	land plants	Cyperaceae	*Cyperus flaccidus*			C		5
plants	land plants	Cyperaceae	*Cyperus fucosus*			C		6/6
plants	land plants	Cyperaceae	*Cyperus fulvus*			C		3/3
plants	land plants	Cyperaceae	*Cyperus haspan*			C		7
plants	land plants	Cyperaceae	*Cyperus haspan subsp. haspan*			C		2/2
plants	land plants	Cyperaceae	*Cyperus holoschoenus*			C		9/5
plants	land plants	Cyperaceae	*Cyperus iria*			C		3/3
plants	land plants	Cyperaceae	*Cyperus leptocarpus*			C		9/7
plants	land plants	Cyperaceae	*Cyperus macrostachyos*			C		3/3
plants	land plants	Cyperaceae	*Cyperus nervulosus*			C		4/4
plants	land plants	Cyperaceae	*Cyperus oxycarpus*			C		1/1
plants	land plants	Cyperaceae	*Cyperus pulchellus*			C		4/4
plants	land plants	Cyperaceae	*Cyperus sp. (Coleman River J.R.Clarkson 3455)*			C		2/2
plants	land plants	Cyperaceae	*Cyperus squarrosus*	bearded flatsedge		C		3/3
plants	land plants	Cyperaceae	*Diplacrum pygmaeum*			C		1/1
plants	land plants	Cyperaceae	*Eleocharis atropurpurea*			C		3/3
plants	land plants	Cyperaceae	*Eleocharis brassii*			C		3/3
plants	land plants	Cyperaceae	*Eleocharis nuda*			C		3/3
plants	land plants	Cyperaceae	*Eleocharis philippinensis*			C		1/1
plants	land plants	Cyperaceae	*Fimbristylis*					2/2
plants	land plants	Cyperaceae	*Fimbristylis acicularis*			C		2/2
plants	land plants	Cyperaceae	*Fimbristylis acuminata*			C		1/1
plants	land plants	Cyperaceae	*Fimbristylis blakei*			C		2
plants	land plants	Cyperaceae	*Fimbristylis caespitosa*			C		1/1
plants	land plants	Cyperaceae	*Fimbristylis clavata*			C		1/1
plants	land plants	Cyperaceae	*Fimbristylis corynocarya*			C		3/3
plants	land plants	Cyperaceae	*Fimbristylis densa*			C		1/1
plants	land plants	Cyperaceae	*Fimbristylis depauperata*			C		7/7
plants	land plants	Cyperaceae	*Fimbristylis dichotoma*	common fringe-rush		C		1/1
plants	land plants	Cyperaceae	*Fimbristylis furva*			C		3/3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	land plants	Cyperaceae	*Fimbristylis littoralis*			C		16/6
plants	land plants	Cyperaceae	*Fimbristylis microcarya*			C		4/4
plants	land plants	Cyperaceae	*Fimbristylis modesta*			C		1/1
plants	land plants	Cyperaceae	*Fimbristylis neilsonii*			C		2/2
plants	land plants	Cyperaceae	*Fimbristylis nuda*			C		8/7
plants	land plants	Cyperaceae	*Fimbristylis nutans*			C		12/2
plants	land plants	Cyperaceae	*Fimbristylis pterigosperma*			C		3/3
plants	land plants	Cyperaceae	*Fimbristylis quinquangularis*			C		1/1
plants	land plants	Cyperaceae	*Fimbristylis signata*			C		1/1
plants	land plants	Cyperaceae	*Fimbristylis simplex*			C		11/11
plants	land plants	Cyperaceae	*Fimbristylis sphaerocephala*			C		1/1
plants	land plants	Cyperaceae	*Fimbristylis subaristata*			C		1/1
plants	land plants	Cyperaceae	*Fimbristylis tetragona*			C		2/2
plants	land plants	Cyperaceae	*Fuirena arenosa*			C		5/5
plants	land plants	Cyperaceae	*Fuirena ciliaris*			C		18/6
plants	land plants	Cyperaceae	*Fuirena incrassata*			C		2/2
plants	land plants	Cyperaceae	*Rhynchospora*					1/1
plants	land plants	Cyperaceae	*Rhynchospora affinis*			C		2/2
plants	land plants	Cyperaceae	*Rhynchospora croydonensis*			C		9/9
plants	land plants	Cyperaceae	*Rhynchospora leae*			C		3/3
plants	land plants	Cyperaceae	*Rhynchospora pterochaeta*			C		1/1
plants	land plants	Cyperaceae	*Schoenoplectiella dissachantha*			C		1/1
plants	land plants	Cyperaceae	*Schoenoplectiella laevis*			C		2/2
plants	land plants	Cyperaceae	*Schoenoplectiella lateriflora var. lateriflora*			C		1/1
plants	land plants	Cyperaceae	*Scleria biflora subsp. biflora*			C		1/1
plants	land plants	Cyperaceae	*Scleria novae-hollandiae*			C		1/1
plants	land plants	Cyperaceae	*Scleria rugosa*			C		12/6
plants	land plants	Droseraceae	*Drosera*					1
plants	land plants	Droseraceae	*Drosera banksii*			SL		1/1
plants	land plants	Droseraceae	*Drosera burmanni*			SL		6/3
plants	land plants	Droseraceae	*Drosera lanata*			SL		1/1
plants	land plants	Droseraceae	*Drosera serpens*			SL		4/4
plants	land plants	Ebenaceae	*Diospyros humilis*	small-leaved ebony		C		1/1
plants	land plants	Elatinaceae	*Bergia pusilla*			C		1/1
plants	land plants	Eriocaulaceae	*Eriocaulon athertonense*			C		4/3
plants	land plants	Eriocaulaceae	*Eriocaulon carpentariae*			C		6/6
plants	land plants	Eriocaulaceae	*Eriocaulon cinereum*			C		8/8
plants	land plants	Eriocaulaceae	*Eriocaulon fistulosum*			C		2/2
plants	land plants	Eriocaulaceae	*Eriocaulon setaceum*			C		2/2
plants	land plants	Eriocaulaceae	*Eriocaulon tortuosum*			C		1/1
plants	land plants	Erythroxylaceae	*Erythroxylum ellipticum*			C		1/1
plants	land plants	Euphorbiaceae	*Euphorbia hassallii*			C		10/10
plants	land plants	Euphorbiaceae	*Euphorbia hirta*		Y			4/4
plants	land plants	Euphorbiaceae	*Euphorbia mitchelliana var. longiloba*			C		1/1
plants	land plants	Euphorbiaceae	*Euphorbia mitchelliana var. mitchelliana*			C		6/6
plants	land plants	Euphorbiaceae	*Euphorbia petala*			C		3/3

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plants	land plants	Euphorbiaceae	*Euphorbia schultzii var. schultzii*			C		1/1
plants	land plants	Euphorbiaceae	*Euphorbia trigonosperma*			C		3/3
plants	land plants	Euphorbiaceae	*Microstachys chamaelea*			C		9/9
plants	land plants	Gleicheniaceae	*Dicranopteris linearis*			C		1
plants	land plants	Gleicheniaceae	*Dicranopteris linearis var. linearis*			C		1/1
plants	land plants	Goodeniaceae	*Goodenia*					1/1
plants	land plants	Goodeniaceae	*Goodenia armitiana*			C		5/5
plants	land plants	Goodeniaceae	*Goodenia effusa*			C		5/5
plants	land plants	Goodeniaceae	*Goodenia janamba*			C		4/4
plants	land plants	Goodeniaceae	*Goodenia lamprosperma*			C		2/2
plants	land plants	Goodeniaceae	*Goodenia minutiflora*			C		4/4
plants	land plants	Goodeniaceae	*Goodenia pilosa*			C		9/9
plants	land plants	Goodeniaceae	*Goodenia pumilio*			C		3/3
plants	land plants	Goodeniaceae	*Goodenia redacta*			C		2/2
plants	land plants	Haemodoraceae	*Haemodorum coccineum*			C		1/1
plants	land plants	Haloragaceae	*Gonocarpus chinensis subsp. verrucosus*			C		6/2
plants	land plants	Haloragaceae	*Myriophyllum dicoccum*			C		3/3
plants	land plants	Haloragaceae	*Myriophyllum implicatum*			C		1/1
plants	land plants	Hydrocharitaceae	*Vallisneria caulescens*			SL		1/1
plants	land plants	Hydroleaceae	*Hydrolea zeylanica*			C		2/2
plants	land plants	Hypericaceae	*Hypericum gramineum*			C		2/1
plants	land plants	Lamiaceae	*Callicarpa candicans*			C		1/1
plants	land plants	Lamiaceae	*Clerodendrum floribundum*			C		1/1
plants	land plants	Lamiaceae	*Mesosphaerum suaveolens*		Y			11/8
plants	land plants	Lamiaceae	*Ocimum americanum*		Y			1/1
plants	land plants	Lamiaceae	*Ocimum caryophyllinum*			C		1/1
plants	land plants	Lamiaceae	*Premna acuminata*			C		1/1
plants	land plants	Lamiaceae	*Salvia misella*		Y			2/2
plants	land plants	Lamiaceae	*Vitex glabrata*			C		1/1
plants	land plants	Lamiaceae	*Vitex helogiton*			C		1/1
plants	land plants	Lauraceae	*Cassytha capillaris*			C		1/1
plants	land plants	Leguminosae	*Acacia armitii*			NT		1/1
plants	land plants	Leguminosae	*Acacia colei var. colei*			C		2/2
plants	land plants	Leguminosae	*Acacia galioides*			C		2/2
plants	land plants	Leguminosae	*Acacia gonoclada*			C		3/3
plants	land plants	Leguminosae	*Acacia hammondii*			C		3/3
plants	land plants	Leguminosae	*Acacia holosericea*			C		15/15
plants	land plants	Leguminosae	*Acacia julifera subsp. gilbertensis*			C		14/14
plants	land plants	Leguminosae	*Acacia leptocarpa*	north coast wattle		C		1/1
plants	land plants	Leguminosae	*Acacia leptoloba*			C		1/1
plants	land plants	Leguminosae	*Acacia leptostachya*	Townsville wattle		C		6/6
plants	land plants	Leguminosae	*Acacia platycarpa*			C		4/4
plants	land plants	Leguminosae	*Acacia rothii*			C		1/1
plants	land plants	Leguminosae	*Acacia shirleyi*	lancewood		C		8/6
plants	land plants	Leguminosae	*Acacia simsii*			C		7/7
plants	land plants	Leguminosae	*Acacia tephrina*			C		1/1

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plants	land plants	Leguminosae	*Acacia torulosa*			C		9/9
plants	land plants	Leguminosae	*Acacia tropica*			C		9/9
plants	land plants	Leguminosae	*Acacia umbellata*			C		2/2
plants	land plants	Leguminosae	*Adenanthera abrosperma*			C		3/3
plants	land plants	Leguminosae	*Aeschynomene indica*	budda pea		C		6/6
plants	land plants	Leguminosae	*Aeschynomene villosa*		Y			6/3
plants	land plants	Leguminosae	*Alysicarpus ovalifolius*		Y			4/4
plants	land plants	Leguminosae	*Aphyllodium biarticulatum*			C		5/5
plants	land plants	Leguminosae	*Cajanus acutifolius*			C		2/2
plants	land plants	Leguminosae	*Cajanus marmoratus*			C		3/3
plants	land plants	Leguminosae	*Canavalia papuana*	wild jack bean		C		2/2
plants	land plants	Leguminosae	*Centrosema pascuorum*		Y			2/2
plants	land plants	Leguminosae	*Chamaecrista absus var. absus*			C		6/6
plants	land plants	Leguminosae	*Chamaecrista grisea*			C		3/3
plants	land plants	Leguminosae	*Chamaecrista longipes*			C		2/2
plants	land plants	Leguminosae	*Chamaecrista mimosoides*	dwarf cassia		C		3/3
plants	land plants	Leguminosae	*Chamaecrista rotundifolia var. rotundifolia*		Y			2/2
plants	land plants	Leguminosae	*Chamaecrista symonii*			C		4/4
plants	land plants	Leguminosae	*Crotalaria brevis*			C		1/1
plants	land plants	Leguminosae	*Crotalaria crispata*			C		1/1
plants	land plants	Leguminosae	*Crotalaria goreensis*	gambia pea	Y			2/2
plants	land plants	Leguminosae	*Crotalaria inaequalis*			C		6/6
plants	land plants	Leguminosae	*Crotalaria medicaginea*	trefoil rattlepod		C		1/1
plants	land plants	Leguminosae	*Crotalaria medicaginea var. linearis*			C		6/6
plants	land plants	Leguminosae	*Crotalaria medicaginea var. medicaginea*			C		1/1
plants	land plants	Leguminosae	*Crotalaria medicaginea var. neglecta*			C		1/1
plants	land plants	Leguminosae	*Crotalaria montana var. angustifolia*			C		1/1
plants	land plants	Leguminosae	*Crotalaria montana var. exserta*			C		2/2
plants	land plants	Leguminosae	*Crotalaria novae-hollandiae subsp. novae-hollandiae*			C		3/3
plants	land plants	Leguminosae	*Crotalaria retusa var. retusa*		Y			1/1
plants	land plants	Leguminosae	*Desmodium brownii*			C		6/6
plants	land plants	Leguminosae	*Desmodium filiforme*			C		14/14
plants	land plants	Leguminosae	*Desmodium muelleri*			C		1/1
plants	land plants	Leguminosae	*Desmodium pullenii*			C		1/1
plants	land plants	Leguminosae	*Desmodium tortuosum*	Florida beggar-weed	Y			1/1
plants	land plants	Leguminosae	*Desmodium trichostachyum*			C		9/6
plants	land plants	Leguminosae	*Erythrophleum chlorostachys*			C		3/2
plants	land plants	Leguminosae	*Galactia tenuiflora forma sericea*			C		2/2
plants	land plants	Leguminosae	*Galactia tenuiflora var. lucida*			C		2/2
plants	land plants	Leguminosae	*Galactia tenuiflora var. macrantha*			C		3/3
plants	land plants	Leguminosae	*Glycine*					8/8
plants	land plants	Leguminosae	*Glycine tomentella*	woolly glycine		C		1/1
plants	land plants	Leguminosae	*Hovea parvicalyx*			C		1/1
plants	land plants	Leguminosae	*Indigofera*					8/8
plants	land plants	Leguminosae	*Indigofera australis subsp. australis*			C		1/1
plants	land plants	Leguminosae	*Indigofera colutea*	sticky indigo		C		3/3

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plants	land plants	Leguminosae	*Indigofera haplophylla*			C		1/1
plants	land plants	Leguminosae	*Indigofera hirsuta*	hairy indigo		C		6/6
plants	land plants	Leguminosae	*Indigofera linifolia*			C		5/5
plants	land plants	Leguminosae	*Indigofera linnaei*	Birdsville indigo		C		2/2
plants	land plants	Leguminosae	*Indigofera pratensis*			C		4/4
plants	land plants	Leguminosae	*Indigofera scabrella*			C		6/6
plants	land plants	Leguminosae	*Macroptilium lathyroides*		Y			1/1
plants	land plants	Leguminosae	*Neptunia gracilis forma glandulosa*			C		2/2
plants	land plants	Leguminosae	*Neptunia gracilis forma gracilis*			C		1/1
plants	land plants	Leguminosae	*Rhynchosia minima var. australis*			C		1/1
plants	land plants	Leguminosae	*Senna obtusifolia*		Y			1/1
plants	land plants	Leguminosae	*Senna occidentalis*	coffee senna	Y			3/3
plants	land plants	Leguminosae	*Senna venusta*			C		1/1
plants	land plants	Leguminosae	*Sesbania brachycarpa*			C		1/1
plants	land plants	Leguminosae	*Sesbania cannabina var. cannabina*			C		2/2
plants	land plants	Leguminosae	*Stylosanthes hamata*		Y			3/3
plants	land plants	Leguminosae	*Stylosanthes humilis*	Townsville stylo	Y			3/3
plants	land plants	Leguminosae	*Stylosanthes scabra*		Y			4/3
plants	land plants	Leguminosae	*Stylosanthes viscosa*		Y			1/1
plants	land plants	Leguminosae	*Tamarindus indica*		Y			1/1
plants	land plants	Leguminosae	*Tephrosia*					9/9
plants	land plants	Leguminosae	*Tephrosia brachyodon var. longifolia*			C		1/1
plants	land plants	Leguminosae	*Tephrosia conspicua*			C		6/6
plants	land plants	Leguminosae	*Tephrosia debilis*			C		1/1
plants	land plants	Leguminosae	*Tephrosia delestangii*			C		7/6
plants	land plants	Leguminosae	*Tephrosia filipes*			C		1/1
plants	land plants	Leguminosae	*Tephrosia filipes subsp. longifolia*			C		1/1
plants	land plants	Leguminosae	*Tephrosia flagellaris*			C		1/1
plants	land plants	Leguminosae	*Tephrosia juncea*			C		7/6
plants	land plants	Leguminosae	*Tephrosia leptoclada*			C		24/24
plants	land plants	Leguminosae	*Tephrosia sp. (Barkly Downs S.L.Everist 3384)*			C		1/1
plants	land plants	Leguminosae	*Tephrosia sp. (Lake Buchanan E.J.Thompson+ BUC2128)*			C		1/1
plants	land plants	Leguminosae	*Tephrosia sp. (Mt Isa P.L.Harris 277)*			C		1/1
plants	land plants	Leguminosae	*Tephrosia sp. (Pannikan Springs A.R.Bean+ 5612)*			C		8/8
plants	land plants	Leguminosae	*Tephrosia sp. (Prairie N.B.Byrnes 3945)*			C		1/1
plants	land plants	Leguminosae	*Tephrosia sp. (Walsh River L.Pedley 4890)*			C		4/4
plants	land plants	Leguminosae	*Tephrosia sp. Irvinebank (I.B.Staples IBS2090)*			C		8/8
plants	land plants	Leguminosae	*Tephrosia subpectinata*			C		1/1
plants	land plants	Leguminosae	*Uraria lagopodioides*			C		5/4
plants	land plants	Leguminosae	*Vachellia bidwillii*			C		2/2
plants	land plants	Leguminosae	*Vachellia clarksoniana*			C		2/2
plants	land plants	Leguminosae	*Vachellia sutherlandii*			C		1/1
plants	land plants	Leguminosae	*Vigna lanceolata var. filiformis*			C		2/2
plants	land plants	Leguminosae	*Vigna lanceolata var. lanceolata*			C		12/12
plants	land plants	Leguminosae	*Vigna sp. (Station Creek R.J.Lawn CQ3284)*			C		2/2
plants	land plants	Leguminosae	*Zornia*					1/1

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plants	land plants	Leguminosae	*Zornia adenophora*			C		10/10
plants	land plants	Leguminosae	*Zornia areolata*			C		7/7
plants	land plants	Leguminosae	*Zornia muriculata subsp. angustata*			C		11/11
plants	land plants	Leguminosae	*Zornia prostrata var. prostrata*			C		11/11
plants	land plants	Lentibulariaceae	*Utricularia blackmanii*			SL		1/1
plants	land plants	Lentibulariaceae	*Utricularia caerulea*	blue bladderwort		SL		6/4
plants	land plants	Lentibulariaceae	*Utricularia chrysantha*			SL		2/2
plants	land plants	Lentibulariaceae	*Utricularia gibba*	floating bladderwort		SL		7/1
plants	land plants	Linderniaceae	*Lindernia aplectra*			C		7/4
plants	land plants	Linderniaceae	*Lindernia lobelioides*			C		1/1
plants	land plants	Linderniaceae	*Torenia crustacea*			C		1/1
plants	land plants	Lindsaeaceae	*Lindsaea ensifolia*			C		3
plants	land plants	Lindsaeaceae	*Lindsaea ensifolia subsp. ensifolia*			C		1/1
plants	land plants	Loganiaceae	*Mitrasacme laricifolia*			C		1/1
plants	land plants	Loganiaceae	*Mitrasacme nudicaulis var. nudicaulis*			C		2/2
plants	land plants	Loganiaceae	*Mitrasacme sp. (Warang M.B.Thomas 1571)*			C		1/1
plants	land plants	Loganiaceae	*Mitrasacme stellata*			C		2/2
plants	land plants	Loganiaceae	*Mitreola petiolata*			C		1/1
plants	land plants	Loranthaceae	*Diplatia grandibractea*			C		2/2
plants	land plants	Loranthaceae	*Lysiana spathulata subsp. spathulata*			C		3/3
plants	land plants	Loranthaceae	*Lysiana subfalcata subsp. maritima*			C		1/1
plants	land plants	Lygodiaceae	*Lygodium flexuosum*			C		3/2
plants	land plants	Lythraceae	*Ammannia muelleri*			C		1/1
plants	land plants	Lythraceae	*Ammannia multiflora*	jerry-jerry		C		4/2
plants	land plants	Lythraceae	*Rotala diandra*			C		6/5
plants	land plants	Lythraceae	*Rotala occultiflora*			C		3/3
plants	land plants	Malvaceae	*Abutilon fraseri subsp. fraseri*			C		1/1
plants	land plants	Malvaceae	*Abutilon hannii*			C		1/1
plants	land plants	Malvaceae	*Abutilon otocarpum*			C		2/2
plants	land plants	Malvaceae	*Herissantia crispa*			C		1/1
plants	land plants	Malvaceae	*Hibiscus burtonii*			C		2/2
plants	land plants	Malvaceae	*Hibiscus leptocladus*			C		2/2
plants	land plants	Malvaceae	*Hibiscus meraukensis*	Merauke hibiscus		C		3/3
plants	land plants	Malvaceae	*Hibiscus sturtii*			C		1/1
plants	land plants	Malvaceae	*Sida*					1/1
plants	land plants	Malvaceae	*Sida acuta*	spinyhead sida	Y			5/5
plants	land plants	Malvaceae	*Sida atherophora*			C		1/1
plants	land plants	Malvaceae	*Sida brachypoda*			C		2/2
plants	land plants	Malvaceae	*Sida cordifolia*		Y			4/4
plants	land plants	Malvaceae	*Sida fibulifera*			C		1/1
plants	land plants	Malvaceae	*Sida hackettiana*			C		5/5
plants	land plants	Malvaceae	*Sida macropoda*			C		1/1
plants	land plants	Malvaceae	*Sida magnifica*			C		2/2
plants	land plants	Malvaceae	*Sida rohlenae subsp. rohlenae*			C		2/2
plants	land plants	Malvaceae	*Sida sp. (Aramac E.J.Thompson+ JER192)*			C		2/2
plants	land plants	Malvaceae	*Sida sp. (Musselbrook M.B.Thomas+ MRS437)*			C		4/2

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plants	land plants	Malvaceae	*Sida spinosa*	spiny sida	Y			4/4
plants	land plants	Malvaceae	*Urena lobata*	urena weed	Y			1/1
plants	land plants	Marsileaceae	*Marsilea*					1/1
plants	land plants	Menispermaceae	*Tinospora smilacina*	snakevine		C		1/1
plants	land plants	Menyanthaceae	*Nymphoides aurantiaca*			SL		1/1
plants	land plants	Menyanthaceae	*Nymphoides crenata*	wavy marshwort		SL		4/4
plants	land plants	Menyanthaceae	*Nymphoides exiliflora*			SL		1/1
plants	land plants	Menyanthaceae	*Nymphoides indica*	water snowflake		SL		8/5
plants	land plants	Menyanthaceae	*Nymphoides parvifolia*			SL		3/3
plants	land plants	Molluginaceae	*Glinus oppositifolius*			C		1/1
plants	land plants	Moraceae	*Ficus coronata*	creek sandpaper fig		C		1/1
plants	land plants	Myrtaceae	*Asteromyrtus symphyocarpa*			C		5/5
plants	land plants	Myrtaceae	*Calytrix exstipulata*			C		8/7
plants	land plants	Myrtaceae	*Corymbia bella*			C		5/3
plants	land plants	Myrtaceae	*Corymbia confertiflora*			C		10/5
plants	land plants	Myrtaceae	*Corymbia curtipes*			C		6/6
plants	land plants	Myrtaceae	*Corymbia gilbertensis*	Gilbert River ghost gum		C		8/5
plants	land plants	Myrtaceae	*Corymbia grandifolia subsp. grandifolia*			C		5/5
plants	land plants	Myrtaceae	*Corymbia pocillum*			C		9/7
plants	land plants	Myrtaceae	*Corymbia polycarpa*	long-fruited bloodwood		C		7/4
plants	land plants	Myrtaceae	*Corymbia setosa subsp. pedicellaris*			C		3/3
plants	land plants	Myrtaceae	*Eucalyptus camaldulensis*			C		6
plants	land plants	Myrtaceae	*Eucalyptus camaldulensis subsp. acuta*			C		1/1
plants	land plants	Myrtaceae	*Eucalyptus camaldulensis subsp. obtusa*			C		2/2
plants	land plants	Myrtaceae	*Eucalyptus chartaboma*			C		6/6
plants	land plants	Myrtaceae	*Eucalyptus distans*			C		9/9
plants	land plants	Myrtaceae	*Eucalyptus leptophleba*	Molloy red box		C		6/4
plants	land plants	Myrtaceae	*Eucalyptus melanophloia subsp. melanophloia*			C		3/3
plants	land plants	Myrtaceae	*Eucalyptus microneura*	Gilbert River box		C		6/6
plants	land plants	Myrtaceae	*Eucalyptus microtheca*	coolibah		C		2/2
plants	land plants	Myrtaceae	*Eucalyptus pruinosa subsp. pruinosa*			C		1/1
plants	land plants	Myrtaceae	*Eucalyptus shirleyi*			C		3/3
plants	land plants	Myrtaceae	*Eucalyptus tectifica*	Darwin box		C		1/1
plants	land plants	Myrtaceae	*Eucalyptus tetrodonta*	Darwin stringybark		C		3/3
plants	land plants	Myrtaceae	*Leptospermum pallidum*			NT		2/2
plants	land plants	Myrtaceae	*Lophostemon grandiflorus subsp. riparius*			C		3/3
plants	land plants	Myrtaceae	*Melaleuca argentea*	silver tea-tree		C		5/2
plants	land plants	Myrtaceae	*Melaleuca citrolens*			C		11/7
plants	land plants	Myrtaceae	*Melaleuca fluviatilis*			C		3/3
plants	land plants	Myrtaceae	*Melaleuca leucadendra*	broad-leaved tea-tree		C		2
plants	land plants	Myrtaceae	*Melaleuca nervosa*			C		7/6
plants	land plants	Myrtaceae	*Melaleuca nervosa subsp. crosslandiana*			C		3/3
plants	land plants	Myrtaceae	*Melaleuca stenostachya*			C		1/1
plants	land plants	Myrtaceae	*Melaleuca stenostachya subsp. stenostachya*			C		6/6
plants	land plants	Myrtaceae	*Melaleuca viridiflora*			C		3
plants	land plants	Myrtaceae	*Melaleuca viridiflora var. attenuata*			C		1/1

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plants	land plants	Myrtaceae	*Melaleuca viridiflora var. viridiflora*			C		5/5
plants	land plants	Myrtaceae	*Thryptomene oligandra*			C		2/2
plants	land plants	Nyctaginaceae	*Boerhavia dominii*			C		1/1
plants	land plants	Nyctaginaceae	*Boerhavia pubescens*			C		2/2
plants	land plants	Nymphaeaceae	*Nymphaea gigantea*			SL		1
plants	land plants	Nymphaeaceae	*Nymphaea immutabilis*			SL		2/2
plants	land plants	Onagraceae	*Ludwigia hyssopifolia*		Y			3/3
plants	land plants	Onagraceae	*Ludwigia octovalvis*	willow primrose		C		13/2
plants	land plants	Onagraceae	*Ludwigia perennis*			C		3/3
plants	land plants	Orobanchaceae	*Buchnera linearis*			C		2/2
plants	land plants	Orobanchaceae	*Centranthera cochinchinensis*			C		4/4
plants	land plants	Orobanchaceae	*Rhamphicarpa australiensis*			C		7/7
plants	land plants	Orobanchaceae	*Striga curviflora*			C		1/1
plants	land plants	Orobanchaceae	*Striga parviflora*			C		3/3
plants	land plants	Pandanaceae	*Pandanus*					8
plants	land plants	Pandanaceae	*Pandanus spiralis*			C		2/2
plants	land plants	Passifloraceae	*Passiflora foetida*		Y			4/4
plants	land plants	Pedaliaceae	*Josephinia eugeniae*	josephinia burr		C		4/4
plants	land plants	Philydraceae	*Philydrum lanuginosum*	frogsmouth		C		2
plants	land plants	Phrymaceae	*Microcarpaea minima*			C		3/3
plants	land plants	Phrymaceae	*Mimulus uvedaliae*			C		4/4
plants	land plants	Phyllanthaceae	*Antidesma ghaesembilla*			C		1/1
plants	land plants	Phyllanthaceae	*Antidesma parvifolium*			C		2/2
plants	land plants	Phyllanthaceae	*Breynia oblongifolia*			C		3/3
plants	land plants	Phyllanthaceae	*Margaritaria dubium-traceyi*			C		3/3
plants	land plants	Phyllanthaceae	*Phyllanthus*					4/4
plants	land plants	Phyllanthaceae	*Phyllanthus carpentariae*			C		4/4
plants	land plants	Phyllanthaceae	*Phyllanthus collinus*			C		1/1
plants	land plants	Phyllanthaceae	*Phyllanthus debilis*		Y			1/1
plants	land plants	Phyllanthaceae	*Phyllanthus eutaxioides*			C		1/1
plants	land plants	Phyllanthaceae	*Phyllanthus exilis*			C		3/3
plants	land plants	Phyllanthaceae	*Phyllanthus minutiflorus*			C		7/7
plants	land plants	Phyllanthaceae	*Phyllanthus sp. (Alexandra River R.Pullen 8936)*			C		6/6
plants	land plants	Phyllanthaceae	*Phyllanthus sp. (Myra Vale J.J.Bruhl+ 1810)*			C		1/1
plants	land plants	Phyllanthaceae	*Phyllanthus sulcatus*			C		9/9
plants	land plants	Phyllanthaceae	*Phyllanthus tenellus*		Y			1/1
plants	land plants	Phyllanthaceae	*Phyllanthus trachygyne*			C		2/2
plants	land plants	Phyllanthaceae	*Phyllanthus virgatus*			C		5/1
plants	land plants	Phyllanthaceae	*Synostemon lissocarpus*			C		1/1
plants	land plants	Phyllanthaceae	*Synostemon rhytidospermus*			C		2/2
plants	land plants	Picrodendraceae	*Petalostigma banksii*			C		4/2
plants	land plants	Picrodendraceae	*Petalostigma pubescens*	quinine tree		C		3/3
plants	land plants	Picrodendraceae	*Petalostigma quadriloculare*			C		1/1
plants	land plants	Plantaginaceae	*Bacopa floribunda*			C		2/2
plants	land plants	Plantaginaceae	*Limnophila brownii*			C		2/2
plants	land plants	Plantaginaceae	*Limnophila fragrans*			C		2/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	land plants	Plantaginaceae	*Stemodia lythrifolia*			C		8/8
plants	land plants	Poaceae	*Alloteropsis cimicina*			C		2/2
plants	land plants	Poaceae	*Alloteropsis semialata*	cockatoo grass		C		2/2
plants	land plants	Poaceae	*Aristida*					1
plants	land plants	Poaceae	*Aristida biglandulosa*			C		2/2
plants	land plants	Poaceae	*Aristida calycina var. calycina*			C		2/2
plants	land plants	Poaceae	*Aristida calycina var. praealta*			C		2/2
plants	land plants	Poaceae	*Aristida dominii*			C		7/7
plants	land plants	Poaceae	*Aristida exserta*			C		2/2
plants	land plants	Poaceae	*Aristida holathera*			C		1/1
plants	land plants	Poaceae	*Aristida holathera var. holathera*			C		4/4
plants	land plants	Poaceae	*Aristida hygrometrica*			C		2/2
plants	land plants	Poaceae	*Aristida ingrata*			C		3/3
plants	land plants	Poaceae	*Aristida jerichoensis var. jerichoensis*			C		2/2
plants	land plants	Poaceae	*Aristida latifolia*	feathertop wiregrass		C		1/1
plants	land plants	Poaceae	*Aristida pruinosa*			C		3/3
plants	land plants	Poaceae	*Aristida queenslandica var. queenslandica*			C		1/1
plants	land plants	Poaceae	*Aristida sciuroides*			C		6/6
plants	land plants	Poaceae	*Aristida superpendens*			C		1/1
plants	land plants	Poaceae	*Arundinella nepalensis*	reedgrass		C		4/1
plants	land plants	Poaceae	*Arundinella setosa*			C		3/3
plants	land plants	Poaceae	*Axonopus compressus*		Y			3
plants	land plants	Poaceae	*Bothriochloa bladhii subsp. bladhii*			C		1/1
plants	land plants	Poaceae	*Bothriochloa pertusa*		Y			1/1
plants	land plants	Poaceae	*Brachyachne ciliaris*	hairy native couch		C		1/1
plants	land plants	Poaceae	*Brachyachne convergens*	common native couch		C		2/2
plants	land plants	Poaceae	*Cenchrus ciliaris*		Y			2/2
plants	land plants	Poaceae	*Chloris inflata*	purpletop chloris	Y			1/1
plants	land plants	Poaceae	*Chloris lobata*			C		4/4
plants	land plants	Poaceae	*Chloris pumilio*			C		1/1
plants	land plants	Poaceae	*Chrysopogon fallax*			C		4/4
plants	land plants	Poaceae	*Chrysopogon pallidus*			C		1/1
plants	land plants	Poaceae	*Cymbopogon bombycinus*	silky oilgrass		C		4/4
plants	land plants	Poaceae	*Cynodon dactylon*		Y			2
plants	land plants	Poaceae	*Cynodon dactylon var. dactylon*		Y			1/1
plants	land plants	Poaceae	*Dactyloctenium*					1/1
plants	land plants	Poaceae	*Dactyloctenium buchananensis*			C		1/1
plants	land plants	Poaceae	*Dactyloctenium radulans*	button grass		C		4/4
plants	land plants	Poaceae	*Dichanthium fecundum*	curly bluegrass		C		4/4
plants	land plants	Poaceae	*Digitaria bicornis*			C		2/2
plants	land plants	Poaceae	*Digitaria breviglumis*			C		3/3
plants	land plants	Poaceae	*Digitaria brownii*			C		3/3
plants	land plants	Poaceae	*Digitaria ciliaris*	summer grass	Y			3/3
plants	land plants	Poaceae	*Digitaria ctenantha*			C		2/2
plants	land plants	Poaceae	*Digitaria fumida*			C		1/1
plants	land plants	Poaceae	*Digitaria gibbosa*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	land plants	Poaceae	*Digitaria longiflora*			C		1/1
plants	land plants	Poaceae	*Digitaria minima*			C		2/2
plants	land plants	Poaceae	*Digitaria nematostachya*			C		1/1
plants	land plants	Poaceae	*Digitaria papposa*			C		1/1
plants	land plants	Poaceae	*Digitaria violascens*	bastard summergrass	Y			1/1
plants	land plants	Poaceae	*Echinochloa colona*	awnless barnyard grass	Y			8/1
plants	land plants	Poaceae	*Echinochloa polystachya*		Y			1
plants	land plants	Poaceae	*Ectrosia*					1/1
plants	land plants	Poaceae	*Ectrosia agrostoides*			C		4/4
plants	land plants	Poaceae	*Ectrosia blakei*			C		1/1
plants	land plants	Poaceae	*Ectrosia confusa*			C		3/3
plants	land plants	Poaceae	*Ectrosia gulliveri*			C		8/8
plants	land plants	Poaceae	*Ectrosia leporina*			C		15/9
plants	land plants	Poaceae	*Ectrosia scabrida*			C		3/3
plants	land plants	Poaceae	*Ectrosia schultzii*			C		2/2
plants	land plants	Poaceae	*Eleusine indica*	crowsfoot grass	Y			1/1
plants	land plants	Poaceae	*Elionurus citreus*	lemon-scented grass		C		5/5
plants	land plants	Poaceae	*Elytrophorus spicatus*			C		2/2
plants	land plants	Poaceae	*Enneapogon lindleyanus*			C		2/2
plants	land plants	Poaceae	*Enneapogon nigricans*	niggerheads		C		2/2
plants	land plants	Poaceae	*Enneapogon pallidus*	conetop nineawn		C		1/1
plants	land plants	Poaceae	*Enneapogon polyphyllus*	leafy nineawn		C		1/1
plants	land plants	Poaceae	*Enneapogon purpurascens*			C		1/1
plants	land plants	Poaceae	*Enteropogon acicularis*	curly windmill grass		C		1/1
plants	land plants	Poaceae	*Eragrostis*					1/1
plants	land plants	Poaceae	*Eragrostis basedowii*			C		3/3
plants	land plants	Poaceae	*Eragrostis concinna*			C		3/3
plants	land plants	Poaceae	*Eragrostis cumingii*			C		4/4
plants	land plants	Poaceae	*Eragrostis exigua*			C		1/1
plants	land plants	Poaceae	*Eragrostis fallax*			C		7/7
plants	land plants	Poaceae	*Eragrostis pubescens*			C		1/1
plants	land plants	Poaceae	*Eragrostis spartinoides*			C		7
plants	land plants	Poaceae	*Eragrostis speciosa*			C		6/6
plants	land plants	Poaceae	*Eragrostis stagnalis*			C		2/2
plants	land plants	Poaceae	*Eriachne armitii*			C		3/3
plants	land plants	Poaceae	*Eriachne ciliata*			C		3/3
plants	land plants	Poaceae	*Eriachne glauca*			C		1/1
plants	land plants	Poaceae	*Eriachne glauca var. glauca*			C		4/4
plants	land plants	Poaceae	*Eriachne humilis*			C		8/8
plants	land plants	Poaceae	*Eriachne melicacea*			C		5/5
plants	land plants	Poaceae	*Eriachne mucronata*			C		2/2
plants	land plants	Poaceae	*Eriachne obtusa*			C		4/4
plants	land plants	Poaceae	*Eriachne rara*			C		2/2
plants	land plants	Poaceae	*Eriachne sp. (Dugald River B.K.Simon+ 3007)*			C		2/2
plants	land plants	Poaceae	*Eriachne stipacea*			C		10/6
plants	land plants	Poaceae	*Eriachne vesiculosa*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	land plants	Poaceae	*Heterachne abortiva*			C		4/4
plants	land plants	Poaceae	*Heterachne gulliveri*			C		9/9
plants	land plants	Poaceae	*Heteropogon contortus*	black speargrass		C		3/3
plants	land plants	Poaceae	*Heteropogon triticeus*	giant speargrass		C		3/3
plants	land plants	Poaceae	*Imperata cylindrica*	blady grass		C		2
plants	land plants	Poaceae	*Ischaemum australe*			C		6
plants	land plants	Poaceae	*Ischaemum australe var. arundinaceum*			C		3/3
plants	land plants	Poaceae	*Ischaemum australe var. villosum*			C		1/1
plants	land plants	Poaceae	*Ischaemum rugosum var. rugosum*			C		1
plants	land plants	Poaceae	*Ischaemum rugosum var. segetum*			C		1/1
plants	land plants	Poaceae	*Melinis repens*	red natal grass	Y			1/1
plants	land plants	Poaceae	*Mnesithea formosa*			C		5/5
plants	land plants	Poaceae	*Mnesithea pilosa*			C		1/1
plants	land plants	Poaceae	*Mnesithea rottboellioides*			C		1/1
plants	land plants	Poaceae	*Oryza australiensis*			C		4/4
plants	land plants	Poaceae	*Oxychloris scariosa*	winged chloris		C		3/3
plants	land plants	Poaceae	*Panicum mindanaense*			C		8/5
plants	land plants	Poaceae	*Panicum paludosum*	swamp panic		C		1/1
plants	land plants	Poaceae	*Panicum robustum*			C		1/1
plants	land plants	Poaceae	*Panicum seminudum var. cairnsianum*			C		5/5
plants	land plants	Poaceae	*Panicum trachyrhachis*			C		1/1
plants	land plants	Poaceae	*Panicum trichoides*			C		5/2
plants	land plants	Poaceae	*Paspalidium caespitosum*	brigalow grass		C		1/1
plants	land plants	Poaceae	*Paspalidium distans*	shotgrass		C		1/1
plants	land plants	Poaceae	*Paspalidium rarum*			C		7/7
plants	land plants	Poaceae	*Paspalum scrobiculatum*	ditch millet		C		4/2
plants	land plants	Poaceae	*Perotis rara*	comet grass		C		4/4
plants	land plants	Poaceae	*Pheidochloa gracilis*			C		1/1
plants	land plants	Poaceae	*Pseudopogonatherum contortum*			C		8/8
plants	land plants	Poaceae	*Pseudoraphis spinescens*	spiny mudgrass		C		4/4
plants	land plants	Poaceae	*Sacciolepis indica*	Indian cupscale grass		C		8/2
plants	land plants	Poaceae	*Sacciolepis myosuroides*			C		11/4
plants	land plants	Poaceae	*Sarga plumosum*			C		6/5
plants	land plants	Poaceae	*Schizachyrium crinizonatum*			C		1/1
plants	land plants	Poaceae	*Schizachyrium dolosum*			C		1/1
plants	land plants	Poaceae	*Schizachyrium fragile*	firegrass		C		2/2
plants	land plants	Poaceae	*Schizachyrium pseudeulalia*			C		1/1
plants	land plants	Poaceae	*Sehima nervosum*			C		1/1
plants	land plants	Poaceae	*Setaria surgens*			C		4/4
plants	land plants	Poaceae	*Sporobolus actinocladus*	katoora grass		C		1/1
plants	land plants	Poaceae	*Sporobolus australasicus*			C		5/5
plants	land plants	Poaceae	*Sporobolus jacquemontii*		Y			1/1
plants	land plants	Poaceae	*Sporobolus scabridus*			C		2/2
plants	land plants	Poaceae	*Thaumastochloa brassii*			C		3/3
plants	land plants	Poaceae	*Thaumastochloa major*			C		5/5
plants	land plants	Poaceae	*Thaumastochloa pubescens*			C		7/7

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	land plants	Poaceae	*Thaumastochloa x heteromorpha*			C		2/2
plants	land plants	Poaceae	*Themeda arguens*			C		5/5
plants	land plants	Poaceae	*Themeda quadrivalvis*	grader grass	Y			4/4
plants	land plants	Poaceae	*Themeda triandra*	kangaroo grass		C		2/1
plants	land plants	Poaceae	*Tripogon loliiformis*	five minute grass		C		1/1
plants	land plants	Poaceae	*Urochloa holosericea subsp. holosericea*			C		3/3
plants	land plants	Poaceae	*Urochloa mosambicensis*	sabi grass	Y			1/1
plants	land plants	Poaceae	*Urochloa piligera*			C		1/1
plants	land plants	Poaceae	*Urochloa subquadripara*		Y			3/3
plants	land plants	Poaceae	*Vacoparis laxiflorum*			C		2/2
plants	land plants	Poaceae	*Yakirra australiensis var. intermedia*			C		1/1
plants	land plants	Poaceae	*Yakirra majuscula*			C		1/1
plants	land plants	Poaceae	*Yakirra muelleri*			C		2/2
plants	land plants	Polygalaceae	*Polygala exsquarrosa*			C		1/1
plants	land plants	Polygalaceae	*Polygala macrobotrya*			C		1/1
plants	land plants	Polygalaceae	*Polygala parviloba*			C		4/4
plants	land plants	Polygalaceae	*Polygala pycnantha*			C		2/2
plants	land plants	Polygalaceae	*Polygala triflora*			C		1/1
plants	land plants	Pontederiaceae	*Monochoria cyanea*			C		5/3
plants	land plants	Portulacaceae	*Calandrinia arenicola*			C		4/4
plants	land plants	Portulacaceae	*Calandrinia gracilis*			C		4/4
plants	land plants	Portulacaceae	*Calandrinia pleiopetala*			C		1/1
plants	land plants	Portulacaceae	*Calandrinia spergularina*			C		1/1
plants	land plants	Portulacaceae	*Calandrinia tumida*			C		1/1
plants	land plants	Portulacaceae	*Calandrinia uniflora*			C		3/3
plants	land plants	Portulacaceae	*Portulaca*					6/6
plants	land plants	Portulacaceae	*Portulaca australis*			C		1/1
plants	land plants	Portulacaceae	*Portulaca bicolor*			C		2/2
plants	land plants	Portulacaceae	*Portulaca filifolia*			C		4/4
plants	land plants	Portulacaceae	*Portulaca oligosperma*			C		5/5
plants	land plants	Portulacaceae	*Sedopsis armitii*			C		1/1
plants	land plants	Portulacaceae	*Sedopsis sp. (Bulimba Station P.I.Forster+ PIF14742)*			C		1/1
plants	land plants	Potamogetonaceae	*Potamogeton octandrus*			SL		2/2
plants	land plants	Proteaceae	*Grevillea decora*			C		1/1
plants	land plants	Proteaceae	*Grevillea decora subsp. decora*			C		5/5
plants	land plants	Proteaceae	*Grevillea glauca*	bushy's clothes peg		C		1/1
plants	land plants	Proteaceae	*Grevillea mimosoides*			C		1/1
plants	land plants	Proteaceae	*Grevillea parallela*			C		3/3
plants	land plants	Proteaceae	*Grevillea striata*	beefwood		C		1/1
plants	land plants	Proteaceae	*Hakea chordophylla*			C		1
plants	land plants	Proteaceae	*Hakea lorea subsp. lorea*			C		1/1
plants	land plants	Pteridaceae	*Cheilanthes brownii*			C		2/2
plants	land plants	Pteridaceae	*Cheilanthes nitida*			C		1/1
plants	land plants	Pteridaceae	*Cheilanthes nudiuscula*			C		3/3
plants	land plants	Pteridaceae	*Pityrogramma calomelanos var. calomelanos*		Y			3/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	land plants	Pteridaceae	*Pteris tripartita*	lacy bracken		SL		2/1
plants	land plants	Restionaceae	*Dapsilanthus spathaceus*			C		1/1
plants	land plants	Rhamnaceae	*Alphitonia excelsa*	soap tree		C		4/3
plants	land plants	Rhamnaceae	*Alphitonia pomaderroides*			C		2/2
plants	land plants	Rhamnaceae	*Ventilago viminalis*	supplejack		C		1/1
plants	land plants	Rhamnaceae	*Ziziphus mauritiana*	Indian jujube	Y			2/2
plants	land plants	Rubiaceae	*Dentella browniana*			C		3/3
plants	land plants	Rubiaceae	*Gardenia vilhelmii*			C		5/4
plants	land plants	Rubiaceae	*Larsenaikia ochreata*			C		2/1
plants	land plants	Rubiaceae	*Mitracarpus hirtus*		Y			1/1
plants	land plants	Rubiaceae	*Paranotis mitrasacmoides subsp. mitrasacmoides*			C		15/15
plants	land plants	Rubiaceae	*Paranotis mitrasacmoides subsp. nigricans*			C		2/2
plants	land plants	Rubiaceae	*Pavetta granitica*			C		2/2
plants	land plants	Rubiaceae	*Psydrax saligna forma saligna*			C		1/1
plants	land plants	Rubiaceae	*Richardia scabra*		Y			1/1
plants	land plants	Rubiaceae	*Scleromitrion galioides*			C		8/8
plants	land plants	Rubiaceae	*Scleromitrion laceyi*			C		1/1
plants	land plants	Rubiaceae	*Spermacoce*					6/6
plants	land plants	Rubiaceae	*Spermacoce baileyana*			C		5/5
plants	land plants	Rubiaceae	*Spermacoce brachystema*			C		3/3
plants	land plants	Rubiaceae	*Spermacoce dolichosperma*			C		2/2
plants	land plants	Rubiaceae	*Spermacoce latimarginata*			C		11/11
plants	land plants	Rubiaceae	*Spermacoce sp. (Lorim Point A.Morton AM1237)*			C		1/1
plants	land plants	Rubiaceae	*Spermacoce sp. (Normanton R.Pullen 8839)*			C		5/5
plants	land plants	Rutaceae	*Boronia bowmanii*			C		2/2
plants	land plants	Salicaceae	*Homalium brachybotrys*			C		1/1
plants	land plants	Santalaceae	*Santalum lanceolatum*			SL		1/1
plants	land plants	Sapindaceae	*Atalaya hemiglauca*			C		1/1
plants	land plants	Sapindaceae	*Dodonaea hispidula var. hispidula*			C		1/1
plants	land plants	Sapindaceae	*Dodonaea oxyptera*			C		4/4
plants	land plants	Sapindaceae	*Dodonaea physocarpa*			C		7/7
plants	land plants	Sapindaceae	*Dodonaea platyptera*			C		1/1
plants	land plants	Sapotaceae	*Planchonella pohlmaniana*			C		2/2
plants	land plants	Solanaceae	*Datura inoxia*		Y			1/1
plants	land plants	Solanaceae	*Physalis angulata*		Y			1/1
plants	land plants	Solanaceae	*Solanum lucani*			C		4/4
plants	land plants	Sparrmanniaceae	*Corchorus aestuans*			C		1/1
plants	land plants	Sparrmanniaceae	*Corchorus pumilio*			C		4/4
plants	land plants	Sparrmanniaceae	*Corchorus sericeus subsp. densiflorus*			C		1/1
plants	land plants	Sparrmanniaceae	*Corchorus sericeus subsp. sericeus*			C		1/1
plants	land plants	Sparrmanniaceae	*Corchorus sidoides subsp. vermicularis*			C		2/2
plants	land plants	Sparrmanniaceae	*Grewia savannicola*			C		4/4
plants	land plants	Sparrmanniaceae	*Triumfetta*					1/1
plants	land plants	Sparrmanniaceae	*Triumfetta marsupiata*			C		6/6
plants	land plants	Sparrmanniaceae	*Triumfetta micracantha*			C		9/9
plants	land plants	Sparrmanniaceae	*Triumfetta pentandra*		Y			3/3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	land plants	Sparrmanniaceae	*Triumfetta rhomboidea*	chinese burr	Y			3
plants	land plants	Stackhousiaceae	*Stackhousia intermedia*			C		4/4
plants	land plants	Sterculiaceae	*Brachychiton diversifolius subsp. orientalis*			SL		1/1
plants	land plants	Sterculiaceae	*Brachychiton paradoxus*			SL		2/1
plants	land plants	Stylidiaceae	*Stylidium adenophorum*			SL		1/1
plants	land plants	Stylidiaceae	*Stylidium centrolepoides*			SL		1/1
plants	land plants	Stylidiaceae	*Stylidium floodii*			SL		2/2
plants	land plants	Stylidiaceae	*Stylidium rotundifolium*			SL		3/1
plants	land plants	Stylidiaceae	*Stylidium schizanthum*			SL		2/2
plants	land plants	Thelypteridaceae	*Cyclosorus interruptus*			SL		2/1
plants	land plants	Thymelaeaceae	*Pimelea sanguinea*			C		2/2
plants	land plants	Violaceae	*Pigea enneasperma*			C		5/5
plants	land plants	Violaceae	*Pigea stellarioides*			C		1/1
plants	land plants	Xyridaceae	*Xyris complanata*	yellow-eye		C		6/2
plants	land plants	Xyridaceae	*Xyris oligantha*			C		4
plants	land plants	Xyridaceae	*Xyris pauciflora*			C		4/4
plants	land plants	Zygophyllaceae	*Tribulopis angustifolia*			C		4/4
plants	land plants	Zygophyllaceae	*Tribulopis pentandra*			C		4/4
plants	land plants	Zygophyllaceae	*Tribulopis solandri*			C		2/2
plants	land plants	Zygophyllaceae	*Tribulus terrestris*	caltrop		C		2/2
plants	uncertain	Indet.	*Indet.*			C		1/1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.*
The codes are Extinct (EX), Extinct in the Wild (PE), Critically Endangered (CR), Endangered (E), Vulnerable (V), Near Threatened (NT), Special Least Concern (SL) and Least Concern (C).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.*
The values of EPBC are Extinct (EX), Extinct in the Wild (XW), Critically Endangered (CE), Endangered (E), Vulnerable (V) and Conservation Dependent (CD).

Records - The first number indicates the total number of records of the taxon (wildlife records and species listings for selected areas).
This number is output as 99999 if it equals or exceeds this value. A second number located after a / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

APPENDIX B FLORA SPECIES LIST

Common name	***Species***
-	*Acacia fascilifera*
-	*Acacia juliflora*
Townsville Wattle	*Acacia leptostachya*
Lancewood	*Acacia shirleyi*
Soap Tree	*Alphitonia excelsa*
-	*Aristida calycina*
-	*Aristida dominii*
Cotton Tree	*Aristida exserta*
Feathertop Wiregrass	*Aristida latifolia*
-	*Aristida sciuroides*
-	*Aristida superpendens*
-	*Brachychiton garrawayae*
-	*Carissa lanceolata*
Golden Beardgrass	*Chrysopogon fallax*
Kapok	*Cochlospermum gillivraei*
Flannel Jute	*Corchorus sidoides*
Georgetown Bloodwood	*Corymbia pocillum*
-	*Corymbia polycarpa*
-	*Dodonaea physocarpa*
-	*Eriachne humilis*
-	*Eriachne melicacea*
-	*Erythrophleum chlorostachys*
Blue Gum	*Eucalyptus camaldulensis*
Queensland Woollybutt	*Eucalyptus chartaboma*
-	*Eucalyptus leptophylla*
Gilbert River Box	*Eucalyptus microneura*
-	*Eucalyptus pruinosa*
-	*Gardenia vilhelmii*
-	*Grevillea parallela*
Beefwood	*Grevillea striata*
Black Speargrass	*Heteropogon contortus*
-	*Lophostemon grandiflorus* subsp. *riparius*
Northern Swamp Box	*Melaleuca citrolens*
Fibre-barked Tea-tree	*Melaleuca stenostachya*
Broad-leaved Tea-tree	*Melaleuca viridiflora*
Australian Millet	*Panicum decompositum*
Quinine Bush	*Petalostigma banksii*
Plume Sorghum	*Sarga plumosum*
-	*Schizachyrium fragile*
-	*Tephrosia brachyodon*
-	*Terminalia platyptera*
-	*Triumfetta micracantha*

APPENDIX C RE SURVEY DATA SHEETS

Site ID	GR1	GR2	GR3	GR4	GR5
RE	2.5.14c/2.5.30/2.5.5a	9.12.33a/9.12.33.c	2.5.14c/2.5.30/2.5.5a	9.5.13a/2.3.26a	9.12.33a/9.12.33c
GTRE	2.5.30	9.12.33c	2.5.30	9.5.13a	9.12.33c
Geology	Light brown sandy loam	Sandy with surface stones	Granite gravel over sand	Tertiary sand	Granite
Landform	Sandy plain	Gentle rise	Sand sheet	Sand sheet	Stony rise
Status	Remnant	Remnant	Remnant	Remnant	Remnant
TEC	No	No	No	No	No
EDL	T1	T1	T1	T1	T1
EDL Height Range (m)	9-Oct	8-Nov	3-Jul	4-7.5	Aug-13
EDL Median Height (m)	9.5	9	4.5	6	11
EDL Cover (%)	12	11	8	15	12
Structural Classification	Low woodland	Low woodland	Low open-woodland	Low woodland	Woodland
T1 Height (m)	9.5	9	4.5	6	11
T1 Cover (%)	12	11	8	15	
T1 Species	*Eucalyptus pruinosa, Melaleuca citrolens, Melaleuca stenostachya*	*Corymbia pocillum*	*Acacia shirleyi, Melaleuca citrolens, Eucalyptus leptophylla*	*Melaleuca citrolens*	*Eucalyptus leptophylla, Eucalyptus chartaboma, Erythrophleum chlorostachys*
T2 Height (m)	6	4			7
T2 Cover (%)	30	40			18
T2 Species	*Brachychiton garrawayae, Terminalia platyptera, Gardenia vilhelmi,*	*Petalostigma banksii, Acacia julifera, Terminalia platyptera*			*Acacia julifera, Alphitonia excelsa*
S1 Height (m)	3	0.8	0.7	3.5	1.5
S1 Cover (%)	10	2	1	5	2
S1 Species	*Acacia julifera, Grevillea striata, Dodonaea physocarpa*	*Dodonaea physocarpa*	*Petalostigma banksii*	*Gardenia vilhelmi*	*Tephrosia brachyodon, Acacia fascilifera*
S2 Height (m)	0.8				
S2 Cover (%)	5				
S2 Species	*Dodonaea physocarpa*				
G Height (m)	1.2	0.5	0.4	0.6	0.25
G Cover (%)	20	5	10	20	5
G Species	*Schizachyrium fragile, Chrysopogon fallax, Aristida exserta, Aristida dominii, Aristida sciuroides, Aristida superpendens, Aristida latifolia*	*Sarga plumosum, Schizachyrium fragile, Aristida supersendens*	*Schizachyrium fragile, Chrysopogon fallax, Aristida exserta, Aristida dominii, Aristida sciuroides, Aristida superpendens, Aristida latifolia*	*Eriachne humilis, Aristida dominii*	*Sarga plumosum, Schizachyrium fragile, Aristida supersendens*
W (%)	0	0		0	0
W Species	None	None	None	None	None
Disturbance	Minor cattle	Minor cattle, historic mine pits	Minor cattle	Minor cattle	Historical mining
Note	None	None	None	None	None

Site ID	GR6	GR7	GR8	GR9	GR10
RE	9.12.33a/9.12.33c	9.12.33a/9.12.33c	9.5.13a/2.3.26a	9.12.33a/9.12.33c	9.5.13a/2.3.26a
GTRE	9.12.33c	9.12.33c	9.5.13a	9.12.33c	9.5.13a
Geology	Pink gravel over sand	Granite	Tertiary sand	Granite	Tertiary sand
Landform	Gentle rise	Gentle rise	Sand sheet	Gentle rise	Sand sheet
Status	Remnant	Remnant	Remnant	Remnant	Remnant
TEC	No	No	No	No	No
EDL	T1	T1	T1	T1	T1
EDL Height Range (m)	8-Dec	9-Dec	5-Nov	8-Nov	6-Sep
EDL Median Height (m)	9.5	10.5	8	9	8
EDL Cover (%)	5	5	7	8	10
Structural Classification	Low open-woodland	Open-woodland	Low open-woodland	Low open-woodland	Low open-woodland
T1 Height (m)	9.5	10.5	8	9	8
T1 Cover (%)	5	5	7	8	10
T1 Species	*Eucalyptus chartaboma, Corymbia pocillum, Eucalyptus microneura*	*Corymbia pocillum, Acacia shirleyi*	*Melaleuca viridifolia*	*Corymbia pocillum, Acacia shirleyi*	*Melaleuca citrolens*
T2 Height (m)	5		5	4	5
T2 Cover (%)	25	20	30	20	15
T2 Species	*Erythrophleum chlorostachys, Acacia julifera, Petalostigma banksii,*	*Acacia julifera, Acacia leptoctachya, Erythrophleum chlorostachys,*	*Melaleuca citrolens*	*Petalostigma banksii, Acacia leptoctachya, Acacia julifera, Erythrophleum chlorostachys,*	*Melaleuca citrolens*
S1 Height (m)	1.7	2.5	1.8	2.8	1.8
S1 Cover (%)	15	5	10	5	10
S1 Species	*Petalostigma banksii*	*Acacia julifiera*	*Petalostigma banksii*	*Acacia julifiera*	*Petalostigma banksii , Erythrophleum chlorostachys*
S2 Height (m)		0.4			
S2 Cover (%)		5			
S2 Species		*Tephrosia brachyodon*			
G Height (m)	1.5	0.5	0.5	0.5	0.7
G Cover (%)	2	10	15	10	15
G Species	*Sarga plumosum, Schizachyrium fragile, Aristida supersendens*	*Sarga plumosum, Schizachyrium fragile, Aristida supersendens*	*Sarga plumosum, Schizachyrium fragile, Aristida exserta*	*Sarga plumosum, Schizachyrium fragile, Aristida supersendens, Aristida exserta*	*Sarga plumosum, Schizachyrium fragile, Aristida exserta*
W (%)	0	0	0	0	0
W Species	None	None	None	None	None
Disturbance	Small historical mining	Fire	None	Fire	None
Note	None	None	None	None	None

Site ID	GR11	GR12	GR13	GR14	GR15
RE	9.12.33a/9.12.27/9.3.24	2.3.29a/2.3.26a	9.12.33a/9.12.27/9.3.24	9.5.10c	9.5.10c
GTRE	9.12.33a	2.3.29a	9.12.33a	9.5.10c	9.12.33a
Geology	Sand	Alluvial sand	Granite	Sandy	Granite
Landform	Sand sheet	Floodplain	Rolling hill	Sandy plain	Rolling hill
Status	Remnant	Remnant	Remnant	Remnant	Remnant
TEC		No	No	No	No
EDL	T1	T1	T1	T1	T1
EDL Height Range (m)	5.5-7	Aug-14	6-Dec	Aug-15	6-Dec
EDL Median Height (m)	7	10	9	12	9
EDL Cover (%)	14	15	6	4	6
Structural Classification	Low woodland	Woodland	Low open-woodland	Open-woodland	Low open-woodland
T1 Height (m)	7	10	6	12	6
T1 Cover (%)	14	15	9	4	9
T1 Species	*Eucalyptus microneura, Petalostigma banksii, Melaleuca citrolens*	*Melaleuca citrolens, Melaleuca viridifolia, Melaleuca stenostachya*	*Corymbia pocillum, Cochlospermum gillivraei,*	*Eucalyptus microneura*	*Corymbia pocillum, Eucalyptus microneura,*
T2 Height (m)		6		5	
T2 Cover (%)		5		15	
T2 Species		*Melaleuca citrolens*		*Petalostigma banksii, Acacia leptostachya*	
S1 Height (m)	0.7		5	2	5
S1 Cover (%)	2		5	25	5
S1 Species	*Acacia leptostachya*		*Acacia leptostachya, Petalostigma banksii*	*Acacia leptostachya*	*Acacia leptostachya, Petalostigma banksii*
S2 Height (m)					
S2 Cover (%)					
S2 Species					
G Height (m)	0.5	0.8	1.7	0.5	1.7
G Cover (%)	70	15	10	10	10
G Species	*Panicum decompositum, Aristida exserta, Heteropogon contortus, Triumfetta micracantha, Schizachyrium fragile*	*Chrysopogon fallax, Ericahne humilis*	*Panicum decompositum, Aristida exserta, Heteropogon contortus, Triumfetta micracantha, Schizachyrium fragile, Chrysopogon fallax*	*Chrysopogon fallax, Ericahne humilis*	*Panicum decompositum, Aristida exserta, Heteropogon contortus, Triumfetta micracantha, Schizachyrium fragile, Chrysopogon fallax*
W (%)		0			
W Species	None	None	None	None	None
Disturbance	Minor cattle	Minor cattle	None	None	None
Note	None	None	None	None	None

Site ID	GR16	GR17	GR18	GR19
RE	2.3.29a/2.3.26a	2.3.21j/2.3.26a	2.3.21j/2.3.26a	2.3.29a/2.3.54/2.5.30/2.3.41
GTRE	2.3.29a	2.3.26a	2.3.29a	2.3.29a
Geology	Sandy alluvium	Sandy alluvium	Sandy alluvium	Sandy alluvium
Landform	Floodplain	Creek	Floodplain	Floodplain
Status	Remnant	Remnant	Remnant	Remnant
TEC	No	No	No	No
EDL	T1	T1	T1	T1
EDL Height Range (m)	4-Jul	10-12.5	6-Oct	7.5-9.5
EDL Median Height (m)	6	12	8	9
EDL Cover (%)	4	18	6	22
Structural Classification	Low open-woodland	Woodland	Low open-woodland	Low woodland
T1 Height (m)	6	12	8	9
T1 Cover (%)	4	18	6	22
T1 Species	*Melaleuca citrolens, Melaleuca viridiflora,*	*Eucalyptus camaldulensis, Brachychiton garrawayae, Corymbia polycarpa, Terminalia platyptera*	*Melaleuca citrolens, Melaleuca viridiflora,*	*Melaleuca viridiflora, Melaleuca citrolens, Erythrophleum chlorostachys, Terminalia platyptera*
T2 Height (m)		7		3
T2 Cover (%)		12		15
T2 Species		*Acacia leptostachya*		*Melaleuca citrolens, Melaleuca viridiflora*
S1 Height (m)	0.7	1.5	0.7	1.5
S1 Cover (%)	1	1	1	10
S1 Species	*Melaleuca citrolens*	*Lophostemon grandiflorus subsp. riparia*	*Melaleuca citrolens, Melaleuca viridiflora*	*Melaleuca citrolens, Erythrophleum chlorostachys*
S2 Height (m)				
S2 Cover (%)				
S2 Species				
G Height (m)	0.25	0.5	0.25	0.5
G Cover (%)	10	5	10	2
G Species	*Eriachne melicacea, Aristida dominii*	*Heteropogon contortus, Aristida sciuroides*	*Aristida dominii, Aristida supersendens*	*Aristida dominii, Aristida sciuroides, Aristida superpendens*
W (%)	0	0	0	0
W Species	None	None	None	None
Disturbance	Moderate cattle	Heavy cattle	Moderate cattle	None
Note	None	None	None	Patchy distribution with dense thickets and open areas

Site ID	Q1	Q2	Q3	Q4	Q5
Survey Date	24/10/2022	24/10/2022	25/10/2022	25/10/2022	25/10/2022
RE	9.12.33c	2.5.30	9.12.33c	2.5.30	2.5.30
Condition	Remnant	Remnant	Remnant	Remnant	Remnant
EDL	T1	T1	T1	T1	T1
EDL Cover (%)	5	25	11	15	15
EDL Median Height (m)	12	12	12	10	10
Structural Classification	Open-woodland	Woodland	Open-woodland	Woodland	Woodland
Landform	Stony slope	Stony slope	Stony Rise	Gentle rise	Gentle rise
TEC	No	No	No	No	No
T1	*Eucalyptus chartaboma*	*Acacia shirleyi, Melaleuca citrolens, Eucalyptus leptophylla*	*Eucalyptus microneura, Corymbia pocillum*	*Acacia shirleyi*	*Melaleuca citrolens*
T2	*Acacia julifera, Petalostigma banksii*		*Gardenia vilhelmi*	*Acacia shirleyi*	*Acacia shirleyi*
S1		*Petalostigma banksii*	*Acacia fasciculifera, Gardenia vilhelmi*	*Petalostigma banksii*	*Petalostigma banksii*
G3			*Sarga plumosum, Schizachyrium fragile, Aristida supersendens*	*Aristida exserta, Aristida dominii, Aristida sciuroides, Aristida superpendens, Aristida latifolia*	*Aristida exserta, Aristida dominii, Aristida sciuroides, Aristida superpendens, Aristida latifolia*
Weed	None	None	None	None	None
Note	None	Pink gravel over yellow sand	None	Thin band of lancewood	Thin band of lancewood end

Site ID	Q6	Q7	Q8	Q9	Q10
Survey Date	25/10/2022	25/10/2022	25/10/2022	26/10/2022	26/10/2022
RE	9.12.33c	9.12.33c	9.12.33c	9.12.33	2.3.29
Condition	Remnant	Remnant	Remnant	Remnant	Remnant
EDL	T1	T1	T1	T1	T1
EDL Cover (%)	15	15	15	20	15
EDL Median Height (m)	8	8	8	6	10
Structural Classification	Low open-woodland	Low open-woodland	Low open-woodland	Low woodland	Woodland
Landform	Sand sheet	Sand sheet	Sand sheet	Sand sheet	Alluvial plain
TEC	No	No	No	No	No
T1	*Melaleuca citrolens*	*Melaleuca citrolens*	*Melaleuca citrolens*	*Melaleuca citrolens*	*Melaleuca citrolens*
T2	*Melaleuca viridifolia*	*Melaleuca viridifolia*	*Melaleuca viridifolia*		
S1		*Petalostigma banksii*	*Petalostigma banksii*		
G3	*Aristida calycina, Schizachyrium fragile*	*Aristida calycina, Schizachyrium fragile*	*Eriachne humilis, Aristida dominii*		*Chrysopogon fallax*
Weed	None	None	None	None	None
Note	None	None	None	None	None

Site ID	Q11	Q12	Q13	Q14	Q15
Survey Date	26/10/2022	26/10/2022	26/10/2022	26/10/2022	26/10/2022
RE	9.5.10c	9.5.10c	9.12.33a	2.3.26a	2.3.26a
Condition	Remnant	Remnant	Remnant	Remnant	Remnant
EDL	T1	T1	T1	T1	T1
EDL Cover (%)	5	5	5	15	15
EDL Median Height (m)	12	12	8	12	12
Structural Classification	Low woodland	Low woodland	Low open-woodland	Woodland	Woodland
Landform	Sand plain	Sand plain	Rolling hills	Alluvial plain	Alluvial plain
TEC	No	No	No	No	No
T1	*Eucalyptus microneura*	*Eucalyptus microneura*	*Eucalyptus microneura*	*Eucalyptus camaldulensis*	*Eucalyptus camaldulensis*
T2	*Petalostigma banksii*	*Petalostigma banksii*	*Petalostigma banksii*		
S1	*Acacia leptostachya*	*Acacia leptostachya*		*Terminalia platyptera*	*Terminalia platyptera*
G3	*Chrysopogon fallax*	*Chrysopogon fallax*	*Aristida exserta, Triumfetta micracantha, Schizachyrium fragile, Chrysopogon fallax*		
Weed	None	None	None	None	None
Note	None	None	None	None	None

APPENDIX D FAUNA SPECIES LIST

Common name	Scientific name	EPBC Act	NC Act
Agile Wallaby	*Notamacropus agilis*	-	C
Antilopine Wallaroo	*Osphranter antilopinus*	-	C
Common Wallaroo	*Osphranter robustus*	-	C
Pig	*Sus scrofa*	-	I
Goat	*Capra hircus*	-	I
White-faced Heron	*Egretta novaehollandiae*	-	C
Black-breasted Buzzard	*Hamirostra melanosternon*	-	C
Black Kite	*Milvus migrans*	-	C
Whistling Kite	*Haliastur sphenurus*	-	C
Australian Bustard	*Ardeotis australis*	-	C
Brolga	*Grus rubicunda*	-	C
Squatter Pigeon (northern subspecies)	*Geophaps scripta peninsulae*	-	C
Peaceful Dove	*Geopelia placida*	-	C
Pheasant Coucal	*Centropus phasianinus*	-	C
Pacific Koel	*Eudynamys orientalis*	-	C
Blue-winged Kookaburra	*Dacelo leachii*	-	C
Sacred Kingfisher	*Todiramphus sanctus*	-	C
Red-backed Kingfisher	*Todiramphus pyrrhopygius*	-	C
Rainbow Bee-eater	*Merops ornatus*	-	C
Brown Falcon	*Falco berigora*	-	C
Red-tailed Black Cockatoo	*Calyptorhynchus banksii*	-	C
Sulphur-crested Cockatoo	*Cacatua galerita*	-	C
Varied Lorikeet	*Psitteuteles versicolor*	-	C
Red-winged Parrot	*Aprosmictus erythropterus*	-	C
Great Bowerbird	*Chlamydera nuchalis*	-	C
Brown Honeyeater	*Lichmera indistincta*	-	C
Little Friarbird	*Philemon citreogularis*	-	C
Blue-faced Honeyeater	*Entomyzon cyanotis*	-	C
White-throated Honeyeater	*Melithreptus albogularis*	-	C
Rufous-throated Honeyeater	*Conopophila rufogularis*	-	C
Yellow-throated Miner	*Manorina flavigula*	-	C
Yellow Honeyeater	*Stomiopera flava*	-	C
Red-browed Pardalote	*Pardalotus rubricatus*	-	C
Weebill	*Smicrornis brevirostris*	-	C
White-throated Gerygone	*Gerygone olivacea*	-	C
Grey-crowned Babbler	*Pomatostomus temporalis*	-	C
Black-faced Woodswallow	*Artamus cinereus*	-	C
Pied Butcherbird	*Cracticus nigrogularis*	-	C
Australian Magpie	*Gymnorhina tibicen*	-	C
Black-faced Cuckooshrike	*Coracina novaehollandiae*	-	C
White-bellied Cuckooshrike	*Coracina papuensis*	-	C
White-winged Triller	*Lalage tricolor*	-	C
Rufous Whistler	*Pachycephala rufiventris*	-	C
Grey Shrikethrush	*Colluricincla harmonica*	-	C
Olive-backed Oriole	*Oriolus sagittatus*	-	C
Willie Wagtail	*Rhipidura leucophrys*	-	C
Magpie-lark	*Grallina cyanoleuca*	-	C
Torresian Crow	*Corvus orru*	-	C
Apostlebird	*Struthidea cinerea*	-	C
Jacky Winter	*Microeca fascinans*	-	C
Masked Finch	*Poephila personata*	-	C
Double-barred Finch	*Taeniopygia bichenovii*	-	C

APPENDIX E LANDSCAPE CONNECTIVITY TOOL OUTPUT

Croydon Gold Mine – connectivity tool results

Analysing impact on Connectivity Areas
SIGNIFICANCE TEST ONE
The regional total area is 143607.85
The regional extent of core remnant is 141958.59
The regional extent of core remnant is 98.85 percent
This level of regional fragmentation sets a local impact threshold of: 50.0 percent

The table below lists the local impact thresholds for categories of regional core remnant extent:

REGIONAL CORE CATEGORY	LOCAL IMPACT THRESHOLD
< 10	2
10 - 30	5
30 - 50	10
50 - 70	20
70 - 90	30
>90	50

Area of core at the local scale (pre impact): 11343.560000000001
Area of core at the local scale (post impact): 11237.95
Percent change of core at the local scale (post impact): 0.93 percent

SIGNIFICANCE TEST TWO
The number of core remnant areas occurring on the site: 1
The number of core remnant areas remaining on the site post impact: 1
(Only core polygons greater than or equal to 1 hectare are included)

RESULT
This analysis has determined any impact on connectivity areas is NOT significant
(A significant reduction in core remnant at the local scale is False OR a change from core to non-core remnant at the site scale is False)

CONTACT US

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APPENDIX C ENVIRONMENTAL AUTHORITY EPML00950913

Permit

Environmental Protection Act 1994

Environmental authority EPML00950913

This environmental authority is issued by the administering authority under Chapter 5 of the Environmental Protection Act 1994.

Environmental authority number: EPML00950913

Environmental authority takes effect on 11 May 2017

The anniversary date of this environmental authority (EA) remains 14 August. An annual return and the payment of the annual fee will be due each year on this day.

Environmental authority holder(s)

Name(s)	Registered address
Wilson Minerals Pty Limited	Suite 1111 340 Scottsdale Drive ROBINA QLD 4226

Environmentally relevant activity and location details

Environmentally relevant activity/activities	Location(s)
Mining – ML other 21, Site Specific	ML5248

Additional information for applicants

Environmentally relevant activities

The description of any environmentally relevant activity (ERA) for which an environmental authority (EA) is issued is a restatement of the ERA as defined by legislation at the time the EA is issued. Where there is any inconsistency between that description of an ERA and the conditions stated by an EA as to the scale, intensity or manner of carrying out an ERA, the conditions prevail to the extent of the inconsistency.

An EA authorises the carrying out of an ERA and does not authorise any environmental harm unless a condition stated by the EA specifically authorises environmental harm.

A person carrying out an ERA must also be a registered suitable operator under the *Environmental Protection Act 1994* (EP Act).

Contaminated land

It is a requirement of the EP Act that an owner or occupier of contaminated land give written notice to the administering authority if they become aware of the following:

ABN 46 640 294 485

- the happening of an event involving a hazardous contaminant on the contaminated land (notice must be given within 24 hours); or
- a change in the condition of the contaminated land (notice must be given within 24 hours); or
- a notifiable activity (as defined in Schedule 3) having been carried out, or is being carried out, on the contaminated land (notice must be given within 20 business days) that is causing, or is reasonably likely to cause, serious or material environmental harm.

For further information, including the form for giving written notice, refer to the Queensland Government website www.qld.gov.au, using the search term 'duty to notify'.

Take effect

Resource projects

Please note that, in accordance with section 200 of the EP Act, if the EA is for a resource activity, the EA will not take effect until the relevant tenure is granted to the applicant.

Signature	Date
Gibbs	11/05/2017

Teale Gibbs
Department of Environment and Heritage Protection
Delegate of the administering authority
Environmental Protection Act 1994

Enquiries:
PO Box 7230
CAIRNS QLD 4870
Ph: (07) 4222 5334
Email: ESCairns@ehp.qld.gov.au

Obligations under the *Environmental Protection Act 1994*

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

Other permits required

This permit only provides an approval under the *Environmental Protection Act 1994*. In order to lawfully operate you may also require permits / approvals from your local government authority and other State Government agencies prior to commencing any activity at the site. For example, this may include permits / approvals with your local Council (for planning approval), the Department of Transport and Main Roads (to access state controlled roads), the Department of Natural Resources and Mines (to clear vegetation), and the Department of Agriculture Forestry and Fisheries (to clear marine plants or to obtain a quarry material allocation).

Conditions of environmental authority

The conditions of approval for this environmental authority are standard conditions contained within the documents entitled:

- Eligibility criteria and standard conditions for mining lease activities (ESR/2016/2241)

Location: ML5248

Croydon, QLD

Relevant activity/ies: Mining - ML other - 21, Site Specific

This **Environmental Authority** incorporates the following schedules:

- Schedule A - General
- Schedule B - Air
- Schedule C - Land
- Schedule D - Waste Management
- Schedule E - Noise and Vibration
- Schedule F - Water
- Schedule G - Definitions
- Schedule H - Maps

Schedule A – General Conditions

Maintenance of Measures, Plant and Equipment

(A1-1) The **environmental authority holder** must:

(a) install all **measures**, plant and equipment necessary to ensure compliance with the conditions of this environmental authority and the general environmental duty;

(b) maintain such **measures**, plant and equipment in a proper condition;

(c) operate such **measures**, plant and equipment in a proper manner; and

(d) ensure that all instruments and devices used for the measurement or monitoring of any parameter under any condition of this environmental authority must be calibrated and appropriately operated and maintained.

(A1-2) No change, replacement or alteration of any plant or equipment is permitted if the change, replacement or alteration increases, or is likely to substantially increase, the risk of environmental harm caused by the mining activities.

Activity

(A2-1) This environmental authority does not authorise environmental harm unless a condition contained within this authority explicitly authorises that harm. Where there is no condition or the environmental authority is silent on a matter, the lack of a condition or silence shall not be construed as authorising harm.

(A2-2) In carrying out the mining **activity**, reasonable and practicable **measures** must be taken to prevent or minimise the likelihood of environmental harm being caused.

(A2-3) All **land** subject to mining activities must be rehabilitated to a **non-polluting**, **stable** and **self-sustaining** landform.

(A2-4) Any management or monitoring plans, systems or programs required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm as often as necessary but at least every two years and amended promptly if required.

(A2-5) The **environmental authority holder** must record, compile, evaluate and keep all monitoring results, records and documents for a period of at least 5 years required by this environmental authority, and any complaints received about the mining **activity**, and produce copies, or make available for inspection all or any of these records upon request by the **administering authority**.

Risk Management

(A3-1) The **environmental authority holder** must conduct a risk assessment for mining activities which conforms to the Australian Standard for Risk Management (AS/NZ 4360:2004) by 31 July 2009.

(A3-2) The **environmental authority holder** must not implement risk control **measures** that contravenes or prevents the implementation of any condition of this environmental authority.

(A3-3) An emergency response/contingency plan must be developed and implemented within the current plan of operations to manage the high risk categories identified in the risk assessment.

Notification

(A4-1) The **environmental authority holder** must notify the **administering authority** by telephone or facsimile immediately after becoming aware of any emergency or incident resulting in, or having the potential to cause, environmental harm or any breach of condition of this environmental authority concerning **releases of contaminants to the environment**.

(A4-2) The notification in condition (A4-1) must include the following:

(a) the environmental authority number and name of holder;

(b) the name and telephone number of the designated contact person;

(c) the location of the emergency or incident;

(d) the date and time of the incident;

(e) the time the holder of the environmental authority became aware of the incident;

(f) the estimated quantity and type of any substances involved in the incident;

(g) a description of the nature and effects of the incident including environmental harm caused, threatened, or suspected to be caused by the incident

(h) any sampling conducted or proposed, relevant to the emergency or incident; and

(i) immediate actions taken to prevent any further release and mitigate any environmental harm caused by the release.

(A4-3) Within fourteen (14) days following the initial notification of an emergency or incident, further written advice must be provided to the administering authority, including the following:

(a) results and interpretation of all samples taken and analysed (if available, if not yet available nominate a timeframe);

(b) outcomes of actions taken at the time to prevent or minimise environmental harm; and

(c) proposed actions to prevent a recurrence of the emergency or incidence.

(A4-4) As soon as practicable, but not more than six (6) weeks following the conduct of any environmental monitoring performed in relation to the emergency or incident, which results in the release of contaminants not in accordance, or reasonably expected to be not in accordance with the conditions of this environmental authority, written advice must be provided of the results of any such monitoring performed to the **administering authority**.

Complaints

(A5-1) All records must be kept of all environmental complaints received about the mining activities including the following details:

(a) name, address and contact number for complainant (if not available record - not identified);

(b) time and date of complaint;

(c) reasons for the complaint;

(d) investigations undertaken;

(e) conclusions formed;

(f) actions taken to resolve complaint;

(g) any abatement **measures** implemented; and

(h) person responsible for resolving the complaint.

This information must be made available for inspection by the **administering authority** on request.

(A5-2) When requested by the **administering authority**, the **environmental authority holder** must undertake relevant specified monitoring within a reasonable and practicable timeframe nominated by the **administering authority** to investigate any complaint of environmental harm at any **sensitive place** or **commercial place**. The results of the investigation (including an analysis and interpretation of the monitoring results) and abatement **measures** implemented must be provided to the **administering authority** within fourteen (14) days of completion of the investigation.

Third Party Auditing

(A6-1) Compliance with the conditions of this environmental authority must be audited by a **suitably qualified** third party auditor, nominated by the **environmental authority holder** and accepted by the **administering authority** once every two years.

(A6-2) The third party auditor must submit a final version of the auditor's report to the **administering authority** within twenty-eight (28) days of completing the audit.

(A6-3) The third party auditor must certify the independent findings of the audit in the report.

(A6-4) The financial cost of the third party audit is the responsibility of the holder of this environmental authority.

Financial Assurance

(A7-1) Prior to the commencement of mining activities under this environmental authority, the **environmental authority holder** must provide a financial assurance of an amount and in a form determined in accordance with the Queensland Environmental Protection Agency's Guideline *Financial assurance for mining activities*, as approved and requested by the **administering authority**.

(A7-2) The financial assurance must remain in force until the **administering authority** notifies the **environmental authority holder** that it is satisfied that no claim on the assurance will be required.

Community

(A8-1) The holder of this environmental authority must establish, promote and maintain easily accessible lines of communication between residents and land owners to the satisfaction of the **administering authority** and provide evidence of this on an annual basis.

Cultural Heritage

(A9-1) The holder of the environmental authority must develop and implement a Cultural Heritage Management Program covering European cultural heritage for all mining leases.

(A9-2) The Cultural Heritage Management Program must be included in the Plan of Operations.

END OF CONDITIONS FOR SCHEDULE A

SCHEDULE B - AIR

(B1-1) The release of dust or any other airborne contaminant resulting from the mining activities must not cause environmental harm at any **sensitive place** or **commercial place**.

(B1-2) In the event of a complaint, the **environmental authority holder** must ensure that dust generated by the mining activities does not cause any of the following criteria at any **sensitive place** or **commercial place** to be exceeded:

(a) dust deposition of 120 milligrams per square metre per day, averaged over one month, when monitored in accordance with the most recent version of Australian Standard AS 3580.10.1 Methods for sampling and analysis of ambient air - Determination of particulate matter - Deposited matter - Gravimetric method;

(b) total suspended particulates (TSP) of 130 micrograms per cubic metre expressed as an 24 hour average, when monitored in accordance with any method for measuring TSP recommended in the latest edition of the Environmental Protection Agency's Air Quality Sampling Manual;

(c) a concentration of particulate matter with an aerodynamic diameter of less than 10 micrometres (PM10) suspended in the atmosphere of 150 micrograms per cubic metre over a 24 hour averaging time, when monitored in accordance with the most recent version of Australian Standard AS 3580.9.6 Determination of suspended particulate matter - PM (sub) 10 high volume sampler with size-selective inlet - Gravimetric method;

(d) total suspended particulates (TSP) of 200 micrograms per cubic metre expressed as a one hour average, when monitored in accordance with any method for measuring TSP recommended in the latest edition of the Environmental Protection Agency's Air Quality Sampling Manual.

(B1-3) If monitoring indicates limits in condition (B1-2) have been exceeded and is attributable to the licensed **activity**, the **environmental authority holder** must implement dust abatement **measures** so that emissions of dust generated by the mining activities cease to exceed limits in condition (B1-2).

END OF CONDITIONS FOR SCHEDULE B

Tb

SCHEDULE C – LAND

(C1-1) **Land** disturbed by mining activities must be rehabilitated in accordance with Schedule C – Table 1

Schedule C – Table 1 (Mining activities and rehabilitation objectives)

Landform (refer Schedule H – Map 1)	Surface area (ha)	Rehabilitation Objectives		
		Post-mine land description	Land classification[1]	Analogue site identification
Golden Butterfly North Pit	1.6	Non-beneficial **land use**	Class VIII	Sites to be rehabilitated to a standard nominated in the **rehabilitation** program developed in accordance with Condition C2-1 based on analogue sites
Golden Butterfly Pit	5.1	Non-beneficial **land use**	Class VIII	
Lady Isabella Pit	1.7	Non-beneficial **land use**	Class VIII	
Content Pit	2.1	Non-beneficial **land use**	Class VIII	
Content Dump	6.3	L.I.G.[2] / disturbed native habitat	Class VI or better	
Golden Butterfly Dump	15.2	L.I.G.[2] / disturbed native habitat	Class VI or better	
Content Hardstand	2.0	L.I.G. / disturbed native habitat	Class VI or better	
Golden Butterfly Hardstand	0.5	L.I.G.[2] / disturbed native habitat	Class VI or better	
Sediment Dams	1.5	L.I.G.[2] / disturbed native habitat	Class VI or better	
Roads / Tracks	3.5	L.I.G.[2] / disturbed native habitat	Class VI or better	

[1] Technical guidelines for the Environmental Management of Exploration and Mining in Queensland (DME), 1995.

[2] L.I.G. (Low Intensity Grazing) defined by criteria listed in Land Use **Acceptance criteria**

(C1-2) Drain the surface of the Content Waste Rock Dump to Content Pit, fill low-lying areas on the Content Waste Rock Dump and import additional growth medium to the Content Waste Rock Dump.

(C1-3) All waste rock dump slopes must be covered with a regrowth medium to support vegetation regrowth and limit erosion.

Post Mine Land Use Plan

(C2-1) A Post Mine Land Use Plan for the **licensed place** must be developed and implemented for a nominal period of:

(a) at least thirty (30) years following the cessation of mining activities on the **licensed place**; or

(b) a shorter period if the **licensed place** is proven to be geo-technically and geo-chemically stable and it can be demonstrated to the satisfaction of the **administering authority** that no release of contaminants from the site will result in environmental harm and be prepared at least 18 months prior to cessation of mining activities on the **licensed place**.

(C2-2) The Post Mine Land Use Plan must be included in the Plan of Operations and updated with each subsequent Plan of Operations, describing how the **rehabilitation** objectives in Schedule C – Table 1 will be achieved. The Post Mine Land Use Plan must include:

(a) schematic representation of final land form inclusive of drainage features; and

(b) slope designs; and

(c) cover design including a report on the effectiveness of existing cover systems; and

(d) drainage design; and

(e) erosion controls on reformed **land**; and

(f) description of experimental design for monitoring of analogue and rehabilitated areas inclusive of statistical design; and

(g) proposed revegetation criteria including :

(i) species diversity, abundance and composition,

(ii) projective cover,

(iii) dry matter production and

(iv) stocking rates to ensure **self-sustaining** vegetation is maintained; and

(h) proposed revegetation methods inclusive of plant species selection, re-profiling, respreading soil, soil ameliorants/amendments, surface preparation and method of propagation; and

(i) materials balance including available top soil and low permeability encapsulation media for capping; and

(j) research program and associated milestones.

(k) geotechnical, geochemical and hydrological studies;

(l) chemical, physical and biological properties of soil and water;

(m) measurable completion criteria for each **rehabilitation** indicator that enables determination of **rehabilitation** success for each disturbance type; and

(n) **rehabilitation** monitoring program, including the monitoring of:

i. surface **water quality**;

ii. groundwater quality;

iii. erosion rates;

iv. integrity and effectiveness of final cover of final cover systems; and

v. health and resilience of vegetative cover

(o) grazing management plan, and;.

(p) Operation and maintenance of:

i. the surface water management system;

ii. groundwater monitoring network;

iii. final cover systems; and

iv. vegetative cover

Rehabilitation Monitoring Program

(C3-1) The holder of the environmental authority must conduct a Rehabilitation Monitoring Program on at least a yearly basis, which must include sufficient spatial and temporal replication to enable scientifically justifiable conclusions as established under the **rehabilitation** program or other methodology to the satisfaction of the **administering authority**.

(C3-2) The Rehabilitation Monitoring Program must be developed by 1 October 2008 and be implemented by a person nominated by the **environmental authority holder** possessing appropriate qualifications and experience in the field of **rehabilitation** management.

(C3-3) Verification of **rehabilitation** success is to be determined by comparison with the criteria documented in the Post Mine Land Use Plan required under Condition C2-1.

Infrastructure

(C4-1) All **infrastructure**, mining equipment and plant erected and/or used for the mining activities must be removed from the **licensed place** prior to surrender, except where agreed in writing by the **administering authority**, landowner and the Minister administering the *Mineral Resources Act 1989.*

Residual Voids

(C5-1) Residual voids, or the contents of residual voids, must not cause any environmental harm other than the environmental harm caused within the footprint of the residual void itself.

Chemicals and Flammable or Combustible Liquids

(C6-1) All explosives, hazardous **chemicals**, corrosive substances, toxic substances, gases and dangerous goods must be stored and handled in accordance with the relevant Australian Standard.

(C6-2) Flammable and combustible liquids, including petroleum products and associated piping and **infrastructure**, must be stored and handled in accordance with the latest edition of Australian Standard 1940 – *The Storage and Handling of Flammable and Combustible Liquids.*

(C6-3) Any **chemicals** and flammable or combustible liquids stored on the **licensed place** that have the potential to cause environmental harm must be stored in or serviced by an effective containment system that is impervious to the materials stored and managed to prevent the release of liquids to **waters** or **land**. Where no relevant Australian Standard is available, the following must be applied:

(a) storage tanks must be bunded so that the capacity and construction of the bund is sufficient to contain at least 110% of a single storage tank or 100% of the largest storage tank plus 10% of the second largest storage tank in multiple storage areas; and

(b) drum storages must be bunded so that the capacity and construction of the bund is sufficient to contain at least 25% of the maximum design storage volume within the bund.

(C6-4) All containment systems for **chemicals** and flammable or combustible liquids must be designed to minimise rainfall collection within the system.

Contaminated Land

(C7-1) Undertake a contaminated **land** assessment / investigation of the **licensed place** in accordance with the **administering authority's** Guidelines for the Assessment & Management of Contaminated Land in Queensland.

END OF CONDITIONS FOR SCHEDULE C

SCHEDULE D – WASTE

General Waste Disposal

(D1-1) The **environmental authority holder** shall not cause, allow or permit any waste generated outside the mine to be received at the mine for storage, treatment, processing or disposal.

Off Site Movement of Regulated Wastes

(D2-1) Where regulated waste is removed from the **licensed place** (other than by a release as permitted under another schedule of this environmental authority), the holder of this environmental authority must ensure that:

(a) the removal and transport of such wastes, where it constitutes an environmentally relevant activity under the *Environmental Protection Regulation 2008*, is carried out by a person licensed for carrying out this activity under the *Environmental Protection Act 1994*; and

(b) records are kept of the following:

(i) the date, quantity and type of waste removed; and

(ii) name of the regulated waste transporters that removed the waste; and

(iii) the intended treatment/disposal destination of the waste.

Note: Records of documents maintained in compliance with a waste tracking system established under the *Environmental Protection Act 1994* or any other law for regulated waste will be deemed to satisfy this environmental authority condition.

Notification of Improper Disposal of Regulated Waste

(D3-1) If the holder of this environmental authority becomes aware that a person has removed regulated waste from the **licensed place** and disposed of the regulated waste in a manner which is not authorised by this environmental authority or improper or unlawful, then the holder of this environmental authority must, as soon as practicable, notify the **administering authority** of all relevant facts, matters and circumstances known concerning the disposal.

(D3-2) Regulated waste generated by maintenance of plant and equipment and absorbent materials used to clean up spills must only be disposed of at a facility whose operator is permitted to accept such waste in accordance with the requirements of the *Environmental Protection Act 1994*.

END OF CONDITIONS FOR SCHEDULE D

SCHEDULE E – NOISE AND VIBRATION

(E1-1) Noise from the mining **activity** must not cause environmental harm at any **sensitive place** or **commercial place**.

(E1-2) In the event of a complaint made to the **administering authority** (which is neither frivolous or vexatious) about noise generated in carrying out the licensed **activity**, and the noise is considered by the **administering authority** to be an unreasonable noise, the holder of this Environmental Authority must take action to ensure that it is no longer an unreasonable noise.

END OF CONDITIONS FOR SCHEDULE E

SCHEDULE F – WATER

General

(F1-1) Contaminants that will, or have the potential to cause environmental harm, must not be released directly or indirectly to any water except as permitted under the conditions of this EA.

(F1-2) The release of contaminants directly or indirectly to **waters** must not:

(a) produce any visible discolouration of **receiving waters**; or
(b) produce any slick or other visible or odorous evidence of oil, grease or petrochemicals nor contain visible floating oil, grease, scum, litter or other objectionable matter.

(F1-3) All determinations of water quality must be:

(a) performed by a person or body possessing appropriate experience and qualifications to perform the required measurements;
(b) made in accordance with methods prescribed in the latest edition of the **administering authority's** monitoring and sampling manual;
(c) collected from the monitoring locations identified within this environmental authority, within 2 hours of each other (reference/downstream) where possible;
(d) carried out on **representative** samples; and,
(e) laboratory testing must be undertaken using a laboratory accredited (e.g. **NATA**) for the method of analysis being used.

(F1-4) The following information must be recorded in relation to all water monitoring required under the conditions of this environmental authority and submitted to the **administering authority** in the specified format when requested:

(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;
(d) the measured or estimated daily quantity of the contaminants released from all release points;
(e) the release flow rate at the time of sampling for each release point;
(f) the results of all monitoring and details of any exceedances with the conditions of this environmental authority; and
(g) water quality monitoring data must be provided to the **administering authority** in the specified electronic format upon request.

Contaminant Release to Waters

(F2-1) The release of contaminants to **waters** must only occur from the release points specified in Schedule F - Table 1 (Contaminant Release Points) and depicted in Schedule H - Map 3 (Location of Monitoring sites on Belmore Creek).

Schedule F - Table 1 (Contaminant Release Points)

Release Point	Easting (GDA94 – Zone 54)	Northing (GDA94 – Zone 54)	Receiving Waters Description
Content Pit (Base of ramp)	628958.5806	7990231.848	Belmore Creek
Lady Isabella Pit (Base of ramp)	629368.5292	7989840.693	Belmore Creek

(F2-2) The release of contaminants to **waters** from the release points must be monitored at the locations specified in Schedule F - Table 1 (Contaminant Release Points) for each quality characteristic and at the monitoring frequency specified in Schedule F - Table 2 (Contaminant Release Limits).

Schedule F - Table 2 (Contaminant Release Limits)

Parameter	Unit	Contaminant Limit[1]	Monitoring[3] Frequency
pH	pH	5.0 (minimum) 9.0 (maximum)	Event based sampling[4] of discharge: One sample must be taken within 24 hours of a discharge event[5] commencing; a second sample must be taken between 24 and 48 hours after the discharge event[5] commences. Where a discharge event[5] has a duration of 48 hours or greater, samples must be taken daily for one week, and once a week thereafter until discharge ceases.
Electrical Conductivity	**µS/cm**	5970[2]	
Sulphate	mg/l	1000[2]	
Fluoride	mg/l	2[2]	
Aluminium	mg/l	0.055[6, 7] x Dilution Factor[8]	
Arsenic	mg/l	0.013[6, 7] x Dilution Factor[8]	
Cadmium	mg/l	0.0002[6, 7] x Dilution Factor[8]	
Cobalt	mg/l	0.0014[6, 7] x Dilution Factor[8]	
Copper	mg/l	0.0014[6, 7] x Dilution Factor[8]	
Nickel	mg/l	0.011[6, 7] x Dilution Factor[8]	
Zinc	mg/l	0.008[6, 7] x Dilution Factor[8]	
Hardness		Interpretation purposes	

[1] Contaminant limits apply for metal/metalloids if total (unfiltered) results exceed limits.

[2] Contaminant limit based on ANZECC (2000) stock water quality guidelines.

[3] Monitoring during discharge event will only be conducted where safe access can be gained.

[4] Grab sampling is the preferred method for sampling collection, however the use of remote sampling techniques such as automated methods is acceptable.

[5] Discharge event is a release of water from a release point as specified in Schedule F – Table 1 (Contaminant Release Points).

[6] Default trigger values – from ANZECC (2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems.

[7] These contaminants can be hardness adjusted.

[8] Dilution Factor is calculated as the volume of the water going down Belmore Creek and the volume of respective **mine affected water** at the time of release.

(F2-3) The release of contaminants to **waters** must not exceed the contaminant release limits stated in Schedule F - Table 2 (Contaminant Release Limits) for each quality characteristic.

Stream Flow Monitoring

(F3-1) The holder of this environmental authority must install, operate and maintain a stream flow gauging station to determine and record stream flows at the locations upstream of each release point as specified in Schedule F - Table 1 (Contaminant Release Points) for any receiving water into which a release occurs.

(F3-2) At the time of release the water flow volume in the respective receiving water must be at least twenty (20) times the volume at which respective **mine affected waters** are released.

Receiving Environment Monitoring and Contaminant Trigger Levels

(F4-1) **Receiving waters** must be monitored at the locations and frequencies defined in Schedule F - Table 3 (Receiving Water Monitoring Locations and Frequency), Schedule H - Map 2 (Surface Water, Sediment and Groundwater Monitoring Sites) and Map 3 (Location of Monitoring Sites on Belmore Creek) and comply with the trigger and contaminant limits defined in Schedule F - Table 4 (Receiving Water Trigger and Contaminant Limits).

Schedule F - Table 3 (Receiving Surface Water Monitoring Locations and Frequency)

Monitoring point	Easting (GDA 94)	Northing (GDA 94)	Monitoring frequency[2]
SW1 Lower Slaughteryard Creek	630350	7986405	Routine sampling[3]: One sample must be taken during wet season (January ~ March) and one sample must be taken during dry season (July ~ September) Event based sampling[3] of discharge: One sample must be taken within 24 hours of a discharge event[4] commencing; a second sample must be taken between 24 and 48 hours after the discharge event[4] commences. Where a discharge event[4] has a duration of 48 hours or greater, samples must be taken daily for one week, and once a week thereafter until discharge ceases.
SW2 Slaughteryard West Tributary at the ML **boundary**	630197	7987640	
SW3 Slaughteryard Creek upstream of the Golden Butterfly WRD	631080	7988157	
SW6 Belmore Creek borrow pit/stock dam	627908	7989454	
BCDS Belmore Creek Downstream	626736.519	7989973.135	
Reference Sites[1]			
SW3b Reference point for Slaughteryard Creek	613208	7988220	
BCUS Reference point for Belmore Creek	627895.251	7990122.388	

[1] Reference sites must:
a. be from the same biogeographic and climatic region; and
b. have similar geology, soil types and topography; and
c. contain a range of habitats similar to those at the test sites;
d. have a similar flow regime; and
e. not be so close to the downstream sites that any disturbance at the downstream site also results in a change at the reference site

[2] Monitoring during discharge event will only be conducted where safe access can be gained.

[3] Grab sampling is the preferred method for sampling collection, however the use of remote sampling techniques such as automated methods is acceptable.

[4] Discharge event is a release of water from a release point as specified in Schedule F – Table 1 (Contaminant Release Points).

Schedule F - Table 4 (Receiving Water Trigger and Contaminant Limits)

Parameter	Unit	Contaminant Trigger Level[1]	Contaminant Limit[2]
pH	pH	20th percentile[3] of reference[4] or 6.0[5] whichever is lower. 80th percentile[3] of reference[4] or 7.5[5] whichever is higher	5.0 (minimum) or 5th percentile[3] of reference[4], whichever is highest, 9.0 (maximum) or 95th percentile[3] of reference[4], whichever is lowest
Electrical Conductivity	µS/cm	80th percentile[3] of reference[4] or 250[5], whichever is higher	5970[2] or 95th percentile[3] of reference[4], whichever is lowest
Turbidity	NTU	80th percentile[3] of reference[4] or 15[5], whichever is higher	N/A
Sulphate	mg/l	80th percentile[3] of the reference[4]	1000[2] or 95th percentile[3] of reference[4], whichever is lowest
Fluoride	mg/l	80th percentile[3] of the reference[4]	2[2] or 95th percentile[3] of reference[4], whichever is lowest
Aluminium	mg/l	80th percentile[3] of reference[4] or 0.055[5], whichever is higher	5[2] or 95th percentile[3] of reference[4], whichever is lowest
Arsenic	mg/l	80th percentile[3] of reference[4] or 0.013[5], whichever is higher	0.5[2] or 95th percentile[3] of reference[4], whichever is lowest
Cadmium	mg/l	80th percentile[3] of reference[4] or 0.0002[5], whichever is higher	0.01[2] or 95th percentile[3] of reference[4], whichever is lowest
Cobalt	mg/l	80th percentile[3] of reference[4] or 0.0014[6], whichever is higher	1[2] or 95th percentile[3] of reference[4], whichever is lowest
Copper	mg/l	80th percentile[3] of reference[4] or 0.0014[5], whichever is higher	1[2] or 95th percentile[3] of reference[4], whichever is lowest
Nickel	mg/l	80th percentile[3] of reference[4] or 0.011[5], whichever is higher	1[2]or 95th percentile[3] of reference[4], whichever is lowest
Zinc	mg/l	80th percentile[3] of reference[4] or 0.008[5], whichever is higher	20[2] or 95th percentile[3] of reference[4], whichever is lowest

[1] All metals and metalloids must be measured as total (unfiltered) and dissolved (filtered). Trigger levels for metal/metalloids apply if dissolved results exceed trigger. Contaminant limits apply for metal/metalloids if total results exceed limits.

[2] Contaminant limit based on ANZECC (2000) stock water quality guidelines;

[3] 20th , 80th and 95th percentiles are calculated using ANZECC (2000) methodology (section 7.4.4.1); where 80th percentile of reference is exceeded and the reference site also exceeds the value during the same event, the value of the reference site during the same event applies as the receiving water trigger level.

[4] Reference sites are defined in Schedule F – Table 3.

[5] Default trigger values – from ANZECC (2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems.

[6] Interim (low reliability) value from ANZECC (2000) section 8.3.7.1

(F4-2) If quality characteristics of the receiving water at the downstream monitoring points identified in Schedule F - Table 3 exceed any of the trigger levels specified in Schedule F - Table 4 the holder of this environmental authority must compare the downstream results to the reference site results in the **receiving waters** and:

(a) where the downstream result is the same or a lower value than the reference site value for the quality characteristic during the same sampling event then no action is to be taken; or
(b) where the downstream results exceed the reference site complete an investigation in accordance with the ANZECC & ARMCANZ 2000 methodology, into the potential for environmental harm and provide a written report to the **administering authority** within three months, outlining:
   i. details of the investigations carried out
   ii. details of the environmental impacts observed; and
   iii. actions taken to prevent environmental harm.

Note: Where an exceedance of a trigger level has occurred and is being investigated, in accordance with (F4-2)(b) of this condition, no further reporting is required for subsequent trigger events for that quality characteristic during the reporting period.

(F4-3) The release of contaminants to **waters** must not exceed the contaminant release limits stated in Schedule F - Table 4 (Receiving Water Trigger and Contaminant Limits) for each quality characteristic.

Stream Sediment Contaminant Levels

(F5-1) Sediment quality of **receiving waters** and reference **waters** must be monitored at the monitoring locations and frequency defined in Schedule F - Table 5 (Receiving Water Monitoring Locations) and identified on Schedule H - Map 2 (Surface Water, Sediment and Groundwater Monitoring Sites) and Map 3 (Location of Monitoring Sites on Belmore Creek) for the parameters defined in Schedule F - Table 6 (Stream Sediment Trigger and Contaminant Levels).

Schedule F – Table 5 (Receiving Stream Sediment Location and Frequencies)

Monitoring point	Easting MGA (GDA 94)	Northing MGA (GDA 94)	Monitoring frequency
SW1 Lower Slaughteryard Creek	630350	7986405	Twice yearly in wet season (January ~ March) & dry season (July ~ September)
SW2 Slaughteryard West Tributary at the ML **boundary**	630197	7987640	
SW3 Slaughteryard Creek upstream of the Golden Butterfly WRD	631080	7988157	
SW6 Belmore Creek borrow pit/stock dam	627908	7989454	
BCDS Belmore Creek Downstream	626736.519	7989973.135	
Reference Sites[1]			
SW3b Reference point for Slaughteryard Creek	613208	7988220	Twice yearly in wet season (January ~ March) & dry season (July ~ September)
BCUS Reference point for Belmore Creek	TBD	TBD	

1. Reference sites must:
   a. be from the same biogeographic and climatic region; and
   b. have similar geology, soil types and topography; and
   c. contain a range of habitats similar to those at the test sites; and
   d. have a similar flow regime; and
   e. not be so close to the downstream sites that any disturbance at the downstream site also results in a change at the reference site

Schedule F - Table 6 (Stream Sediment Trigger and Contaminant Levels)

Parameter	Unit	Trigger Level	Contaminant Limit
Aluminium	mg/kg	Reference value[1]	3 times the reference value[1]
Arsenic	mg/kg	Reference value[1] or 20[2], whichever is higher.	70[3] or 3 times the reference value[1], whichever is higher
Boron	mg/kg	Reference value[1]	3 times the reference value[1]
Cadmium	mg/kg	Reference value[1] or 1.5[3], whichever is higher.	10[3] or 3 times the reference value[1], whichever is higher
Chromium	mg/kg	Reference value[1] or 80[2], whichever is higher.	370[3] or 3 times the reference value[1], whichever is higher
Cobalt	mg/kg	Reference[1]	3 times the reference value[1]
Copper	mg/kg	Reference[1]or 65[2], whichever is higher.	270[3] or 3 times the reference value[1], whichever is higher
Mercury	mg/kg	Reference value[1] or 0.15[2] whichever is higher.	1[3] or 3 times the reference value[1], whichever is higher
Nickel	mg/kg	Reference value[1]or 21[2], whichever is higher.	52[3] or 3 times the reference value[1], whichever is higher.
Selenium	mg/kg	Reference value[1]	3 times the reference value[1]
Zinc	mg/kg	Reference value[1] or 200[2] or, whichever is higher.	410[3] or 3 times the reference value[1], whichever is higher

[1] Reference sites are defined in Schedule F - Table 3.
[2] ANZECC (2000) Interim Sediment Quality Guidelines – low values based on total sediments
[3] ANZECC (2000) Interim Sediment Quality Guidelines – high values based on total sediments

(F5-2) If the bed of the receiving water exceed any of the trigger levels specified in Schedule C - Table 6 (Stream Sediment Trigger and Contaminant Levels), the holder of this environmental authority must compare the results of the downstream site to the data from reference monitoring sites and:

(a) if the level of contaminants at the downstream site does not exceed the reference monitoring site data, then no action is to be taken; or

(b) if the level of contaminants at the downstream site is greater than the reference monitoring site data, complete an investigation in accordance with the ANZECC & ARMCANZ 2000 methodology, into the potential for environmental harm and provide a written report to the **administering authority** within three (3) months, outlining:

i. details of the investigations carried out;

ii. details of the environmental impacts observed; and

iii. actions taken to prevent environmental harm.

Note: Where an exceedance of a trigger level has occurred and is being investigated, in accordance with F5-2(b) of this condition, no further reporting is required for subsequent trigger events for that quality characteristic within the three month investigation period.

(F5-3) Releases of contaminants must not result in an exceedance of sediment contaminant limits stated in Schedule F - Table 6 (Stream Sediment Trigger and Contaminant Levels).

(F5-4) All stream sediment sampling must be undertaken in accordance with the most recent version of Australian Standard AS 5667.12 Guidance on Sampling of Bottom Sediments of 1998.

Onsite Water Storages

(F6-1) Water storages stated in Schedule F - Table 7 (Water Storage Monitoring) must be monitored for the water quality characteristics specified in Schedule F - Table 8 (Onsite Water Storage Contaminant Limits).

Schedule F – Table 7 (Water Storage Monitoring)

Water Storage Description	Easting (GDA94)	Northing (GDA94)	Frequency of Monitoring
Golden Butterfly Pit	631140	7987525	Twice yearly in wet season (January ~ March) & dry season (July ~ September)
Golden Butterfly North Pit	630545	7987921	
Lady Isabella Pit	629473	7990023	
Content Pit	629048	7990435	
SW3a Golden Butterfly WRD	630913	7988253	
SW4 Stock water dam	631049	7987892	
SW5 Sediment dam at lease **boundary**	628691	7990012	

Schedule F - Table 8 (Onsite Water Storage Contaminant Limits)

Quality Characteristic	Test Value	Contaminant Limit[1]
pH (pH unit)	Range	Greater than 4, Less than 9[3]
EC (µS/cm)	Maximum	5970[1]
Turbidity (TDS)	Maximum	4000[1]
Sulphate (mg/L)	Maximum	1000[1]
Fluoride (mg/L)	Maximum	2[1]
Aluminium (mg/L)[2]	Maximum	5[1]
Arsenic (mg/L)[2]	Maximum	0.5[1]
Boron (mg/L)[2]	Maximum	5[1]
Cadmium (mg/L)[2]	Maximum	0.01[1]
Chromium (mg/L)[2]	Maximum	1[1]
Cobalt (mg/L)[2]	Maximum	1[1]
Copper (mg/L)[2]	Maximum	1[1]
Mercury (mg/L)[2]	Maximum	0.002[1]
Nickel (mg/L)[2]	Maximum	1[1]
Selenium (mg/L)[2]	Maximum	0.02[1]
Zinc (mg/L)[2]	Maximum	20[1]

Notes:
[1]Contaminant limit based on ANZECC & ARMCANZ (2000) stock water quality guidelines.
[2]Total measurements (unfiltered) must be taken and analysed.
[3]Page 4.2-15 of ANZECC & ARMCANZ (2000) "Soil and animal health will not generally be affected by water with pH in the range of 4-9".

(F6-2) In the event that **waters** defined in Schedule F – Table 7 exceed the contaminant limits defined in Schedule F – Table 8, the holder of the environmental authority must implement **measures** to prevent access to **waters** by all livestocks and minimise access by native fauna.

Groundwater

(F7-1) Groundwaters must be monitored at the locations and frequencies defined in Schedule F – Table 9 & Schedule H – Map 2 for parameters identified in Schedule F – Table 10:

Schedule F – Table 9 (Groundwater monitoring locations and frequency)

Monitoring Point	Easting (GDA94)	Northing (GDA94)	Surface RL[1] (m)	Monitoring Frequency
BH1 west of Golden Butterfly Pit	631270	7987673	119	Annually during the dry season
BH2 east of Golden Butterfly Pit	630985	7987444	110	Annually during the dry season
BH3 east of Golden Butterfly Waste Rock Dump	630998	7987934	115	Annually during the dry season
BH5 east of Golden Butterfly Waste Rock Dump	630987	7988051	116	Annually during the dry season
BH7 east of Golden Butterfly Waste Rock Dump	631000	7988150	117	Annually during the dry season
BH8 (east of Golden Butterfly Waste Rock Dump)	630591	7988061	123	Annually during the dry season
BH9 east of Golden Butterfly Waste Rock Dump	630647	7987997	122	Annually during the dry season
BH10 west of Content Waste Rock Dump	628746	7989851	103	Annually during the dry season
BH11 west of Content Waste Rock Dump	628868	7990005	104	Annually during the dry season
BH12 west of Content Waste Rock Dump at lease **boundary**	628633	7989962	102	Annually during the dry season
GBMB1 Slaughteryard Creek	630894	7987274	110	Annually during the dry season
GBMB3Slaughteryard Creek	630685	7987087	113	Annually during the dry season
GBMB6 Slaughteryard Creek	630257	7986656	111	Annually during the dry season
SY1 Slaughteryard Creek	630226	7986408	107	Annually during the dry season

[1] RL measurement to be taken from top of bore casing.

(F7-2) If groundwaters from compliance bores identified in Schedule F – Table 9 exceed any of the trigger levels stated in Schedule F – Table 10, the **environmental authority holder** must complete an investigation in accordance with the ANZECC (2000) methodology, into the potential for environmental harm, and provide a written report to the **administering authority** within 3 months of the date of the original exceedence, outlining:

(i) details of the investigations carried out; and

(ii) actions taken to prevent environmental harm.

Note: a period of greater than 3 months may be approved if authorised by the administering authority.

Schedule F – Table 10 (Groundwater trigger levels)

Parameter	Unit	*1.1.1.1 Trigger Levels*	Limit Type
pH	pH unit	20th percentile[1,5] of reference[4] or 6.0[3], whichever is lower. 80th percentile[1,5] of reference[4] or 7.5[3], whichever is higher.	Median[6]
EC	**µS/cm**	80th percentile[1,5] of reference[4] or 250[3], whichever is higher.	Median[6]
Sulphate	mg/L	80th percentile[1,5] of reference[4]	Median[6]
Fluoride	µg/L	80th percentile[1,5] of reference[4]	Median[6]
Aluminium	µg/L	80th percentile[2,5] of reference[4] or 55[3], whichever is higher	Median[6, 7] or 95th percentile[5,6,7]
Arsenic	µg/L	80th percentile[2,5] of reference[4] or 13[3,9], whichever is higher.	Median[6, 7] or 95th percentile[5,6,7]
Cadmium	µg/L	80th percentile[2,5] of reference[4] or 0.2[3], whichever is higher.	Median[6, 7] or 95th percentile[5,6,7]
Cobalt	µg/L	80th percentile[2,5] of reference[4] or 1.4[8], whichever is higher.	Median[6, 7] or 95th percentile[5,6,7]
Copper	µg/L	80th percentile[2,5] of reference[4] or 1.4[3], whichever is higher.	Median[6, 7] or 95th percentile[5,6,7]
Nickel	µg/L	80th percentile[2,5] of reference[4] or 11[3], whichever is higher.	Median[6, 7] or 95th percentile[5,6,7]
Zinc	µg/L	80th percentile[2,5] of reference[4] or 8.0[3], whichever is higher.	Median[6, 7] or 95th percentile[5,6,7]

[1] For stressors, trigger values are based on the 20th or 80th percentile of at least 18 and not more than 24 consecutive reference site samples[4], derived using the EPA (2006) methodology (section 3.4.3.1).
Where insufficient data is available, an interim trigger value can be derived from ≥ 8 but ≤17 consecutive reference site samples[4], derived using EPA (2006) methodology (section 3.4.3.1).

[2] For toxicants, trigger values are based on the 80th percentile of at least 10 and no more than 24 consecutive reference site samples[4], derived using the EPA (2006) methodology (Table D1, and section 3.4.3.1).

[3] Default trigger values – from ANZECC (2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems.

[4] Reference sites are defined in Schedule F – Table 9.

[5] 20th, 80th and 95th percentiles are calculated using ANZECC (2000) methodology (section 7.4.4.1).

[6] The median and 95th percentile must be determined on the most recent three (3) consecutive routine monitoring samples. Comparison against trigger and contaminant limits should be made to maximum test values collected during discharge and flow events.

[7] The median limit type is used if the 80th percentile trigger level is used, or if the default trigger level is used when there are <24 reference site values used to calculate the 80th percentile. The 95th percentile limit type is used if the default trigger level is used when there are 24 reference site values used to calculate the 80th percentile.

[8] Interim (low reliability) value from ANZECC (2000) section 8.3.7.1.

[9] If arsenic (soluble) exceeds 13 µg/L then speciation to As(III) and As(V) must be conducted. The As(III) and As(V) levels must not exceed the 80th percentile of reference site samples[4] or the respective default trigger level: As(III) – 24 µg/L; As(V) – 13 µg/L.

Analysis for soluble metal concentrations only, not totals.

Note – where there is insufficient reference site data available to establish an 80th percentile trigger value and no default values are available the maximum allowable change in water quality at the receiving water monitoring sites (defined in Schedule F – Table 1) is reference site value for that sampling occasion plus ten percent (10%).

(F7-3) Groundwaters from bores identified in Schedule F – Table 9, must not exceed any of the limits defined in Schedule F –Table 11.

Schedule F – Table 11 (Groundwater contaminant limits)

Parameter	Unit	Test Value	Contaminant Limit
pH	pH unit	Range	Greater than 5, less than 9
EC	**µS/cm**	Maximum	5970[1]

Parameter	Unit	Test Value	Contaminant Limit
Turbidity	TDS	Maximum	4000[1]
Sulphate	mg/L	Maximum	1000[1]
Fluoride	mg/L	Maximum	2[1]
Aluminium[2]	mg/L	Maximum	5[1]
Arsenic[2]	mg/L	Maximum	0.5[1]
Cadmium[2]	mg/L	Maximum	0.01[1]
Cobalt[2]	mg/L	Maximum	1[1]
Copper[2]	mg/L	Maximum	1[1]
Nickel[2]	mg/L	Maximum	1[1]
Zinc[2]	mg/L	Maximum	20[1]

[1] Contaminant limit based on ANZECC (2000) stock water quality guidelines.

[2] Analysis for soluble metal concentrations only, not totals.

(F7-4) Annual groundwater monitoring reports analysing groundwater chemistry and hydrogeological status of all groundwater bores and groundwater conditions are to be prepared by November each year as an element of the water management strategy review.

(F7-5) Construct additional monitoring bores BH10, BH11 & BH12 to the west of the Content Waste Rock Dump and BH 8 & BH9 between the Golden Butterfly North Pit and the Golden Butterfly Waste Rock Dump and SY1 on Slaughteryard Creek.

(F7-6) Before 30 June 2009 conduct additional investigations / monitoring to confirm the conceptual **licensed place** hydro-geological model, including:

(a) obtaining additional hydro-geological information (e.g. geological information, bore and pit water levels).

(b) compile and analyse existing groundwater quality data from the town water supply bores.

(c) installing an additional deep monitoring bore (SY1) between the Golden Butterfly Pit and Slaughteryard Creek to supplement the existing monitoring network.

(d) surveying of pit lake water levels and erection of water level gauging stages.

(e) investigate the state of equilibrium of pit water levels.

(f) include the latest information obtained from the additional hydro-geological investigations / monitoring in subsequent amendments to the Croydon Gold Mine EMPlan.

(g) conduct a bore census of the area surrounding the **licensed place**.

Stormwater

(F8-1) An erosion and sediment control plan must be developed and implemented for the activities on the **licensed place** which has been certified by a **suitably qualified** person, Certified Professional in Sediment and Erosion Control (CPESC), or a professional with appropriate experience and / or qualifications accepted by the **Administering authority** and be included in the Plan of Operations.

(F8-2) Erosion protection **measures** and sediment control **measures** must be implemented and maintained to minimise erosion and the release of sediment and contamination of storm water.

Acid Rock Drainage and Leachate management

(F9-1) All reasonable and practicable **measures** must be implemented to prevent hazardous **leachate** being directly or indirectly released or likely to be released as a result of the **activity** to any groundwater or water course.

Water Management Strategy

(F10-1) A water management strategy must be prepared for inclusion in the Plan of Operations. The strategy will include:

(a) data collation and identify existing data requirements

(b) design and detail additional works as required

(c) implement / construct additional works

(F10-2) An annual review of the water management strategy must be submitted by November each year.

Receiving Environment Monitoring Program (REMP)

(F11-1) The **environmental authority holder** must develop and implement a Receiving Environment Monitoring Program (REMP) to monitor, identify and describe any adverse impacts to surface water **environmental values**, quality and flows due to the authorised mining **activity**. This must include monitoring the effects of the mine on the **receiving environment** periodically (under **natural flow** conditions) and while **mine affected water** is being discharged from the site. For the purposes of the REMP, the **receiving environment** is the **waters** of the Belmore Creek and connected or surrounding waterways within 10 km downstream of the release. The REMP should encompass any sensitive **receiving waters** or **environmental values** downstream of the authorised mining **activity** that will potentially be directly affected by an authorised release of mine affected water.

(F11-2) The REMP must:

a) Assess the condition or state of **receiving waters**, including upstream conditions, spatially within the REMP area, considering background water quality characteristics based on accurate and reliable monitoring data that takes into consideration temporal variation (e.g. seasonality); and
b) Be designed to facilitate assessment against water quality objectives for the relevant **environmental values** that need to be protected; and
c) Include monitoring from background reference sites (e.g. upstream or background) and downstream sites from the release (as a minimum, the locations specified in Schedule F - Table 3); and
d) Specify the frequency and timing of sampling required in order to reliably assess ambient conditions and to provide sufficient data to derive site specific background reference values in accordance with the *Queensland Water Quality Guidelines* 2006. This should include monitoring during periods of **natural flow** irrespective of mine or other discharges; and
e) Include monitoring and assessment of all water quality parameters listed in Schedule F - Table 2; and
f) Include, where appropriate, monitoring of metals/metalloids in sediments (in accordance with ANZECC & ARMCANZ 2000, BATLEY and/or the most recent version of AS5667.*1 Guidance on Sampling of Bottom Sediments*); and
g) Include, where appropriate, monitoring of macroinvertebrates in accordance with the AusRivas methodology, and
h) Apply procedures and/or guidelines from ANZECC & ARMCANZ 2000 and other relevant guideline documents; and
i) Describe sampling and analysis methods and quality assurance and control; and
j) Incorporate stream flow and hydrological information in the interpretations of water quality and biological data.

(F11-3) A report outlining the findings of the REMP, including all monitoring results and interpretations in accordance with conditions F11-1 and F11-2 must be prepared annually and made available on request to the **administering authority**. This must include an assessment of background reference water quality, the condition of downstream water quality compared against water quality objectives, and the suitability of current discharge limits to protect downstream **environmental values**.

END OF CONDITIONS FOR SCHEDULE F

SCHEDULE G – Definitions

Key terms and/or phrases used in this document are defined in this section and **bolded** throughout this document. Applicants should note that where a term is not defined, the definition in the *Environmental Protection Act 1994*, its regulations or environmental protection policies must be used. If a word remains undefined it has its ordinary meaning.

Acceptance criteria means the **measures** by which the actions implemented to rehabilitate the land are deemed to be complete (same as completion criteria).

Administering authority means the Department of Environment and Heritage Protection or its successor or predecessors.

Boundary means within 1m of the cadastral **boundary** of the approved place.

Chemical means:

a) an agricultural chemical product or veterinary chemical product within the meaning of the Agricultural and *Veterinary Chemicals Code Act 1994* (Commonwealth); or

b) a dangerous good under the Australian Code for the Transport of Dangerous Goods by Road and Rail approved by the Australian Transport Council; or

c) a lead hazardous substance within the meaning of the Workplace Health and Safety Regulation 1997;

d) a drug or poison in the Standard for the Uniform Scheduling of Drugs and Poisons prepared by the Australian Health Ministers' Advisory Council and published by the Commonwealth; or

e) any substance used as, or intended for use as:

   (i) a pesticide, insecticide, fungicide, herbicide, rodenticide, nematocide, miticide, fumigant or related product; or

   (ii) a surface active agent, including, for example, soap or related detergent; or

   (iii) a paint solvent, pigment, dye, printing ink, industrial polish, adhesive, sealant, food additive, bleach, sanitiser, disinfectant, or biocide; or

   (iv) a fertiliser for agricultural, horticultural or garden use; or

   (v) a substance used for, or intended for use for mineral processing or treatment of metal, pulp and paper, textile, timber, water or wastewater; or

   (vi) manufacture of plastic or synthetic rubber.

Commercial place means a place used as an office or for business or commercial purposes, other than a place within the boundaries of the operational land.

EC means electrical conductivity.

Environmental authority holder means the holder of this environmental authority.

Environmental value as defined under Chapter 1 of the *Environmental Protection Act 1994.*

General waste means waste other than regulated waste.

Infrastructure means water storage dams, levees,, roads and tracks, buildings and other structures built for the purpose of the mining activity.

Land in the 'land schedule' of this document means land excluding waters and the atmosphere, that is, the term has a different meaning from the term as defined in the *Environmental Protection Act 1994.* For the purposes of

the *Acts Interpretation Act 1954*, it is expressly noted that the term 'land' in this environmental authority relates to physical land and not to interests in land.

Land use term to describe the selected post mining use of the land, which is planned to occur after the cessation of mining operations.

Leachate means a **liquid** that has passed through or emerged from, or is likely to have passed through or emerged from, a material stored, processed or disposed of at the site that contains soluble, suspended or miscible contaminants likely to have been derived from the said material.

Licensed place means the mining activities carried out at the mining tenements detailed in the Environmentally relevant activity and location details table (page 1) of this environmental authority.

Liquid means any substance that:

1. has an angle of repose of less than five degrees; or
2. becomes free flowing at or below 60 degrees Celsius or when it is transported; or
3. is not generally capable of being picked up by a spade or shovel.

m means metres.

Measures has the broadest interpretation and includes plant, equipment, physical objects, monitoring, procedures, actions, directions and competency.

Mine affected water:

a) means the following types of water:
   i) pit water, tailings dam water, processing plant water;
   ii) water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 of the Environmental Protection Regulation 2008 if it had not formed part of the mining activity;
   iii) 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 the standards and requirements of an Erosion and Sediment Control Plan to manage such runoff, provided that this water has not been mixed with pit water, tailings dam water, processing plant water or workshop water;
   iv) groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated;
   v) groundwater from the mine's dewatering activities;
   vi) a mix of mine affected water (under any of paragraphs i)-v) and other water.

b) 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, has only been in contact with:
   i) 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; or
   ii) 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, for example:
      a. areas that are been capped and have monitoring data demonstrating hazardous material adequately contained with the site;

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b. evidence provided through monitoring that the relevant surface water would have met the water quality parameters for mine affected water release limits in this environmental authority, if those parameters had been applicable to the surface water runoff; or

iii) both.

NATA means National Association of Testing Authorities.

Natural flow means the flow of water through waters caused by nature.

Non-polluting means having no adverse impacts upon the receiving environment.

Receiving environment means all groundwater, surface water, land, and sediments that are not disturbed areas authorised by this environmental authority.

Receiving waters means all groundwater and surface water that are not disturbed areas authorised by this environmental authority.

Rehabilitation means the process of reshaping and revegetating land to restore it to a **stable** landform and in accordance with the **acceptance criteria** set out in this environmental authority and, where relevant, includes remediation of contaminated land.

Releases of contaminants to the environment means to:

1. deposit, discharge, emit or disturb the contaminant; and
2. cause or allow the contaminant to be deposited, discharged, emitted or disturbed; and
3. fail to prevent the contaminant from being deposited, discharged emitted or disturbed; and
4. allow the contaminant to escape; and
5. fail to prevent the contaminant from escaping.

Representative means a sample set which covers the variance in monitoring or other data either due to natural changes or operational phases of the mining activities.

RL means reduced level, relative to mean sea level as distinct from depths to water.

Self-sustaining means an area of land which has been rehabilitated and has maintained the required **acceptance criteria** without human intervention for a period nominated by the administering authority.

Sensitive place means:

- a dwelling, residential allotment, mobile home or caravan park, residential marina or other residential premises; or
- an educational institution; or
- a medical centre or hospital; or
- a protected area under the Nature Conservation Act 1992, the Marine Parks Act 1992 or a World Heritage Area; or
- a public park or gardens; or
- a place used as a workplace, an office or for business or commercial purposes which is not part of the mining **activity** and does not include employees accommodation or public roads.

Stable means geotechnical stability of the rehabilitated landform where instability related to the excessive settlement and subsidence caused by consolidation / settlement of the wastes deposited, and sliding / slumping instability has ceased.

Suitably qualified means a person who has professional qualifications, training, skills or experience relevant to the nominated subject matter and can give authoritative assessment, advice and analysis on performance relating to the subject matter using the relevant protocols, standards, methods or literature.

Waters includes river, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, unconfined water, natural or artificial **watercourse**, bed and bank of any waters, dams, non-tidal or tidal waters (including

the sea), stormwater channel, stormwater drain, roadside gutter, stormwater run-off, and groundwater and any part thereof.

µS/cm means micro siemens per centimetre.

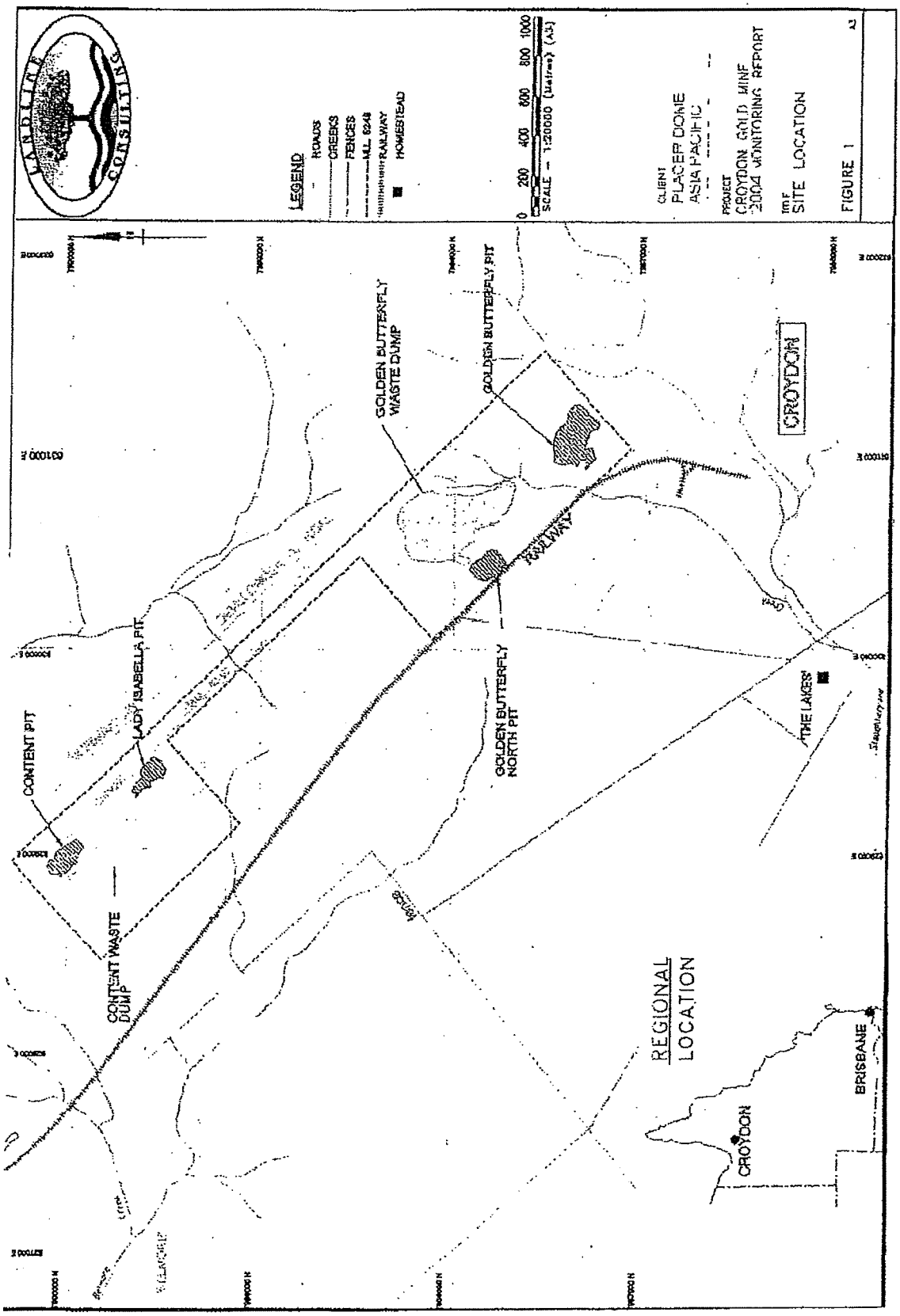
Watercourse has the same meaning given in the *Water Act 2000*.

Water quality means the chemical, physical and biological condition of water.

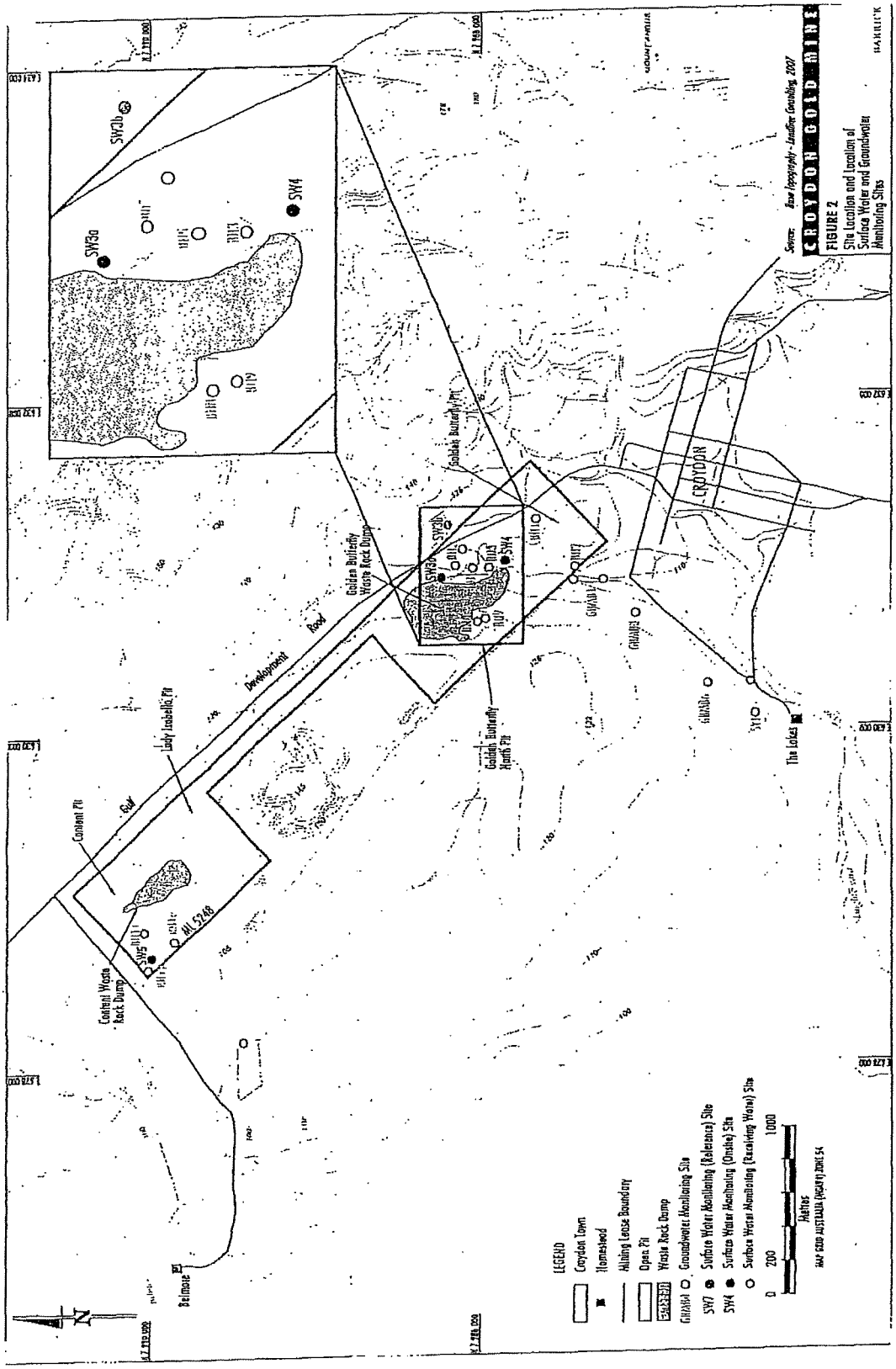
END OF CONDITIONS FOR SCHEDULE G

SCHEDULE H – MAPS

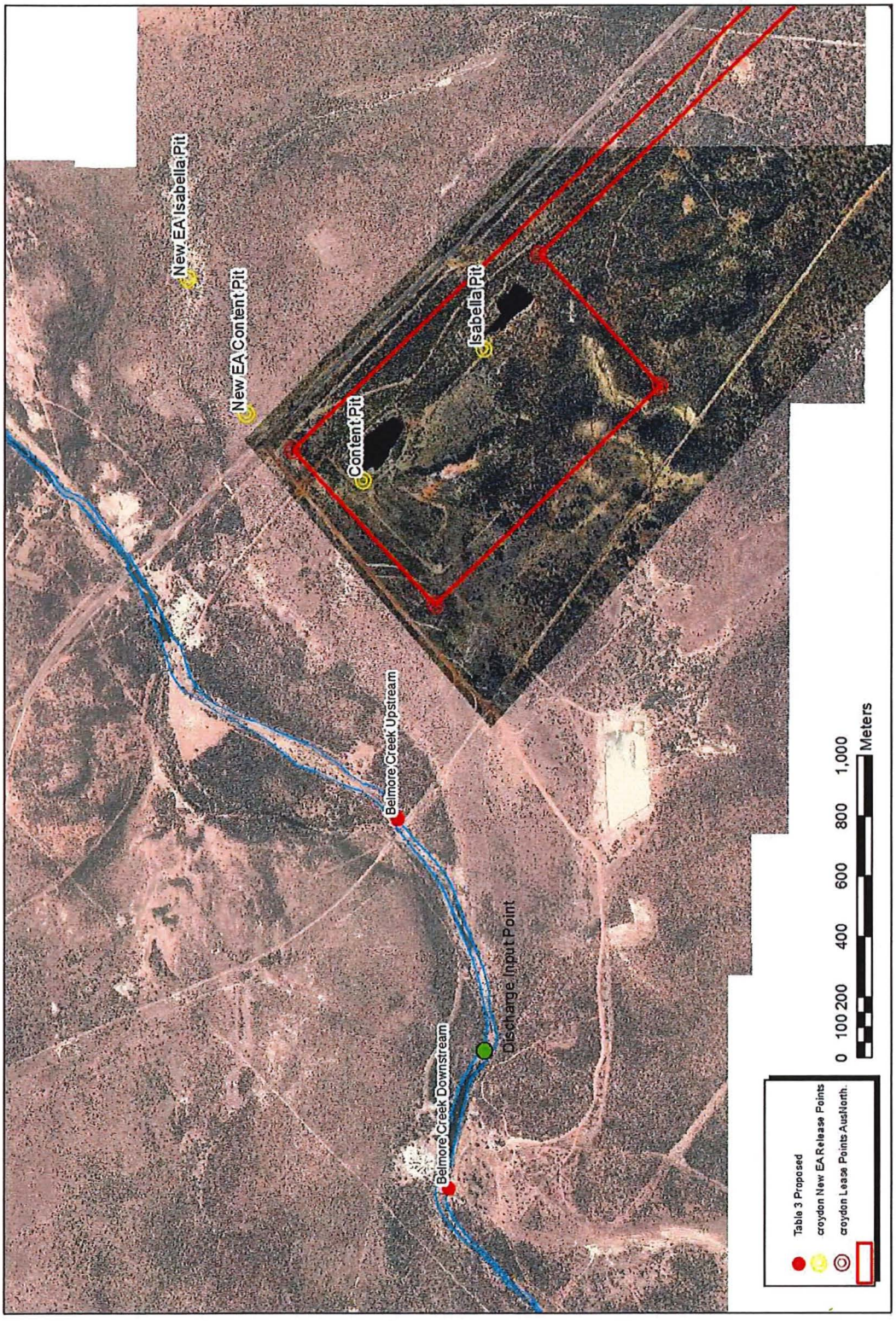
Map 1 – Mine Related Landforms



Map 2 – Surface Water, Sediment and Groundwater Monitoring Sites



Map 3 – Location of Monitoring Sites on Belmore Creek



END OF CONDITIONS FOR SCHEDULE H

END OF PERMIT

APPENDIX D FINAL REHABILITATION REPORT

DRAFT REPORT

Final Rehabilitation Report
Croydon Gold Mine
ML 5248

Released by DES
RTI Act 2009

Prepared for

Goldfields Limited
1 Castlereagh Street
Sydney NSW 2000

HLA-Envirosciences Project No F1715/2

by

CTPI 49-Sch4 MSc FAusIMM CPEnv
Senior Principal (Mining)

6 November 2001

23 NOV 2001

23/11

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Principal Environmental Scientist (Mining)
HLA-Envirosciences Pty Limited
PO Box 73 HRMC NSW 2310

Dear CTPI 4

At the Council meeting on 15th November 2001 the following was resolved:

That Council accept the advice of the Environmental Protection Agency in the following manner:-

- *Council not provide a landholder statement until such time that Council is happy with the state of the mine;*
- *Undertake the surrender process with the Environmental Protection Agency giving advice in relation to Council concerns;*
- *That Council request to be advised when technical aspects of the rehabilitation success is reviewed by Environmental Protection Agency Technical and Contaminated Land Staff prior to surrender in order that this advice be considered by Council; and*
- *That when a site based management plan is in place for the longer term monitoring and management requirements that Council ensures that it has had adequate input into the Plan to satisfy any concerns that may exist.*

I have perused previous correspondence regarding the Landowner/Landholder statement and I look forward to working with you in order to finalise this matter.

Yours sincerely

CTPI 49-Sch4

Lisa Wain
A/Chief Executive Officer

19 November 2001

CROYDON SHIRE

ESTABLISHED
IN 1900
BY THE CONSOLIDATION
OF THE
CROYDON DIVISIONAL BOARD
(EST. 1886)
AND
THE CROYDON
MUNICIPAL COUNCIL
(EST. 1895)

Released by DES RTI Act 2009

FACSIMILE TRANSMISSION

To: Queensland Environmental Protection Agency

Attention: Dean Ellwood

Fax Number: +61 (7) 4744 7800

From: CTPI 49-Sch4

Date: 26 November 2001

Subject: Croydon Shire Council

Project Number: F1715/2/F1715 Ellwood Fax 26-Nov-01

Number of pages (including this cover sheet): 2

Documents faxed in this transmission to follow by mail: No

Message:

Dear Dean,

Please find attached the letter received this morning from Croydon Shire Council. I will contact Lisa Wain in an attempt to find our where we should proceed from here.

Regards,

CTPI 49-Sch4

Transmitted by: CTPI 49-Sch4

If you do not receive all pages, please call CTPI 49-Sch4 **on** 02 49680044

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This document was prepared for the sole use of Goldfields Limited and the regulatory agencies that are directly involved in this project, the only intended beneficiaries of our work. No other party should rely on the information contained herein without the prior written consent of HLA-Envirosciences Pty Limited and Goldfields Limited.

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EXECUTIVE SUMMARY

This Final Rehabilitation Report has been prepared by HLA-Envirosciences Pty Limited on behalf of Goldfields Limited to support an application for relinquishment of ML 5248.

The Croydon Gold Mine, located close to the town of Croydon in north-west Queensland, was operated between 1987 and 1990. During this time ore was obtained from four open pits commonly known as Golden Butterfly, Golden Butterfly North, Content and Lady Isabella. ML 5248 is linear in nature, resembling a dumbbell and runs approximately south-east north-west from Croydon. The two Golden Butterfly open pits are located in the south-east portion of the lease and this is joined to the north-western portion which contains the other two pits by a narrow strip that served as a haul road. A waste rock dump accompanies each pair of open pits. Processing of the ore was undertaken on an adjacent lease that is not the subject of this Report.

Initial rehabilitation of the mine site was undertaken in 1993 and comprised bunding and fencing of the open pits and partial rehabilitation of the waste rock dumps. Goldfields acquired ML 5248 in 1995 after a takeover of the previous holder and, after an assessment of progress, undertook additional rehabilitation during 1996.

An Amended Decommissioning Plan for the site was submitted in 1996 and this has been accepted as the Plan of Operations for the lease. Monitoring of the effectiveness of the rehabilitation commenced in 1996 in accordance with this Plan.

Water quality monitoring has shown that the relinquishment criteria proposed in the Decommissioning Plan have been met at the nominated compliance point. However, the occurrence of localised acid drainage from the Content waste rock dump has meant that desired compliance at another monitoring point has not been met. This acid drainage remains localised and further monitoring has shown that its impact is not detectable at the boundary of the lease.

Vegetation and erosion monitoring confirms that the waste rock dumps are relatively stable and that native vegetation communities are progressing towards a self-sustaining system.

A contamination assessment was undertaken in 1996. This identified that potential acid drainage from the waste rock dumps was the only concern and the rehabilitation program was undertaken with control of this issue in mind. With the exception of the localised acid drainage from the Content waste rock dump, this has proved to be very effective.

Earthen bunds and stock fences surround the only other remaining features on the site, the open pits. While three of these contain acid water with elevated concentrations of some metals, modelling has shown that filling and overflow of these pits is highly unlikely. They are therefore nominated for inclusion on the Environmental Management Register.

ML 5248 overlies land that is either Crown Land or Croydon town common. The two landholders, the Department of Natural Resources and Mines and the Croydon Shire Council have been requested to supply Landowner/Landholder Statements but these have not been supplied despite follow-up requests.

This Report shows that the long-term environmental risks at the mine site are minimal and, therefore, relinquishment of the lease is supported.

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1.0 INTRODUCTION

Goldfields Kalgoorlie Limited (formerly Pancontinental Mining Limited) is the holder of ML 5248 situated immediately to the west of Croydon township, North Queensland (refer to Figure 1). ML 5248 formed part of the Croydon Gold Project and was mined from 1987 until 1990. In 1993, a Decommissioning Plan was prepared, submitted to, and accepted by the Department of Minerals and Energy (DME). Rehabilitation works then commenced according to the Decommissioning Plan.

In 1995 Goldfields Limited (Goldfields) acquired a controlling interest in Pancontinental Mining Limited and immediately commenced reviewing the environmental performance of all sites in conjunction with its then parent, RGC Limited. Goldfields and RGC decided it was necessary to undertake further rehabilitation work at Croydon. An Amended Decommissioning Plan was prepared, incorporating relinquishment criteria, a monitoring program and a commitment to prepare an annual report on the performance of the rehabilitation against the criteria. This additional rehabilitation work was undertaken in late 1996.

Control of the site now rests with Goldfields, following the divestment of the Company by RGC in late 1998.

This Final Rehabilitation Report has been prepared by HLA-Envirosciences Pty Limited (HLA), on behalf of Goldfields, to support an application for relinquishment of the Mining Lease.

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Figure 1: Site Location

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2.0 PROJECT DETAILS

The following table presents the project details as required by the EPA Guideline on preparation of Final Rehabilitation Reports.

Table 1: Project Details

	Details
EA Number	T 2465
Holder's Name and Contact Details	Goldfields Kalgoorlie Limited PO Box R986 Royal Exchange Post Office NSW 1225
Tenure Number and Termination Date	ML 5248 31 August 2009
Project Name	Croydon Gold Mine
Contact Person	Goldfields' Representative: CTPI 49-Sch4 Tel: (02) 8223 2408 Project Controller: CTPI 49-Sch4 HLA-Envirosciences Pty Limited Tel: (02) 4968 0044
Author of FRR	CTPI 49-Sch4 HLA-Envirosciences Pty Limited
Location Information	Part Lot 952, C3591 Part Lot 46, USL48265 Part Lot 78, USL48265 Approximately 0.5 km north-west of Croydon

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3.0 PROJECT DESCRIPTION

ML 5248 is located to the north-west of the township of Croydon in North Queensland (refer Figure 1). The lease is approximately 1.7 km^2 in area and extends along a corridor adjacent to the south side of the Normanton Developmental Road.

3.1 Mining History

The Croydon Gold Project was operated between 1987 and 1990 by an unincorporated joint venture between Central Coast Exploration NL (CCE) and Pancontinental Mining Limited (Pancon). Mining took place on several leases, including ML 5248, to the west and north-west of Croydon. Ore processing was carried out at facilities located on CCE leases that are not the subject of this Final Rehabilitation Report. Mining and ore processing on both Pancon and CCE leases was carried out by Barrick Mine Management (BMM).

The Pancon operation commenced in December 1988 with mining from the Golden Butterfly Pit, located within the eastern portion of ML 5248, as shown on Figure 1. The mining operation was subsequently expanded with the development of the Golden Butterfly North Pit (adjacent to Golden Butterfly) and the Content and Lady Isabella pits located within the western portion of the lease area. Pancon's mining operation at Croydon ceased in April 1990, with processing of ore from these leases completed in August 1990. In total, approximately 445,000 tonnes of ore were treated to produce around 63,000 ounces of gold.

Following the cessation of mining in 1990, a portion of the original lease area was relinquished by Pancon. Only those areas covering the open pits and waste dumps, plus a connecting corridor, were retained. The current lease boundary is indicated on Figure 1.

3.2 Landforms

On completion of mining, ML 5248 included the following mining-related landforms:

- Golden Butterfly Pit and surrounds;
- Golden Butterfly North Pit;
- Golden Butterfly Waste Rock Dump;
- Content Waste Rock Dump;
- Content Pit and surrounds; and
- Lady Isabella Pit.

In addition, mining hardstand areas (including old ore stockpile and crusher pad areas), a haul road and numerous open exploration drill holes related to the Pancon operations, remained within the lease area. Open shafts and adits from historical (ie. pre-1900) mining activities were also present within the area.

Generally, these landforms (with the exception of the pits) have revegetated with grasses and shrubs, either from past sowing activities or by natural colonisation. These landforms, however, have been subject to some disturbance through erosion and livestock or vehicle trafficking. All open pits hold water,

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recharged either through direct rainfall, runoff or from groundwater entry. Each pit is surrounded by an earthen safety bund at least 1 metre high and a three-strand barbed wire fence and is clearly signposted.

Undisturbed areas surrounding the mining landforms, but within ML 5248, are generally grassed and/or partially covered with trees and are typical of the Gulf savanna land system.

3.3 Drainage

ML 5248 is located within the catchment of Slaughteryard Creek. The lease area is drained by a number of smaller tributaries, including Town Creek (from the Croydon township) and Belmore Creek (located within Belmore Station to the west) as well as Slaughteryard Creek itself. The site drainage is as follows:

- Eastern portion - southward, directly via Slaughteryard Creek and Town Creek; and
- Western portion - generally westward via minor drainages to Belmore Creek thence into Slaughteryard Creek to the south west of Croydon.

An area of higher relief between the eastern and western portions of the lease acts as a drainage divide between these areas.

3.4 Land Use and Capability

The pre-mining land use within ML 5248 comprised cattle grazing on the western portion of the lease, with low levels of grazing on the eastern portion. Some cattle grazing continues in the western portion of the lease.

An assessment of pre-mining land capability was undertaken by Woodward-Clyde and reported in Woodward-Clyde (1993), in accordance with Rosser et al (1974). The assessment comprised inspection and sampling of soils not disturbed through mining within and adjacent to ML 5248. Based on this assessment, the pre-mining land capability of ML 5248 was determined as Class VII. Rosser et al (1974) defines Class VII as land that is not suitable for cultivation but on which pastoral use is possible only with careful management and on which pasture improvement involving the use of machinery is considered impracticable.

From 1990 to 1995 the Croydon Shire Council (CSC) used water from the Golden Butterfly North Pit (refer Figure 1) to supplement the existing town water supply, which was based on a borefield located on Slaughteryard Creek downstream from the lease area. Water was pumped from the pit to a tank (Town Tank) located on a hill at the south-eastern boundary of the lease area, for reticulation to the township. During 1995, a new water supply dam was constructed to the north of Croydon and is now used as the town water supply. The Golden Butterfly North Pit and the borefield are no longer used to supply water to the township. However, the water supply reticulation system from the borefield, including water pipes, tank and pumps, has been retained.

3.5 Land Tenure

The locations of the mining related landforms, as described above, with respect to land tenure are described in Table 2 below.

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Table 2: Underlying Land Tenure for Mining Related Landforms

LOCATION	MINING LANDFORM	BACKGROUND LAND TENURE
Eastern Portion of Lease Area	Golden Butterfly Pit	Town Common, Croydon Shire Council
	Golden Butterfly North Pit	
	Golden Butterfly Waste Rock Dump	
Western Portion of Lease Area	Content Pit	Crown Land, Department of Natural Resources and Mines
	Lady Isabella Pit	
	Content Waste Rock Dump	

Hardstand areas, the haul road, drill holes and shafts occurred within both land tenure areas.

Information regarding landholder requirements for the area is provided in Section 6.1.

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4.0 STATUS REPORT

The following section provides a summary of the rehabilitation of the site, commitments and their status, results of the monitoring program and an assessment of continuing requirements for the area.

4.1 Rehabilitation

With the exception of the open pits, the components of ML 5248 that were disturbed by mining have been rehabilitated. Details of this rehabilitation follow.

4.1.1 Pre-1996 Rehabilitation History

Planning for rehabilitation of ML 5248 commenced in November 1992 at a site meeting involving representatives from Pancon, the Department of Minerals and Energy and Woodward-Clyde. During this meeting, the principal environmental concerns relating to the lease area were identified as:

- Development of acidic water in the open pits;
- Discharge of acidic water into Slaughteryard Creek from the Golden Butterfly waste rock dump and adjacent areas;
- Off-lease movement of groundwater from the Golden Butterfly pits; and
- Erosion and potential instability of mining-related landforms.

Pancon committed, at that time, to address each of these concerns. In 1993, Pancon initiated a rehabilitation program that involved the following works:

- ***Golden Butterfly Waste Dump***: re-profiling of the waste rock dump surface, including flattening of batters to a nominal slope of 3(H) to 1(V); construction of cover layers over plateau areas of the waste dump; construction of drainage runoff control areas and construction of stormwater diversion bunds.
- ***Content Waste Dump***: re-profiling of the western batter to a nominal 3H:1V slope; construction of cover layers over this batter and clean-up of waste rock piles adjacent to the dump.
- ***Open pits*** (Golden Butterfly, Golden Butterfly North, Lady Isabella and Content) - construction of perimeter safety bunds, fencing around each pit and erection of warning signs.

Revegetation of the waste dump surfaces was carried out by hand broadcasting of seed following completion of the earthworks portion of the program. Species used included improved pasture grasses, legumes and native shrubs.

4.1.2 1995 Rehabilitation Objectives

In 1995, Goldfields acquired a controlling interest in Pancon and immediately commenced reviewing the environmental performance of all Pancon sites. This review and subsequent work was conducted by Goldfields in collaboration with its then major shareholder RGC Limited and made use of the expertise and resources available within the RGC Group.

In reviewing the rehabilitation status of ML 5248, Goldfields considered that the rehabilitation works conducted to date were not adequate in meeting its corporate environmental standards. In addition, it was found, based on these corporate standards, that the 1993 Decommissioning Plan (Woodward-Clyde, 1993)

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did not comprehensively address the environmental issues or meet the overall rehabilitation objectives for the site. This review provided the catalyst for updating the 1993 Decommissioning Plan.

The rehabilitation objectives adopted for ML 5248 were to:

- Secure the site for the long term by inhibiting the formation of Acid Drainage (AD) and subsequent release of AD products into the surrounding environment; and
- Enhance the overall stability and sustainability of the developed landforms.

These objectives were to be achieved by isolating AD-producing material, either through disposal in open pits or capping with low permeability constructed covers and, in conjunction with these works, to re-profile the existing landforms, as appropriate, and to revegetate final surfaces (either covered or uncovered). Additionally, all practical measures were to be taken to ensure the safety of the public and livestock using the site. A rehabilitation works program was carried out within ML 5248 in 1996 based on these general rehabilitation requirements.

4.1.3 1996 Rehabilitation Program

Goldfields undertook an analysis of rehabilitation options that included assessment of engineering feasibility, success in achieving the objectives and cost. From that assessment, the rehabilitation scenario outlined in Table 3 was selected by Goldfields for ML 5248:

Table 3: 1995 Rehabilitation Scenario

Landform	Favoured Rehabilitation Option
Waste Dumps	Re-profiling and Capping
Pits	Do Nothing
Other Areas:	
- Stockpile Area	Remove AD potential rock
- Haul Road	Do nothing
- Western side of Content Pit	Remove AD potential rock
- Drainage Channel	Remove AD potential material
- North of Golden Butterfly Pit	Do nothing

An upgraded rehabilitation works program for ML 5248 was commenced in August 1996 and completed in December 1996. This program comprised the following works:

- Golden Butterfly Waste Rock Dump

  Clay fill capping and rock fill surface protection of the entire waste dump surface, including construction of a key trench around the dump perimeter;

- Content Waste Dump

  Re-profiling of batter slopes (other than the western batter), with clay fill capping and rock fill surface protection of the entire dump surface;

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- Other lease area activities, including:

  (i) Removal of potentially acid producing waste rock within hardstand areas adjacent to the Golden Butterfly and Content Waste Rock Dumps, with disposal of the excavated waste to adjacent open pits; and
  (ii) Removal of channel bed sediments within the reach of the Slaughteryard Creek tributary that drains the Golden Butterfly waste dump.

- Miscellaneous rehabilitation works that were considered necessary to complement the above major activities or to comply with specific background landholder requirements, as follows:

  (i) Backfilling of open drill holes and removal of associated rubbish;
  (ii) Construction of surface drains and a pond to collect surface water drainage from the Content Waste Rock Dump (for the purpose of surface water sampling);
  (iii) General site clean-up;
  (iv) Backfilling of open mine shafts;
  (v) Removal of AD producing material from an area adjacent to the lease which had the potential to affect that part of the Belmore Creek catchment on ML5248; (This material was discovered during the course of the rehabilitation works program, was a significant AD source, and had the potential to mask any benefit from the works around the waste dump site) and
  (vi) Revegetation of disturbed areas including rehabilitated waste dumps.

The objective of the revegetation program was to establish a sustainable vegetative cover and provide long-term stabilisation and protection of waste dump surfaces and other disturbed areas on ML 5248. The revegetation work carried out comprised sowing with a seed mix of native tree and shrub species similar to those found in the surrounding native woodland communities.

A monitoring program was then established to measure success in achieving the rehabilitation objectives.

A report on this rehabilitation program is attached as Appendix 1.

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4.2 Commitments and Conditions

Because of the age of the site, there are no specific rehabilitation or closure requirements placed on formal authorities such as the Mining Lease. Some commitments have been included in the 1996 Decommissioning Plan.

4.2.1 Plan of Operations and Commitments

The 1996 Amended Decommissioning Plan prepared by Woodward-Clyde was submitted to the DME and accepted as the Plan of Operations for ML 5248. Approval of this Plan is current until the end of 2001.

The Plan also included a summary of commitments by Goldfields. These actions and goals were established in order to achieve the rehabilitation objectives and completion criteria for lease relinquishment. The list of commitments, together with an assessment of compliance, is included as Appendix 2.

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4.2.2 Environmental Authority Conditions

The Environmental Authority, which is actually the Mining Lease, has a number of Special Conditions relevant to lease relinquishment. These Conditions, and an assessment of compliance, are shown in Table 4.

Table 4: Mining Lease Conditions and Status

	Status
2. The Lessee shall at all times cause all steps and things to be taken and done to prevent mineralised or impure water or sludge or mining debris resulting from mining operations within the boundaries of the Lease from unlawfully polluting, obstructing, damaging or interfering with the sea, any watercourse, lake or reservoir or any land.	Remediation works undertaken in 1996 were aimed at preventing acid drainage leaving the lease. The effectiveness of this work has been demonstrated through the monitoring program.
9. The Lessee shall grade and contour the mined area, overburden and waste rock dumps progressively, so that: a) final voids are landscaped and connected to the drainage pattern in the area for best practical advantage for use as water storage areas; b) rock and overburden dumps are contoured to conform as nearly as is practicable to the adjoining landforms in terms of slopes and slope lengths; and c) all disturbed areas are stabilized against the natural forces of erosion.	As three of the voids contain acid water, Goldfields considers that this condition should not be complied with. Golden Butterfly North pit has water directed into it to maximise storage. Waste rock dumps have been regraded to a maximum slope of 3H:1V, similar to natural slopes in the area. Waste rock dumps have been stabilised by a rock mulch and vegetation cover.
10. After an area has been contoured in accordance with condition 9 the Lessee shall: a) cover the surface of the contoured area with the soil removed in compliance with condition 8; and b) take such measures as the Minister may direct to promote the stabilization of the area and the regrowth of vegetation during the term of the lease.	Where available, topsoil has been used on the surfaces of the waste rock dumps to enhance vegetation establishment. Stabilization has been achieved by a combination of rock mulch and vegetation cover.
13. When the Minister so requires, the Lessee shall ensure that overburden or waste rock dumps that react with water to produce substances toxic to animal and plant life are covered by an approved layer of inert material.	Potentially acid forming waste rock dumps have been capped with a compacted clay layer to reduce the potential for production of acid drainage.

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Condition	Status
14. All fences on the Lease shall be kept intact at all times, except that, where the Lessee requires to remove a fence an alternative fence of a standard equal to or better than the displaced fence shall be provided by the Lessee.	Open pits have been fenced and are currently maintained by Goldfields. Other fences on the lease are also maintained in this manner.
17. The Lessee shall maintain the Lease area in a tidy state and, prior to the termination of the Lease, remove all machinery and plant unless otherwise approved.	All machinery and plant associated with the modern mining operation have been removed. Some historic machinery remains *in situ*.

4.3 Results of the Monitoring Program

Regular monitoring of surface and groundwater quality, vegetation establishment and erosion potential has been undertaken since late 1996. The results of these programs are reviewed in this section.

4.3.1 Monitoring Reports

Regular monitoring has been conducted at Croydon since 1996 for:

- Surface water quality;
- Groundwater quality;
- Vegetation establishment on waste rock dumps; and
- Erosion on waste rock dumps.

Annual monitoring reports, presenting the results from the previous year's monitoring and providing an evaluation of the progress towards the aims and objectives of the Amended Decommissioning Plan, have been produced since 1996.

Reports on ML 5248 addressing various aspects of the mining rehabilitation program are:

- Woodward-Clyde (1993). *Pancontinental Mining Limited - ML 5248 Mine Decommissioning Plan*. Report No. 4371 December 1993;
- Woodward-Clyde (1994). *ML 5248 Mine Decommissioning - Croydon 1994 Annual Inspection Report*. May 1994;
- Woodward-Clyde (1996). *Croydon Gold Mine 1996 Monitoring Report ML 5248*. Report No. 280/0005 October 1996;
- Woodward-Clyde (1997). *Croydon Gold Mine (Amended) Decommissioning Plan for ML 5248.* Prepared for Pancontinental Mining Limited, May 1997;
- ERA Environmental Services (1997). *Croydon Mine Revegetation Monitoring, May 1997.* Prepared for RGC Limited;
- Woodward-Clyde (1998a). *Croydon Gold Mine 1997 Annual Monitoring Report. February 1998*;
- ERA Environmental Services (1998). *Croydon Mine Revegetation Monitoring, November 1997.* Prepared for RGC Limited, February 1998;
- Fawcett Mine Rehabilitation Services Pty Limited (1998). *Croydon Site Inspection Report. May 1998*;

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- Woodward-Clyde (1998b). *Croydon Gold Mine 1997-98 Annual Monitoring Report*. August 1998.
- ERA Environmental Services (1999). *Croydon Mine Revegetation Monitoring, November 1998.* Prepared for RGC Limited, March 1999;
- Fawcett Mine Rehabilitation Services Pty Limited (1999). *Croydon Site Inspection Report. April 1999*;
- Woodward-Clyde (1999). *Croydon Gold Mine 1998-99 Monitoring Report*. Prepared for Goldfields Limited. Report A8601308\R369-D;
- EWL Sciences (1999). *Croydon Mine Revegetation Monitoring, November 1999*. Prepared by EWL Sciences Pty Limited for Goldfields Kalgoorlie Limited, December 1999;
- HLA-Envirosciences (2000). *Croydon Gold Mine 1999-2000 Monitoring Report*. Project No. F1715, November 2000; and
- Lane, A. (2001). *Final Report Croydon Mine Revegetation Monitoring, November 2000*. Prepared for Goldfields Kalgoorlie Limited by Annie Lane, March 2001.

4.3.2 Relinquishment Criteria

Relinquishment criteria were proposed in the 1996 Amended Decommissioning Plan and accepted by the DME. Relevant criteria for each monitoring program are summarised at the beginning of each section in this report. A complete set of the relinquishment criteria is attached as Appendix 3.

4.3.3 Surface Water Quality

This section provides information on the surface water quality monitoring program and the analytical results obtained during the monitoring period. The locations of monitoring points are shown on Figure 2.

4.3.3.1 Relinquishment Criteria

A summary of the approved relinquishment criteria for surface water is provided in Table 5.

Table 5: Lease Relinquishment Criteria - Surface Water

Category	Parameters	Relinquishment Criteria
SW Series	pH, TDS, EC, Ca, Mg, Na, SO_4, As, Cd, Cu, Fe, Pb, Mn, Ni, Zn.	Livestock watering guidelines (ANZECC, 1992) or 115% of background surface water quality*
Open Pits	pH, TDS, EC, Ca, Mg, Na, SO_4, As, Cd, Cu, Fe, Pb, Mn, Ni, Zn.	No relinquishment criteria

* = whichever is greater

The SW Series comprises monitoring sites for surface drainage within ML 5248. Results for this monitoring are compared against the ANZECC (1992) livestock watering guidelines. If the results exceed these guidelines, they are then compared against 115% of the background water quality (defined as analytical results for locations SW3 and SW4). If no guideline is suggested for a parameter in the ANZECC criteria, it is assumed that this is not a key water quality parameter and no comparison to background data is conducted. The acceptable criteria for each analyte, based on ANZECC (1992) livestock watering guidelines, are provided in Appendix 3.

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Figure 2: Surface Water Monitoring Locations

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Goldfields nominated SW1 as the compliance point for ML 5248 and aimed for compliance with the surface water quality criteria at both SW2 and SW5 (refer to Figure 2). This nomination has been adopted by Goldfields.

Background surface water quality for the site is measured at SW3 and SW4.

The 1996 Amended Decommissioning Plan stated that relinquishment criteria for the quality of contained water are not set, as no beneficial use has been established for the open pits. Nevertheless, monitoring of water quality in the open pits has continued throughout the year.

4.3.3.2 Results and Discussion

A complete set of surface water monitoring results is included in Appendix 4.

As can be seen in Table A4-1, water quality at SW1, the nominated compliance point, has been consistently below the relinquishment criteria since monitoring started in January 1996. All parameters have been at least one order of magnitude below the livestock watering guideline limit. While the concentration of arsenic appears to have risen since January 2001, the concentration is still 25 times lower than the guideline.

Water quality at SW2 (Table A4-2), one of the two points at which compliance was also sought, is also good, with all parameters at least one order of magnitude below the corresponding guideline value and many of them over two orders of magnitude lower.

SW5 is located at a small dam in the drainage line from the Content waste rock dump. The water quality at this site was good between December 1996 and December 1997, but started deteriorating in January 1998 (Table A4-6). The drop in pH (Figure 3) and increase in TDS (Figure 4), sulphate (Figure 5) and some of the metals suggested the presence of acid drainage. While the concentration of sulphate did not remain elevated above the livestock watering guideline after April 1998, that of cadmium has been consistently above the relevant guideline concentration since December 1997 and appears to have stabilised at around twenty times the guideline concentration (Figure 6). This is most likely because the pH of the drainage is at the optimum level for mobilisation of cadmium while other metals have become relatively insoluble. Mobilisation of cadmium will likely continue until the supply of the metal is exhausted or the characteristics of the drainage change.

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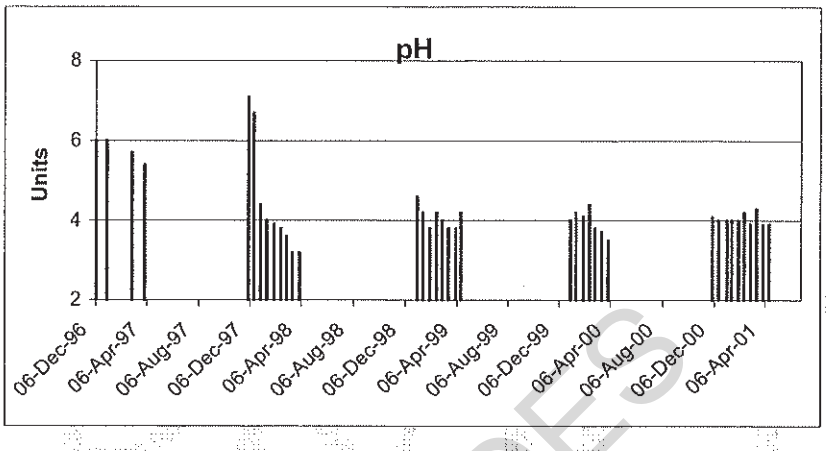

Figure 3: pH at SW5 over Time

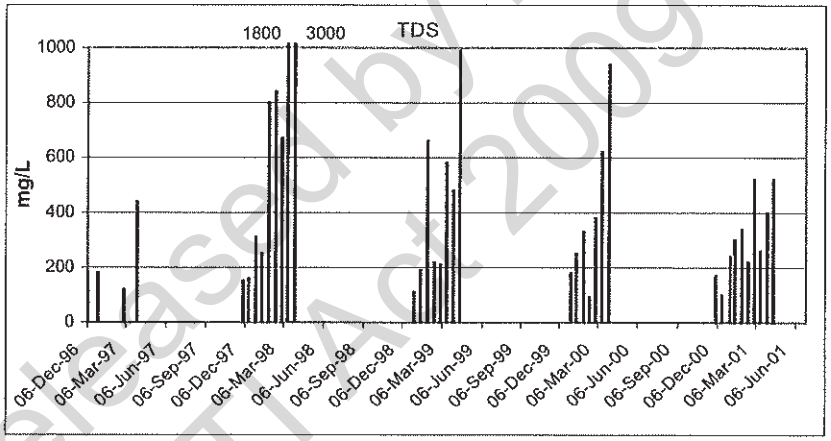

Figure 4: Total Dissolved Solids at SW5 over Time

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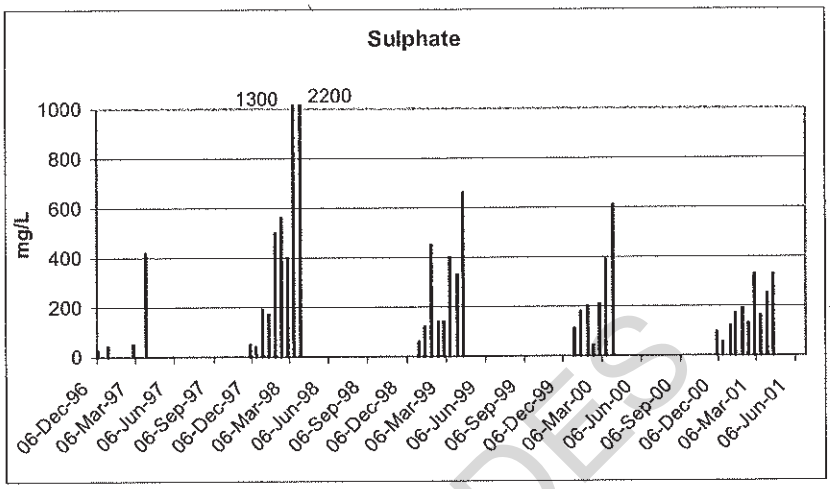

Figure 5: Sulphate Concentration at SW5 over Time

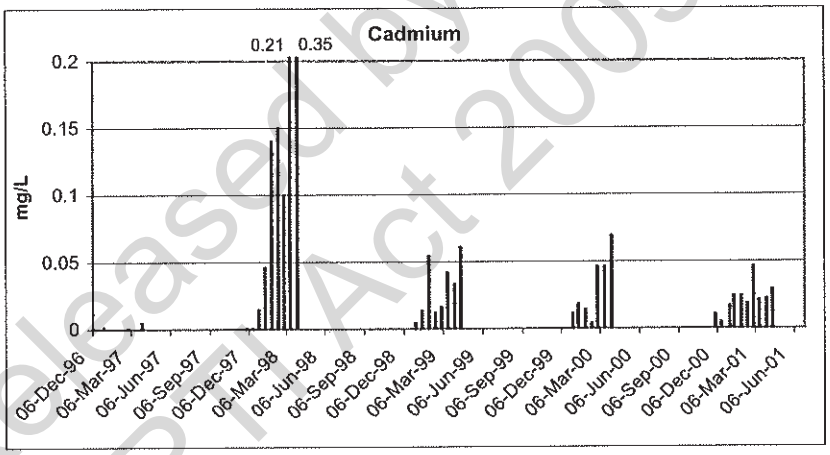

Figure 6: Cadmium Concentration at SW5 over Time

Following the detection of this acid drainage, presumed to originate at a localised point on the western batter of the Content waste rock dump, an additional water monitoring point was established further downstream of SW5 at the boundary of the adjacent pastoral property. This point was designated SW6 and the results of monitoring since June 1998 are shown in Table A4-7. Despite the occurrence of the acid drainage upstream, the monitoring at this point shows that the water quality has been consistently well below the livestock watering guideline concentrations. For most parameters, concentrations have been at least two orders of magnitude lower than the guideline. The concentration of arsenic has been below the limit of detection until early 2001 but is still 50 times lower than the guideline value of 0.5 mg/L (Figure 7).

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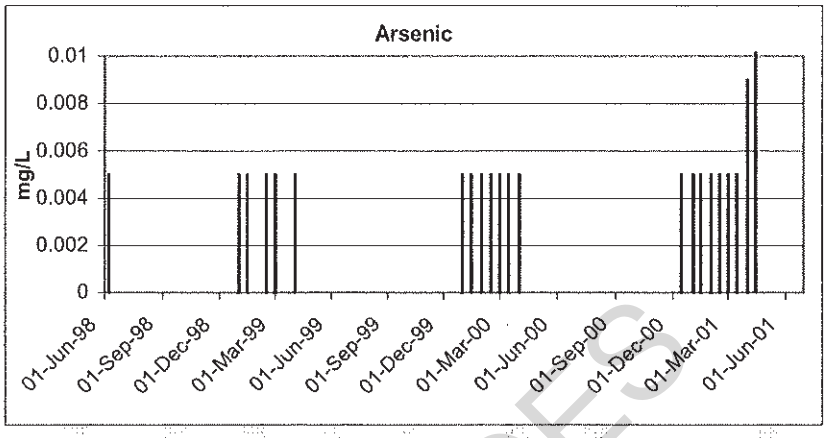

Figure 7: Arsenic Concentration at SW6 over Time

Although no relinquishment criteria were established for the open pits, water samples continue to be collected and analysed on a quarterly basis. The results of this monitoring are tabulated in Appendix 4.

Three of the four open pits, Golden Butterfly, Content and Isabella, contain water that has a low pH, generally around 3.0, and only lightly elevated concentrations of dissolved solids and major ions (Tables A4-8 to A4-11). The water in the Golden Butterfly pit has the lowest pH (around 2.5) and highest TDS (around 8,500 mg/L) and sulphate (around 6,000 mg/L) concentrations. Concentrations of arsenic, cadmium, copper, nickel and zinc are also elevated and, in most cases, are at least twice the corresponding livestock watering guideline. In contrast, water in the Content and Isabella pits is slightly less acid (pH around 3.5 in each case) with much lower concentrations of TDS, sulphate and metals. Ion both of these pits only the cadmium concentration is above the livestock watering guideline.

The water in the Golden Butterfly North pit is totally different in composition, being neutral to slightly alkaline with low concentrations of major ions and metals. Although there are no completion criterion for the open pits, none of the livestock watering guidelines are exceeded in this water.

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4.3.4 Groundwater Quality

This section provides information on the groundwater monitoring program.

4.3.4.1 Relinquishment Criteria

A summary of the lease relinquishment criteria for groundwater is provided in Table 6.

Table 6: Lease Relinquishment Criteria - Groundwater

Category	Parameters	Relinquishment Criteria
GBMB Series Bores	pH, TDS, EC, Ca#, Mg#, K, Na, SO_4, Cl, As, Cd, Cu, Fe, Pb, Mn, Ni, Zn.	Maintain existing water quality measured during the 1990-1993* period
BH Series Bores	pH, TDS, EC, SO_4, Fe.	No relinquishment criteria

= no criteria available as parameter added in 1996 Decommissioning Plan

* = see ranges in Appendix 3

The list of analytes for the GBMB Series is a modified suite based on a review of the 1993 Decommissioning Plan parameter list and the results of past monitoring.

Monitoring locations for these bores are shown on Figure 8.

4.3.4.2 Results and Discussion

The results of water quality analyses in the GBMB series bores are included in Appendix 4 as Tables A4-12 to A4-17.

None of the GBMB series bores has water that, in a strict sense, meets the relinquishment criteria established in the 1996 (Amended) Decommissioning Report. However, in most cases, this is because the criteria are very strict rather than because the quality of the water is poor. For example, for GBMB1 to meet the criterion for TDS the concentration in the water should be between 390 and 520 µS/cm, a very narrow range. Similarly, because the range of pH in this bore between 1990 and 1993 was 3.6 to 6.15, water with a pH value of 7.0 would not meet the relinquishment criterion even though it is neutral and "better" quality water. Therefore, non-conformance with the relinquishment criteria is an artefact of the baseline quality varying very little rather than a test of suitability for use.

In all cases there are no substantial departures in water quality from the relinquishment criteria and the quality of the water in the boreholes is generally good, being neutral or slightly acid with relatively low concentrations of TDS, major ions and metals. None of the measurable parameters appears to have changed with time since the current monitoring program commenced in early 1996.

The water in GBMB2 is noticeably different to that in the other boreholes, having higher concentrations of TDS, major ions and some metals eg. manganese. While GBMB1water also has TDS, sodium and sulphate concentrations higher than the remaining boreholes, they are lower than those in GBMB2.

As no construction details for these boreholes can be located, it cannot be determined whether these differences are due to the influence of the mine or because the boreholes are located in different aquifers.

Given the absence of any trends with time, it is unlikely that the quality of the water in these boreholes will ever meet the relinquishment criteria proposed in the 1996 (Amended) Decommissioning Plan. As there is no longer any beneficial use of this water, we consider that maintaining the requirement to meet the nominated relinquishment criteria for the GBMB series boreholes is unnecessary. The monitoring shows that the quality of the water in these boreholes has not changed as a result of the rehabilitation and we consider that it is adequate for lease relinquishment.

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Figure 8: Groundwater Monitoring Locations

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Results of water quality monitoring in the BH series bores are attached in Appendix 4 as Tables A4-18 to A4-21.

The BH series monitoring bores were established for two purposes. BH1 and BH2 were installed in November 1995 on the northern and southern sides of the Golden Butterfly pit respectively. Their purpose was to monitor the groundwater depth and quality close to the pit and to assess any relationship between pit water quality and the quality of the surrounding groundwater. Five additional shallow bores (BH3 to BH7) were established as monitoring points in May 1996 adjacent to the Golden Butterfly waste rock dump to monitor possible shallow groundwater influences within the Slaughteryard Creek area resulting from drainage from the dump. Two of these bores, BH3 and BH7, were sampled as part of the environmental monitoring program. Completion criteria were not nominated for any of the BH series bores.

The quality of the water in BH1 and BH2 differs markedly, suggesting that the bores intersect two different and possibly unconnected aquifers. This is further substantiated by the water levels, which are also markedly different. The water in BH1 can be characterised as neutral or slightly alkaline, with a TDS around 1,000 mg/L and low sulphate (around 450 mg/L) and iron (variable between <0.05 and 2 mg/L) concentrations. Although the water in BH2 is acid (pH around 3.5), the TDS, sulphate and iron concentrations are comparable with those in BH1. With the exception of pH in BH2, the water quality in these bores is more similar to that in the GBMB series than the Golden Butterfly pit itself.

Therefore, these bores are showing no indication that water is permeating out from the Golden Butterfly pit into the surrounding aquifers.

The water in BH3 is slightly acidic with relatively low concentrations of TDS, sulphate and iron. In contrast, water in BH7 has a similar pH but higher concentrations of the other parameters. There are no obvious trends in water quality since monitoring commenced and these holes are not showing any apparent influence of the nearby waste rock dump.

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4.3.5 Vegetation

This section summarises the results of the vegetation monitoring since May 1997.

4.3.5.1 Relinquishment Criteria

The lease relinquishment criteria for the establishment of vegetation are summarised in Table 7.

Table 7: Lease Relinquishment Criteria - Vegetation

Category	Parameters	Relinquishment Criteria
Vegetation	Landscape Function Analysis (LFA)	Capture and decomposition of leaf litter within troughs is occurring Vegetational structural complexity trending towards control sites Vegetation compositional complexity trending towards control sites Habitat complexity trending towards control sites

Category	Parameters	Relinquishment Criteria
	Vegetation Measures: Species richness Species frequency Plant density Growth rate	No criteria for vegetation measures

These terms were defined in the 1996 (Amended) Decommissioning Plan as follows:

- Vegetational structural complexity - a measure of how well the tree layer is developing, determined by measuring tree diameter at breast height (DBH);
- Vegetation compositional complexity - the measure of how well the site is developing the mix of plant species found on the control sites;
- Habitat complexity - a measure to demonstrate how well vegetation structures and other landscape features, and their suitability as sites for wildlife, are developing;
- Species richness - the number of species per unit area; and
- Species frequency - percentage of quadrats in which that species is recorded.

Vegetation monitoring is based on Landscape Function Analysis (LFA), a method developed by the CSIRO (CSIRO, 1997). The basis of LFA is to measure how well a rehabilitated landscape is using water and nutrients, its ability to resist erosion and the landscape's progress towards becoming a stable self-sustaining unit in comparison with selected control sites with similar topography.

Species richness, species frequency, plant density and growth rate are parameters additional to LFA. These parameters and LFA are measured at permanent locations on the rehabilitated and control sites. The first monitoring of vegetation was conducted in May 1997 and subsequent monitoring has occurred every November. This timing, at the end of the dry season, is considered most appropriate for the monsoonal tropics.

Six monitoring sites have been located on revegetation areas and the control (Site 7) is located in natural bushland roughly midway between the two former operating areas. Sites 1 to 4 are situated on slopes of the Golden Butterfly waste rock dump while Site 5 is located on a slope of the Content waste rock dump. Only one site was located on the Content dump because the revegetation was much more uniform on that dump and one site was considered appropriate. The remaining monitoring site, Site 6, is located on the flat former hardstand area adjacent to the Content dump.

The locations of the vegetation monitoring sites are shown on Figure 9.

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Figure 9: Location of Revegetation and Erosion Monitoring Sites

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4.3.5.2 Results and Discussion

The most recent report on the vegetation monitoring provides an assessment in November 2000. This report concluded that *"the rehabilitation of the Croydon site is progressing towards self-sustaining ecosystems* [ie. meeting the vegetation criteria described in Table 7] *in terms of:*

- *Vegetation density and composition of the rehabilitation sites are trending towards those of the natural site; and*
- *Landscape processes such as soil stability, infiltration capacity and nutrient cycling capacity are gradually trending toward those of the natural sites".*

Although Landscape Function Analysis (LFA) parameters were proposed as vegetation relinquishment criteria for the Croydon site, appropriate methods for calculation of these have not been developed. The CSIRO has developed a procedure for the calculation of Habitat Complexity but, as this was developed some time after vegetation monitoring commenced at Croydon, it has not been used in the program. Accordingly, these indicators cannot be used to demonstrate the progress of vegetation re-establishment.

Data are available on the four vegetation measures described in the completion criteria table (Table 7).

Sixteen tree and shrub species were included in the seed mix used during the 1996-97 revegetation program. Most of these were recorded in at least one quadrat during the November 2000 monitoring (Table 8). In addition, other species were recorded at some sites; these reflect either difficulty in identification or self-seeding from surrounding vegetation. In all, nineteen tree and shrub species were recorded at the revegetation sites. Of these, seven were acacias, seven were eucalypts and five belonged to other genera, including *Melaleuca*, *Atalaya*, *Erythrophleum* and *Hakea*.

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Table 8: Species Seeded and Recorded at Monitoring Sites

	Rate (kg/ha)	1	2	3	4	5	6	Control
Acacia decora	0.1		√					
Acacia julifera	0.1			√	√	√		
Acacia platycarpa	0.2				√			
Acacia shirleyi	0.25	√	√	√		√		√
Acacia torulosa	0.2			√	√	√		
Acacia tropica	0.005							
Erythrophleum chlorostachys	0.1							√
Eucalyptus confertiflora	0.08		√	√				
Eucalyptus leptophleba	0.14	√	√	√	√	√		
Eucalyptus melanophloia	0.3	√	√	√	√	√		
Eucalyptus miniata	0.34	√		√		√	√	√
Eucalyptus polycarpa	0.18	√	√	√		√	√	
Eucalyptus setosa	0.14	√			√			
Hakea arborescens	0.02							
Melaleuca nervosa	0.05							
Melaleuca viridiflora	0.25	√		√				
Species not Seeded								
Melaleuca leucadendron		√						
Acacia holosericea			√		√	√		
Hakea sp.			√					
Acacia difficilis				√				
Atalaya sp.					√			
Acacia sp.		√						
Eucalyptus sp.		√			√			
Alphitonia sp.								√

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All of the sites except Site 6 have equal, or greater, tree species richness than the control (site 7), as shown in Table 9. Site 2 appears to have recovered from the effects of the fire in 1998, while Site 6 still shows the effects of vegetation dieback as a result of acid drainage from the Content waste rock dump. There is a general decrease in species richness, bringing the monitoring sites closer to the control.

Table 9: Tree Species Richness at Monitoring Sites

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Control
Nov 1997	10	13	10	10	8	11	4
Nov 1998	10	6	10	8	8	8	5
Nov 1999	8	11	13	9	12	5	5
Nov 2000	10	8	10	9	8	2	4

The dominant genus at a site in terms of density and frequency is either *Acacia* or *Eucalyptus*. In most cases the differences in number of plants belonging to each genus is not substantial and their relative proportions are reasonably constant. The exception is Site 6, where there are no acacias and only resprouting eucalypts, mainly *E. confertiflora* and *E. polycarpa*.

Tree species density at all sites has been decreasing and approaching that of the control (Figure 10: Tree Species Density at Monitoring Sites

). In contrast, the density of herbs at all sites has increased recently, parallelling the situation at the control site (Figure 11). With the exception of Site 6, where approximately one hectare of revegetation has been affected by acid drainage, Lane concluded that plant health and vigour is *"on a par with other sites"*.

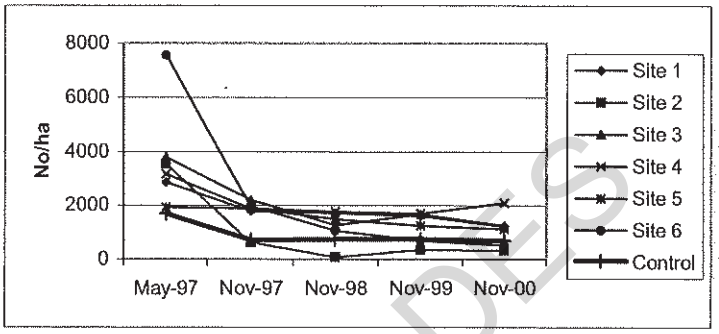

Figure 10: Tree Species Density at Monitoring Sites

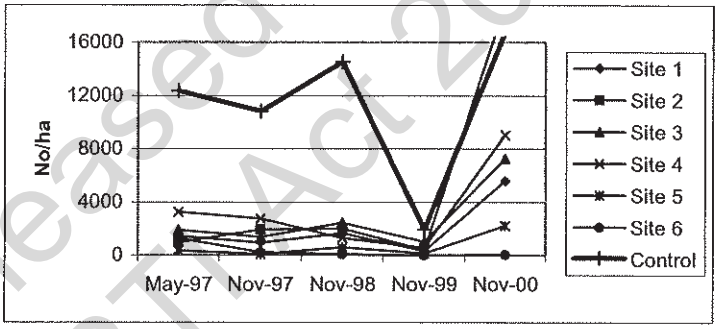

Figure 11: Herb Species Density at Monitoring Sites

Trees and shrubs have continued to increase steadily in height during the period of the monitoring program (Figure 12 for trees [note logarithmic scale on vertical axis], Figure 13 for shrubs), and both are trending towards the heights at the control site.

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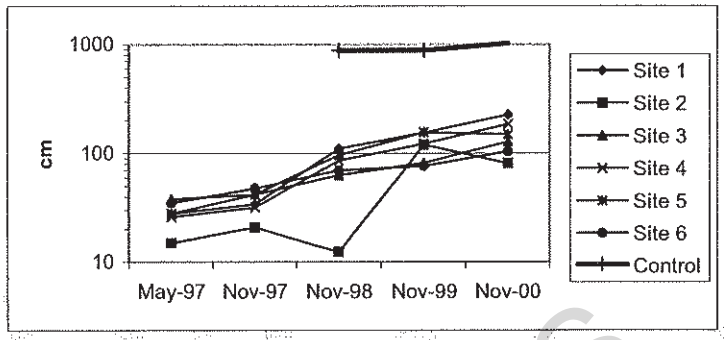

Figure 12: Mean Height of Eucalypts at Monitoring Sites

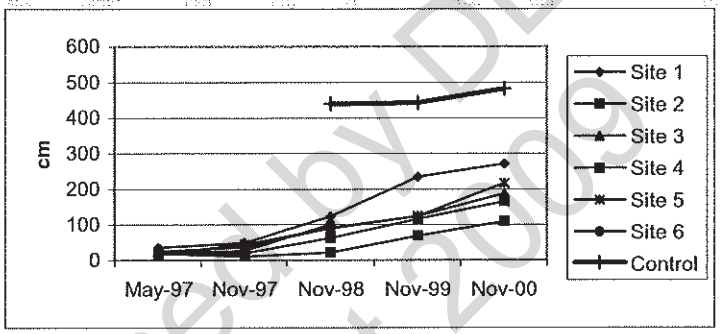

Figure 13: Mean Height of Acacias at Monitoring Sites

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4.3.6 Erosion

This section summarises the results of the erosion monitoring since May 1997.

4.3.6.1 Relinquishment Criteria

The relinquishment criteria for erosion have been defined and are presented in Table 10.

Table 10: Lease Relinquishment Criteria - Erosion

Category	Parameters	Relinquishment Criteria
Erosion	(LFA) Soil Surface Condition Class • Surface stability • Infiltration • Nutrient recycling	Trending towards control site
	Integrity of bank and trough systems on waste dump slopes Erosion gully stability and depth	Maintained Erosion depth not greater then 300 mm

The monitoring of erosion is very similar to that of the vegetation. The LFA procedure of Tongway and Ludwig is used to examine the way resources such as water, soil and litter are regulated down a transect through a system of banks, troughs, slopes and flats (Tongway and Ludwig, 1997).

Ten soil surface features are assessed and ranked into classes. These soil surface condition classes (SSCC) are then grouped and summarised to indicate the:

- Stability of the soil surface;
- Water infiltration storage capacity of the soil; and
- Degree of nutrient cycling processes.

The sites used are those sampled for vegetation monitoring (Figure 9).

4.3.6.2 Results and Discussion

The following summary has been adopted from the conclusions that were reached by Annie Lane in the report on the November 2000 monitoring.

The Landscape Function Analysis survey showed that there were no substantial changes to landscape surface condition. Soil surfaces were stable, and minor rilling that was recorded at some sites in previous surveys had not deteriorated. Rip lines remained essentially intact but were shallower due to infilling. The soil surface stability index either remained unchanged or increased slightly at all sites (Figure 14). Similarly, there was little movement in the indicators of infiltration (Figure 15) and nutrient cycling capacity (Figure 16). These indicators are slow to increase due to the absence of topsoil and decomposing litter. Litter accumulation is the major component of these two indices and their values will inevitably increase as the volume and rate of decomposition of litter increases.

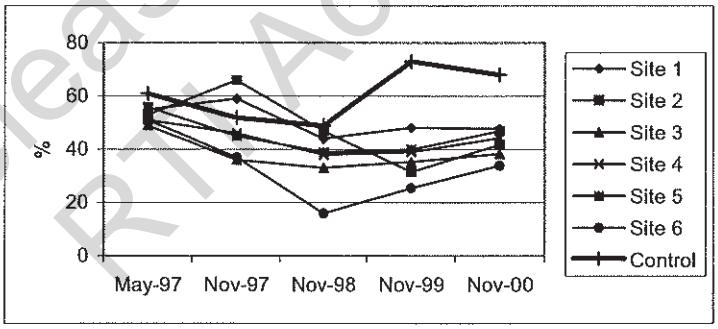

Figure 14: Stability Index at Monitoring Sites

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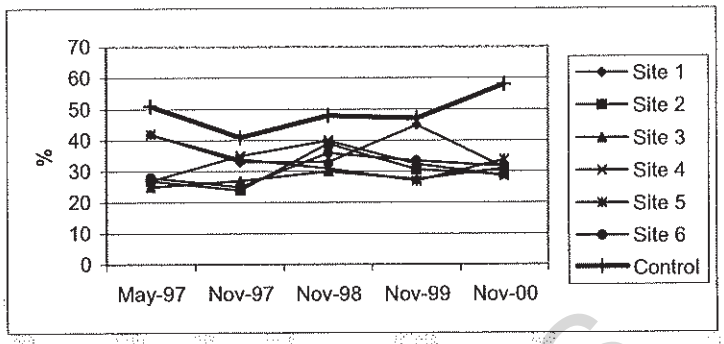

Figure 15: Infiltration Index at Monitoring Sites

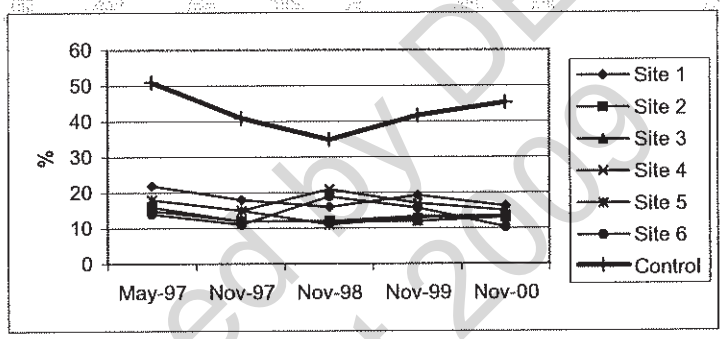

Figure 16: Nutrient Cycling Index at Monitoring Sites

4.4 Continuing Requirements

The monitoring of vegetation and landscape function shows that the ecosystems on the rehabilitated waste rock dumps and hardstand areas are continuing to develop and trend towards the control site. Vegetation cover on the waste rock dumps is increasing and the vegetation is generally progressing towards a stable ecosystem (see Plate 1 and Plate 2).

Goldfields committed to establishing a vegetation cover that would develop and provide protection for the soil surface such that erosion would not exceed that of the natural ground surface. These data show that this commitment has been met at all sites except for the area adjacent to the Content waste rock dump that has been affected by acidic leachate from the adjacent dump. However, the affected area is relatively small and does not appear to be increasing in area. Lane (2001) estimated that the area of vegetation affected was no more than one hectare.

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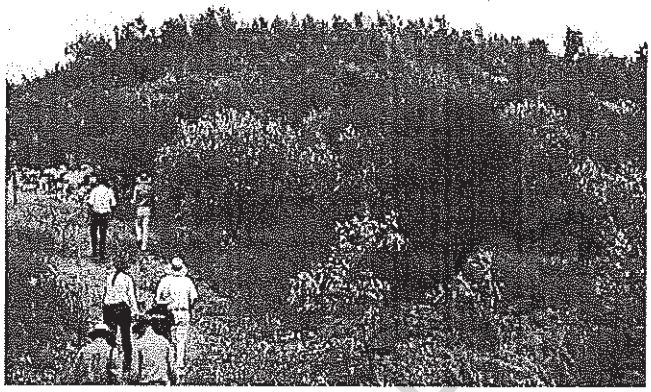

Plate 1: Vegetation Cover on Golden Butterfly Waste Rock Dump (February 2001)

The occurrence of a fire at Site 2 in 1998 provided an opportunity to examine the resilience of the newly established vegetation cover. Despite the trees and shrubs being severely impacted upon by the fire, these rapidly recovered and have continued to develop. This provides some assurance that the vegetation cover is self-sustaining and that it can recover after natural perturbations.

Plate 2: Vegetation Cover on Batter of Content Waste Rock Dump (February 2001)

The vegetation cover established by the revegetation program consists of local species and there are few weed species present. The only maintenance that has been required since 1996 is a program of weed control within the lease area that has concentrated on removal of isolated plants of Calotrope (*Calotropis procera*) (Plate 3). This weed species is ubiquitous in the Croydon area and it is likely that localised infestations will continue.

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Control of Calotrope on the lease area could be incorporated into any control programs initiated by the landholders. No other maintenance of the site is considered necessary.

Plate 3: Isolated Calotrope Plant on Golden Butterfly Waste Rock Dump

5.0 CONTAMINATED LAND ASSESSMENT

During the rehabilitation of the site in 1996, any areas with visible contamination such as acid drainage and hydrocarbons were excavated and the soil was buried in one of the open pits. This section provides details of the investigations undertaken at that time and the current status of the lease.

5.1 1996 Site Assessment

Environmental monitoring carried out within the site following Pancon's initial (1993) rehabilitation program (monitoring data reported in Woodward-Clyde, 1994 and 1996) indicated that these works were inadequate to achieve the rehabilitation objective as outlined in Section 1.0, with evidence of continuing acid drainage and erosion from the waste dumps. Upon acquisition of the controlling interest in Pancon, Goldfields commissioned a detailed site assessment to identify the nature and extent of the problem areas. This site assessment formed the basis for design and implementation of a revised and upgraded rehabilitation works program.

The scope of the site assessment was as follows:

(i) identification of acid producing materials within the existing waste dumps and identification of other visible areas of potentially acid producing material, including former ore stockpile and associated hardstand areas;

(ii) characterisation of surface and groundwater within the site, with particular emphasis on discharge from the southern portion of the lease; and

(iii) review of the existing environmental monitoring program currently in place for the tenement (contained within the 1993 Decommissioning Plan).

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The site assessment was carried out in December 1995 and April 1996 by Woodward-Clyde, on behalf of Goldfields.

A description of the methodology and results of these works is provided below.

5.1.1 Assessment Methodology

The purpose of this program was to identify the various rock types within the waste rock dumps and surrounding areas and, based on field and laboratory testing, to assess the acid producing potential of these materials.

The investigation was concentrated within areas that were known or suspected to contain acid producing materials. These areas were:

- Golden Butterfly waste rock dump and near surrounds; and
- Content waste rock dump and near surrounds.

The waste dump surrounds incorporate former hardstand and ore stockpile areas and drainage alignments which were potentially impacted by waste dump areas.

The program comprised excavation of 49 test pits within these areas. Materials recovered from each pit were geologically logged, and tested for pH and electrical conductivity (EC) in the field. Representative samples of each identifiable waste rock unit were collected for laboratory analysis. Analysis for total sulphur and acid neutralising capacity (ANC) was carried out on these samples for estimation of the maximum potential acidity (MPA) and net acid producing potential (NAPP).

Classification of the waste rock materials into three broad categories was undertaken using the three categories shown in Table 11.

Table 11: Classification of Waste Rock for Acid Drainage Potential

MPA : ANC Ratio	Net Acid Producing Potential
> 1:1 and total sulphur > 0.25%	Potentially Acid Producing
Between 1:3 and 1:1	Indeterminate
< 1:3 and total sulphur <0.25%	Non Acid Producing

Note: Where waste rock has been exposed to oxidisation, as in the case of the Croydon site, the testwork is unable to accurately gauge the degree to which the waste has already oxidised. As a result, sulphate oxidation products which are no longer acid producing are included in the maximum potential acidity. Therefore the net acid producing potential (NAPP) may be over estimated.

These categories, in conjunction with the field testing (pH and EC) results, were used to characterise the waste rock materials sampled during the investigation program.

5.1.2 Results of the Waste Rock Dump Assessment

Golden Butterfly Waste Dump

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The relationship between material type in the Golden Butterfly dump and acid producing potential is shown in Table 12.

Table 12: Relationship between Golden Butterfly Dump Rock Type and Acid Drainage Potential

Material	Potential for Acid Production
Red Sand/Sandstone	Indeterminate
White Granite	Indeterminate
Clay	Non Acid Producing*
Grey Granite	Potential Acid Producing

* Inferred classification - no confirmation testwork carried out.

The assessment indicates the profile within the waste dump comprises a surface soil layer (clay and red sand) overlying grey granite waste. At a number of sites, sandstone or white granite materials were encountered beneath the surface soils. These granites most likely originated from the Golden Butterfly North Pit and are scattered throughout the dump.

Content Waste Dump

The relationship between material type in the Content dump and acid producing potential is shown in Table 12.

Table 13: Relationship between Content Dump Rock Type and Acid Drainage Potential

Material	Potential for Acid Production
Brown Sandy Topsoil	Indeterminate
Red Gravelly Clay	Indeterminate
Grey Granite	Generally non acid producing but with some localised acid producing areas

The site investigation indicates the profile comprises a brown sandy topsoil layer overlying grey granite waste. Thin layers of red gravelly clay were encountered in some areas. Grey granite was found on the dump surface in a number of locations.

Other Areas

Waste rock characteristics within other parts of the lease were as follows:

Haul Road: Waste rock materials within the haul road comprised a mixture of granite, sand and red gravelly clay. The mixed waste material was considered to be potentially acid producing; however, due to the level of compaction within the haul road formation, these materials were effectively encapsulated.

Stockpile Area: The stockpile area comprised surficial red sand/sandstone overlying grey granite, similar to those encountered within the Golden Butterfly waste dump. The sand/sandstone were of indeterminate acid producing potential and the granites potentially acid producing.

Western Side of: This area was underlain generally by grey granite waste, similar to that

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Content Pit:	encountered within the Content dump. Therefore it was potentially acid producing
Drainage Channel:	This tributary of Slaughteryard Creek within the channel area, downstream from the Golden Butterfly waste dump, comprised red clay to brown sandy clay. This channel was considered to be an area of contamination due to acidic drainage from the waste dump. The soils themselves were, however, considered to be non acid producing.
North of Golden Butterfly Pit:	The natural soils encountered within this area were considered to be non-acid producing.

5.2 Site Rehabilitation Work

Following the site assessment, Goldfields and its consultants prepared rehabilitation options for each of the mining related landforms on the site. These options are shown in Table 14.

A further review of the options for each of the areas resulted in the development of the preferred rehabilitation plan that would achieve the objectives set by Goldfields. The selected actions are shown in Table 15.

Table 14: Rehabilitation Options Considered by Goldfields

Landform	Rehabilitation Option	
Waste Rock Dumps	(i)	Do nothing
	(ii)	Drainage redirection
	(iii)	Re-profiling and capping
	(iv)	Removal
Open Pits	(i)	Do nothing
	(ii)	Backfilling
Other Areas*	(i)	Do nothing
	(ii)	Removal

* Includes stockpile areas, haul road, western side of the Content dump, drainage channel and sandy area to the north of the Golden Butterfly pit

Table 15: Selected Rehabilitation Options

Landform	Selected Option
Waste Rock Dumps	Re-profiling and capping
Open Pits	Do nothing
Other Areas:	Removal of suspect material as follows:
Stockpile area	Remove
Haul road	Do nothing
Western side of Content pit	Remove
Drainage channel	Remove
North of Golden Butterfly pit	Do nothing

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5.2.1 Rehabilitation Specifications

The reasons for selecting these options and the specifications developed for each landform were as follows.

Waste Rock Dumps
The do nothing and drainage redirection options would not assist in compliance with the adopted rehabilitation objectives as acid drainage would continue to occur. Backfilling of the open pits with the waste rock dump material was the most expensive option and would not result in total removal of the dumps. Therefore the re-profiling and capping option was selected. Design features of this option were:

(i) Re-profiling works

Batter slopes to 3H:1V minimum, with benches of 5 metres width provided at a maximum of 50 metres vertical spacing.

(ii) Waste Dump Cover Configuration

As the site investigation and previous water quality monitoring showed there was potential for acid drainage to occur from the Golden Butterfly waste rock dump, Goldfields decided to rehabilitate the entire dump. The acid drainage potential from the Content waste rock dump was assessed by Woodward-Clyde to be lower and some of the dump surface had rehabilitation that was considered acceptable. Therefore, all but the western batter of the Content dump was proposed for rehabilitation. A two layer cap, with the specification shown in Table 16, was proposed for the waste rock dump rehabilitation work.

Table 16: Waste Rock Dump Cover Configuration

Layer	Surface	Batters
Capping layer	Clay fill - 600 mm thickness - permeability < 10^{-8} m/s*	Clay fill - 450 mm thickness - permeability < 10^{-8} m/s*
Surface protection layer	Rock fill - 400 mm thickness	Rock fill - 400 mm thickness

* Re-compacted to 98% of standard maximum dry density at –2% to +3% of optimum

Open Pits
Woodward-Clyde concluded that there was limited potential for net outward movement of Golden Butterfly pit water into the surrounding shallow groundwater system, although the impact on deeper aquifers was not assessed. Based on preliminary calculations they considered there was no risk of overtopping of the pits and therefore the "Do nothing" option was considered appropriate.

Other Areas
The site assessment identified areas that were potentially acid forming or that were contaminated by acid drainage. Woodward-Clyde considered it prudent that material from these areas that was considered suspect should be removed, leaving any other material in situ. Removal of material was to be on a visual basis, supported by occasional field pH measurements when considered appropriate.

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5.2.2 Upgraded Rehabilitation Works Program

The program of works developed by GOLDFIELDS and Woodward-Clyde comprised the following tasks:

- Golden Butterfly waste rock dump
  Clay fill capping and rock full surface protection of the entire waste rock dump surface, including construction of a key trench around the dump perimeter;
- Content waste rock dump
  Re-profiling of batter slopes (other than the western batter) with clay fill capping and rock fill surface protection of the entire dump surface; and
- Other lease area activities, including:
  - Removal of potentially acid producing waste rock within hardstand areas adjacent to the Golden Butterfly and Content waste rock dumps, with disposal of the excavated material to the adjacent open pits;
  - Removal of channel bed sediments within the reach of the Slaughteryard Creek tributary which drained the Golden Butterfly waste rock dump.

Miscellaneous rehabilitation works considered necessary to complement the major activities or to comply with specific background landholder requirements were:

- Backfill of open drill holes and removal of associated rubbish;
- Construction of surface drains and a pond to collect surface water drainage from the Content waste rock dump (for the purpose of surface water sampling);
- General site clean-up;
- Backfilling of open mine shafts; and
- Reclamation of between 10,000 and 15,000 m^3 of arsenopyrite-rich material from an area adjacent to the lease and controlled by Union Mining and placing in the Golden Butterfly open pit. This material was reclaimed because it appeared to be highly reactive and was producing acidic leachate that reported to locations that would be used for compliance monitoring of the rehabilitation works.

This rehabilitation program was undertaken between August 1996 and January 1997. A report on the works undertaken, prepared by CTPI 49-Sch4 the project superintendent, is attached as Appendix 1.

Following the earthworks, all areas were sown in February 1997 with a seed mix of native tree and shrub species (see Table 8) similar to those found in the surrounding native woodland communities.

5.3 Current Status of the Site

An evaluation of the monitoring program that was established to demonstrate the effectiveness of the rehabilitation work has been included in Section 4.3. The current status of the site with regard to contamination is summarised in this section.

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5.3.1 Open Pits

As outlined in previous sections, the primary contamination issue with the open pits is the presence of acidic water in the Golden Butterfly, Content and Lady Isabella pits. Each pit is surrounded by an earthen bund approximately 2 metres high and also a barbed wire fence to limit access by humans and grazing animals.

In order to assess the potential for the open pits to overflow, Goldfields commissioned HLA-Envirosciences Pty Limited (HLA) to undertake an evaluation of the likelihood of the pits overflowing in extreme weather conditions. A copy of the HLA report on this desktop study is attached as Appendix 5 and a summary of the conclusions is provided here.

HLA studied the Golden Butterfly pit as the monitoring data set was most complete for this site. HLA reached the following conclusions in this study:

> *Based on the above assumptions and calculations, it is unlikely that the pit would be overtopped in even the wettest year on record. The available data show that without groundwater inflow, the pit would lose water even in a wet year. The only conditions that may cause the pit to overtop would be a rise in the groundwater levels, equivalent to the top of the pit. In that case there would be water on the ground at other locations before it got to the top of the pit. Taking the worst case scenario that the pit water level will recover to the highest level recorded in the two boreholes, there would still be 3.7 metres of freeboard in the pit at the end of a 90 percentile wet season. All of these assumptions are based on the continued maintenance and integrity of the bunds around the pit ensuring that no surface runoff from the surrounding catchments can enter the pit.*

5.3.2 Waste Rock Dumps

The rehabilitation work on the Golden Butterfly waste rock dump has proven effective in eliminating the acid drainage that apparently occurred from this site, as demonstrated by the surface water monitoring program (Section 4.3.3). In addition, the good establishment of vegetation on the dump (see Plate 1) is demonstration of the continued integrity of the rehabilitation cover.

Although the rehabilitation work on most of the Content waste rock dump is also successful (see Plate 2), there has been surface and shallow groundwater expression of acid drainage that has resulted in some dieback of vegetation on the toe of the western batter of the dump (Plate 4) and the adjacent former hardstand area (Plate 5). The results of the vegetation monitoring at this site show that the revegetation was initially successful and that the plants died back at the same time that acid drainage was detected in late 1997 (see Figure 10: Tree Species Density at Monitoring Sites

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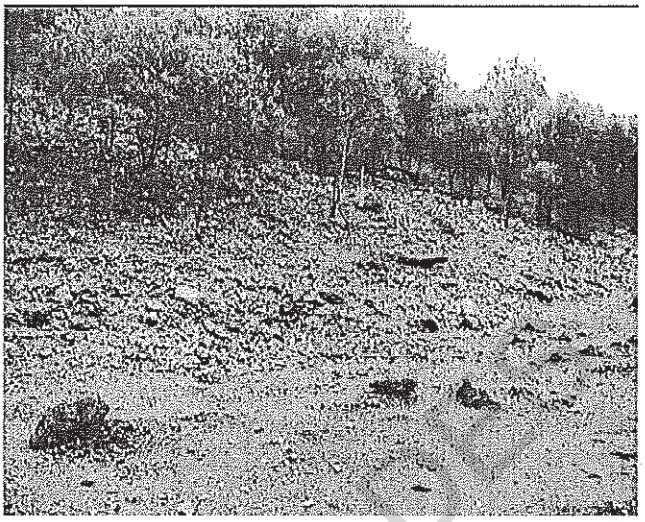

Plate 4: Lower Batter of Content Waste Rock Dump showing Effect of Acid Drainage

Since that time, the bare area on the waste rock dump has remained the same size, at less than 100 m^2 and the area of the adjacent scalded land has also remained relatively stable at less than 1 hectare. While the quality of water leaving this site is poor, it has not deteriorated over time and the downstream water quality has remained quite good (see Section 4.3.3).

It would appear that this small area of acid producing rock was identified during the 1996 site assessment but not considered for remediation because of the apparently successful rehabilitation of the western batter of the dump. Remediation of this site now would require extensive disturbance of the dump cover by stripping it back to the dump surface and installing an engineered cover at considerable cost and effort. Appropriate cover materials would have to be located and transported to the site, requiring further rehabilitation of the borrow area. Excavation of the dump surface could also result in further acid drainage being triggered in areas currently not affected. Given the relatively small area affected by the acid drainage, and the apparent chemical stability of the drainage, Goldfields considers that further remediation work on the Content waste rock dump is not warranted.

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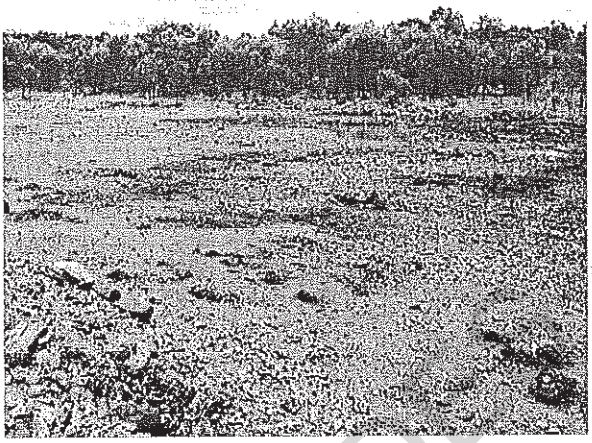

Plate 5: Former Hardstand Area adjacent to Content Waste Rock Dump

5.3.3 Other Areas

The rehabilitation work undertaken on other areas appears to have been successful and the monitoring shows no acid drainage occurring elsewhere on the site. Vegetation establishment has also been good and consistent with the surrounding vegetation (Plate 6).

Plate 6: Former Hardstand West of Golden Butterfly Open Pit

5.4 CONCLUSION

While contamination of the site resulting from acid drainage has not been totally removed, the remaining areas affected by acid drainage are either isolated from the public and livestock (the open pits) or relatively small and not expanding (part of the Content waste rock dump and hardstand area). These are considered not to provide a threat to future use of the site.

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The open pits are adequately fenced and bunded and will not be a threat to humans or animals so long as these protections remain intact. While three of the pits contain acid water, preliminary modelling has shown that the likelihood of overflow is extremely low.

HLA and Goldfields propose that the entire site be recorded on the Environmental Management Register as a former mining site.

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6.0 LANDHOLDER/LANDOWNER ISSUES

This section summarises the views of the landholders to the rehabilitation program and outlines Goldfields' position with regard to transfer of any residual liability for the mining lease area.

6.1 Landholder Requirements

Woodward-Clyde summarised the outcomes of discussions with the underlying landholders of the lease area, the Queensland Department of Lands (now the Department of Natural Resources and Mines) and Croydon Shire Council. These were as follows.

Queensland Department of Lands (DoL)

Landholder requirements were received in 1993 from the DoL Regional Operations Manager of Land Services, Cairns and were confirmed verbally in 1996. The desired post-mining land use as indicated by DoL is grazing. Specific rehabilitation requirements include the following:

- *That road areas be rehabilitated with natural vegetation cover using endemic species, apart from minimal access roads suitable for local usage. (The location of the access tracks should be ascertained by reference to CSC);*
- *DoL has no specific requirements with regard to fencing around reserves but advises that the replacement or maintenance of any fencing damaged/removed/erected in the mining process be reviewed in consultation with the landowners in the locality, with their legal boundaries taken into consideration;*
- *Areas used for grazing be revegetated with improved pasture;*
- *All foreign equipment and rubbish removed; and*
- *Suitable vegetation be established to control soil erosion where necessary.*

Croydon Shire Council (CSC)

Landholder preferences were received in October 1993 from CSC and revised following discussions in 1996. The desired post-mining land use as indicated by the CSC is Town Common with a portion of the site being allocated as town water supply catchment (with grazing being discouraged within these areas). In addition, the following specific requirements were indicated:

- *Maximisation of watershed catchment into Golden Butterfly North Pit (although CSC is not likely to require this resource again since the construction of a new water supply dam);*
- *Retention of access to Golden Butterfly North, Lady Isabella and Content pits; and*
- *Use of native tree species in the revegetation program.*

Further to these requirements, CSC has confirmed that restrictions to livestock access within the Town Common area would be continued. CSC would take responsibility for control of access through fencing, and maintenance as required.

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HLA has attempted to confirm these requirements by writing to the Department of Natural Resources and Mines (NR&M) and the Croydon Shire Council in March 2001 requesting completion of the Landowner/Landholder Statement required by the EPA. At the time of writing this report these statements had not been returned despite follow-up letters and telephone calls. The only response has been a letter from NR&M stating:

> *The area known as ML5248 appears to have been well revegetated, and all old mining equipment has been removed. However, there is an outstanding requirement to conduct a contaminated land assessment on the site to determine if contamination poses a threat to the future use of the site. On this basis, this Department cannot agree that the site has been adequately rehabilitated.*
>
> [Letter from CTPI 49-Sch4, District Manager, to HLA dated 14 May 2001]

This is a comment on the perceived adequacy of the rehabilitation rather than the landholder statement required by the EPA. HLA contacted NR&M in early June 2001 requesting completion of the Statement but this has not been received by either HLA or Goldfields.

6.2 On-going Commitments

Goldfields considers that the rehabilitation of ML5248 is complete and that the monitoring undertaken between 1996 and 2001 demonstrates that the rehabilitation objectives have been met. Therefore there are no management, maintenance or monitoring requirements beyond normal maintenance of fences and management of weeds that would normally be undertaken by a responsible landholder in the area.

6.3 Financial Assurance

Goldfields considers there is no requirement for continuation of the financial surety for ML5248 and applies for cancellation of this requirement.

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7.0 AUDIT STATEMENT

7.1 Introduction

Name of Auditor:	CTPI 49-Sch4
Qualifications/Experience:	MSc, FAusIMM (CPEnv) Senior Auditor in the Environmental Program, Quality Society of Australasia, CTPI 49-Sch4
Relationship to the EA Holder:	Consultant engaged by Goldfields as nominated Project Controller and to prepare the annual monitoring reports and Final Rehabilitation Report for ML5248
Date of Audit:	6 November 2001
Method of Audit:	Review of previous documentation relating the environmental management of ML5248; Review of monitoring data; Site Inspections; Discussions with representatives of Goldfields Limited; Preparation and review of the Final Rehabilitation Report.
Project Name:	ML 5248, Croydon Gold Mine

7.2 Audit Report

I have conducted an audit of documentation and evidence against commitments in the approved Plan of Operations and conditions of the EA for the Croydon Gold Mine and consider that these commitments have been met for this project.

The Final Rehabilitation Report that has been prepared for this project is accurate and reflects the current status of the site. Rehabilitation is complete and the completion criteria nominated in the 1996 (Amended) Decommissioning Plan for the site (the Plan of Operations) have either been met or are considered inappropriate for the site. I consider that there are no on-going monitoring requirements and that any maintenance required is no different to that normally undertaken on similar land in the region.

I consider that the financial surety held over ML5248 is no longer required and can be cancelled.

7.3 Conclusion

This Final Rehabilitation Report adequately summarises the rehabilitation that has been undertaken by the leaseholder and the current condition of the ML. All conditions of the Environmental Authority have been met.

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7.4 Certification

I, CTPI 49-Sch4 being aware that it is an offence under Section 171 of the Environmental Protection Act 1994 to provide false or misleading information, state that:

(i) I am authorised to sign on behalf of the person (meaning a corporation or individual) holding the Environmental Authority;
(ii) All information provided is true and complete; and
(iii) I understand that information given with this Final Rehabilitation Report and Audit Statement could become available to the public in accordance with the Freedom of Information Act 1992.

Signed ..... Date .....

CTPI 49-Sch4

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8.0 REFERENCES

ANZECC (1992). *Australian Water Quality Guidelines for Fresh and Marine Waters*. Australia and New Zealand Environment and Conservation Council, Canberra.

CSIRO Division of Wildlife and Ecology, Canberra, (1997). *Indicators of Ecosystem Rehabilitation Success and Selection of Demonstration Sites. LFA Survey of ERA Ranger Minesite*. Internal Report for CSIRO Minesite Rehabilitation Program.

ERA Environmental Services (1997). *Croydon Mine Revegetation Monitoring, May 1997*. Prepared for RGC Limited.

ERA Environmental Services (1998). *Croydon Mine Revegetation Monitoring, November 1997*. Prepared for RGC Limited, February 1998.

ERA Environmental Services (1999). *Croydon Mine Revegetation Monitoring, November 1998*. Prepared for RGC Limited, March 1999.

EWL (2000). *Croydon Mine Revegetation Monitoring, November 1999*. Prepared for Goldfields Limited by EWL Services Pty Limited, March 2000.

Fawcett Mine Rehabilitation Services Pty Limited (1998). *Croydon Site Inspection Report, May 1998*.

Fawcett Mine Rehabilitation Services Pty Limited (1999). *Croydon Site Inspection Report, April 1999*.

HLA-Envirosciences (2000). Croydon Gold Mine 1999-2000 Monitoring Report. Prepared for Goldfields Limited by HLA-Envirosciences Pty Limited, November 2000.

Tongway, D.J. and Ludwig, J.A., (1993). *Rehabilitation of Minesites and Pastoral Lands: The Ecosystem Approach*, in Proceedings. Green and Gold. Goldfields International Conference on Arid Landcare. 29 October-1 November 1993. A Kalgoorlie-Boulder Centenary Event 1893-1993.

Tongway, D.J. and Ludwig, J.A., (1997). *The Conservation of Water and Nutrients within Landscapes*, in Landscape Ecology Function and Management. Eds, J. Ludwig, D. Tongway, D. Freudenberger, J. Noble and K. Hodgkinson. CSIRO Publishing, Melbourne.

Woodward-Clyde (1993). *Pancontinental Mining Limited - ML 5248 Mine Decommissioning Plan*. Report No. 4371 December 1993.

Woodward-Clyde (1994). *ML 5248 Mine Decommissioning - Croydon 1994 Annual Inspection Report*. May 1994.

Woodward-Clyde (1996a). *Croydon Gold Mine (Amended) Decommissioning Plan for ML 5248*. Prepared for Pancontinental Mining Limited.

Woodward-Clyde (1996b). *Croydon Gold Mine 1996 Monitoring Report ML 5248*. Report No. 280/0005 October 1996.

Woodward-Clyde (1997). *Croydon Gold Mine 1997 Annual Monitoring Report*. Prepared for RGC Limited. Report A8601308\R042-C.

Woodward-Clyde (1998). *Croydon Gold Mine 1997-98 Annual Monitoring Report*. Prepared for RGC Limited. Report A8601308\R163-C.

Woodward-Clyde (1999). *Croydon Gold Mine 1998-99 Monitoring Report*. Prepared for Goldfields Limited. Report A8601308\R369-D.

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APPENDIX 1

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FAWCETT MINE REHABILITATION SERVICES PTY LTD

P.O.BOX 781, HOWARD SPRINGS, NT • 0835 • PH (08) 8988 1348 • FAX (08) 8988 1218
ABN 92 073 811 855

4 May, 2001

CTPI 49-Sch4
Goldfields Limited
Box R986
Royal Exchange Post Office
NSW 1225

cc: CTPI 49-Sch4 - HLA Envirosciences

Dear CTPI 4

Please find following a report on rehabilitation works undertaken at Croydon in 1996 and 1997. Fawcett Mine Rehabilitation Services Pty Limited (FMRS) acted as Project Superintendent on behalf of the lease owners Pancontinental. In addition CTPI 49-Sch4 acted as the Registered Mine Manager as required by Queensland mining legislation during the rehabilitation programme.

FMRS's range of responsibilities during this project were:

1. Supervise the contractor (Cardross P/L) on a daily basis to ensure that they conformed with the tender specifications.
2. Supervision and direction of the geotechnical contractors (Earthtech P/L).
    a. Earthtech were to have originally been employed by Cardross, however due to concerns over Cardross's proposed testing frequency and backcharge costs, they were employed directly by Pancontinental and directed by FMRS.
3. Approve variations from the contract as and when required.
4. Design, implement and supervise the revegetation programme.
5. Liaison with the Qld DME and local government officials during the execution of the project.

I was on site from the 27th of August 1996 until the 23rd of November 1996 (with the exception of the dates listed below) acting as Contract Superintendent and again between the 16th and 24th of January 1997 to undertake the revegetation programme.

During the period 27th of August 1996 until the 23rd of November 1996, I was off site at the following times:

20th to the 24th of September - during this period no earthworks were undertaken due to the original equipment fleet being demobilised and delays in sourcing replacements.

12th to the 16th of October. - during this period CTPI 49-Sch delegated for me and I remained in daily phone contact.

6th to the 13th of November.. - during this period CTPI 49-Sch delegated for me and I remained in daily phone contact.

The earthworks programme consisted of the following major components:

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1. Selection and development of a borrow pit as a source of capping material.

2. Stripping existing vegetation from the surfaces of Golden Butterfly and Content Waste Rock Dumps in preparation for capping. Minor reprofiling of the dumps surfaces.

3. Plugging open drillholes.

4. Backfilling historic shafts and associated minor workings within the lease area.

5. Stripping material affected by acidic leachate in the headwaters of Slaughteryard Creek adjacent to eastern toe of the Golden Butterfly WRD.

6. Construction of a haul road from the borrow pit on Belmore Station to the waste rock dumps.

7. Formation of drainage structures on both waste rock dumps - intermediate contour drains and drop structures.

8. Reclaiming of material from the Golden Butterfly hardstand area.

9. Reclaiming of material from the Content hardstand area.

10. Placement of a compacted clay cover over the entire surface of Golden Butterfly WRD.

11. Placement of a rock armour layer over the compacted clay layer placed on Golden Butterfly WRD.

12. Reshaping of the eastern batter of Content WRD to a 1V : 3H slope.

13. Placement of a compacted clay cover over all but the western batter of Content WRD.

14. Placement of a rock armour layer over the compacted clay layer placed on Content WRD.

15. Construction of a surface water control structure (SW 5) at the north-western corner of the lease.

16. Reduction in width of the original mine haul road between Content and Golden Butterfly from approximately 10 metres to 3 metres wide.

17. Removal of infrastructure used during the rehabilitation programme, ie:

    a. Haulroads.

    b. Rail crossing

    c. Heavy equipment servicing and laydown area.

    d. Used earthmoving tyres etc.

18. Additional out of scope earthworks undertaken included:

    a. Reclaiming some 10 to 15,000 m^3 of arsenopyrite rich material from an area adjacent to the lease and controlled by Union Mining. Reclaimed material was placed in the Golden Butterfly open pit. I felt it necessary to reclaim this material as it appeared to be highly reactive and was producing acidic leachate that reported to locations that would be used for compliance monitoring of the rehabilitation works.

19. All water used for construction purposes was sourced initially from Content open pit and

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subsequently from Lady Isabella open pit.

BORROW PIT

Previous site investigation work undertaken by Woodward-Clyde had located three potential clay borrow sources on Belmore Station. Approval was sought and received from the station owners CTPI 49-Sch4 to develop a borrow pit on their property.

An area of approximately 10 hectares was stripped of vegetation and sandy topsoil, this was located approximately 1.5 km west of Content WRD. The final surface area of the borrow pit was about 7 hectares and its depth varied from 2 metres in the southeast corner to about 5 metres in the northwest corner. As much as possible attempts were made to limit the surface area and maximise the depth of the pit in order to create a viable farm dam.

STRIPPING WASTE ROCK DUMP SURFACES

All vegetation was stripped from the surfaces of the waste rock dumps, stockpiled and burnt prior to earthworks commencing on either of them. In addition minor reprofiling to remove surface irregularities was then performed over both waste rock dumps. This work was done in accordance with the specifications set out in the tender.

DRILLHOLE PLUGGING

A number of open diamond drillholes were known to exist on the lease. These were rehabilitated in the following manner:

- PVC collar excavated to approximately 0.5 to 1.0 metres below surface.
- Hole plugged with a cast conical concrete plug.
- Excavation backfilled to surface and compacted using an excavator bucket.

From my recollection approximately 30 drillholes were located and plugged in the above manner.

BACKFILLING HISTORIC WORKINGS

All historic mine workings that were judged to be potential safety hazards to humans or fauna within the lease boundaries were located and backfilled. Backfilling was undertaken using a Caterpillar 950 loader. Typically spoil piles adjacent to the workings were used for the backfilling. Backfill was mounded up over the shaft to allow for potential slumping caused by consolidation of the backfill over time. Where there was a deficit of material, additional clean fill was sourced from the closest available source. Approximately 15 shafts were backfilled, they varied in depth from 2 metres to 10 metres.

STRIPPING AFFECTED MATERIAL IN SLAUGHTERYARD CREEK

Soils surrounding and the sediments in the upper section of Slaughteryard Creek adjacent to the southeastern end of Golden Butterfly WRD had become saturated with acidic seepage sourced from the WRD. This material was excavated and placed into Golden Butterfly open pit. Material to be removed was selected on the following basis:

1. Lateral extent of excavation was determined by vegetation impacts, ie; all material

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within the area not supporting a grass cover was assumed to be affected.

2. The vertical limit of excavation was determined by:

   a. In the creek line and immediate surrounds material was excavated to bedrock - this generally extended 1 to 2 metres either side of the original drainage line.

   b. Beyond the zone described in a. the excavation was tapered to daylight at the perimeter defined in1.

3. Any areas where salts formed after 1. and 2. had additional material removed.

4. A number of checks of soil pH were done on 1 in 5 slurries using test strips as a field check. Records of these tests were not kept.

A total of 16,093 m^3 of material was removed from this area. This work was performed using a 950 loader and 10 m^3 body trucks.

CONSTRUCTION OF HAULROAD

A haulroad was constructed from the borrow pit on Belmore Station to connect up with the existing haulroad between Content and Golden Butterfly. In addition a new sect of road was constructed to run along the western side of Golden Butterfly WRD. It was also necessary to construct a crossing over the Normanton to Croydon railway line capable of supporting heavy (100 tonne +) earthmoving machinery.

FORMATION OF DRAINAGE STRUCTURES

Tender specifications called for the construction of drainage berms and rock-lined drop structures on Golden Butterfly WRD and for a drainage channel on Content WRD. These were all constructed as per the specifications in the following manner:

1. Shape to the structure formed in the WRD either by excavation or fill as required.

2. Compacted clay layer placed with appropriate compaction and moisture content testing.

3. For the drop-structures a layer of woven geofabric was then placed over the compacted clay.

4. A layer of selected coarse armour rock was then placed over the geofabric.

RECLAIMING GOLDEN BUTTERFLY HARDSTAND

The former Golden Butterfly hardstand area was located immediately to the west of Golden Butterfly pit and extended west to Slaughteryard Creek. It consisted of an area that had been filled with waste rock to form a level surface on which a crushing plant had been located and ore stockpiled. Material was excavated from this area until the Superintendent was satisfied that the original ground surface had been exposed. The area was then graded to remove any remaining loose material.

During excavation three distinct layers of material were observed in the hardstand:

1. Coarse waste rock layer with a well compacted surface.

2. Red sand layer up to 0.5 metres thick.

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3. Coarse waste rock.

The thickness of material removed from the hardstand varied from a few centimetres along its eastern edge to approximately 2.5 metres at its western extremity. At the northern end of this area historic tailings were encountered so the area of excavation was expanded to remove this material as well. Material was excavated using a Komatsu PC650 (65 tonne) excavator, and hauled in two Komatsu HD 465 (50 tonne) off-highway dump trucks.

A total of 51,200 m^3 of material was removed from this area, compared with the provisional estimate provided in the tender documentation of 27,000 m^3.

RECLAIMING CONTENT HARDSTAND

The former Content hardstand area was located immediately to the west of Content Waste Rock Dump and extended approximately 100 m to the west. Similar to the Golden Butterfly hardstand, it consisted of an area that had been filled with waste rock to form a level surface on which a crushing plant had been located and ore stockpiled.

The tender specifications called for this material to be hauled to and dumped into the Golden Butterfly open pit. However, the followings changes were made at the Superintendent's direction (note material was identified as potentially acid forming - PAF - if it showed a paste pH <4/4.5 in a field test using indicator strips) :

1. The eastern face of Content WRD was at angle of repose, it was filled out to a batter slope of 1V : 3H prior to capping using PAF material from the hardstand. It was excavated and placed using Caterpillar 633 Scrapers. This required approximately 8,000 m^3 of material.

2. 23,500 m^3 of non-PAF material was identified and used to provide the rock armour used to cover Content WRD. Material was pushed up into large windrows (2 to 3 m high) using a D9 dozer, then loaded into 50 tonne off-highway dump trucks using a PC 650 excavator.

3. The remaining material (regardless of its properties) approximately 10,000 m^3 was hauled to and dumped into the Golden Butterfly open pit.

Material was excavated from the Content hardstand area until the Superintendent was satisfied that the original ground surface had been exposed.

A total of 44,950 m^3 of material was removed from this area, compared with the provisional estimate provided in the tender documentation of 25,000 m^3.

CLAY CAPPING GOLDEN BUTTERFLY WRD

The entire surface of Golden Butterfly WRD was covered with a compacted clay cover. The thickness of the cover varied depending on its location on the dump as per the tender specifications.

The contractor initially had significant difficulties meeting the tender specifications both for compaction as well as moisture content. Approximately the first 4000 m^3 of material laid failed to meet one or both of the specifications and had to be pulled up and relaid. Once the contractor had developed a technique for conditioning the clay in the borrow pit, no further problems complying with the moisture content requirements were encountered. Likewise once sufficient suitable compaction equipment arrived on site no further significant problems were met in achieving the required compaction.

Material was placed in layers with a nominal thickness of 300 mm prior to compaction. The

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surface of the dump or preceding layer was wet down prior to placing the next layer. Layer thickness was constantly inspected by the Superintendent and where excessive thickness (>400mm) was observed the contractor was instructed to cut it back before commencing compaction.

The compacted clay layer was tied into a cutoff keyway around the entire perimeter of the WRD. This keyway was excavated until solid bedrock was encountered or to a depth of two metres, whichever occurred first. The keyway was excavated to a minimum of 2.5 metres wide to allow a 633 Scraper to fit in it. Moisture conditioned clay was then placed in the keyway in layers and compacted to specification using an Ingersol Rand SP 100 compactor.

There was a rigorous programme of quality control maintained throughout the placement of the compacted clay layer with typically 10 to 15 measurements being taken per day which from my recollection equated to approximately one test per 200 m^3 of material placed. This compares with the testing density required by the tender specifications of one test per 2000 m^3.

ROCK ARMOURING GOLDEN BUTTERFLY WRD

The entire surface of the WRD was covered with a layer of benign rock armour placed on top of the compacted clay layer. This material consisted of bleached, lightly weather granite. This material had previously been identified as non acid forming and a number of field paste pH tests were undertaken during its excavation to confirm this. No records of the field pH tests were retained. The material was sourced from the northwestern corner of the WRD and appears to have originated from the excavation of Golden Butterfly North open pit.

Approximately 70,000 m^3 of rock armour was placed over the dump surface in layer thicknesses varying between 0.3 m and 0.45 m, depending on the contract specification. Rock armour was excavated by a PC 650 excavator, hauled by two 50 tonne off-highway dump trucks and spread using a Caterpillar D6H dozer.

RESHAPING EASTERN BATTER OF CONTENT WRD

The eastern face of Content WRD was at angle of repose, it was filled out to a batter slope of 1V : 3H prior to capping using PAF material from the hardstand. It was excavated and placed using Caterpillar 633 Scrapers and required approximately 8,000 m^3 of material to complete. Material was placed in layers of between 0.3 and 0.5 metres thick and spread and compacted using a Caterpillar 825.

CLAY CAPPING CONTENT WRD

All of the surface of Content WRD with the exception of the western batter, was capped with a compacted clay cover in the same manner as that used for Golden Butterfly WRD. Quality control testing to ensure that compaction and moisture content were within contract specifications was carried out at the same frequency as Golden Butterfly WRD.

ROCK ARMOURING CONTENT WRD

As stated in a preceding section, rock armour was sourced from identified non acid forming material excavated from the Content hardstand area. It was placed over the entire surface of the WRD, with the exception of the westem batter, which was considered to have been rehabilitated during the 1993 programme. Rock armour was placed to a minimum thickness of 0.45 m.

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CONSTRUCTION OF SW 5

A drainage control structure was constructed in the northwest corner of the lease. It consisted of two compacted bunds each about 300 metres long at right angles to each other meeting at the extreme northwest corner of the lease. At this point a pond approximately 25 metres by 25 metres square by 1.5 metres deep was excavated on the upstream side of the bunds. A spillway over the bunds was also constructed at this point. This structure has become SW 5 sampling point.

ADDITIONAL WORKS

A single stock-proof fence was erected around the Golden Butterfly Pit, Golden Butterfly North Pit, Golden Butterfly hardstand and Golden Butterfly WRD. This supplemented and encapsulated the existing fences around the two pits. A single stock-proof fence was also erected around the Content Pit, Lady Isabella Pit, Content hardstand and Content WRD. This supplemented and encapsulated the existing fences around the two pits.

A weed control programme was initiated to control infestations of Calotrope (*Calotropis procera*) observed around the southern end of Golden Butterfly WRD.

COSTS & VOLUMES

	Surface area - m^2	Volume of material moved - m^3	Cost
Golden Butterfly WRD			
Clearing dump surfaces	159,500		$5,775
Clearing borrow area	98,000		$2,754
Topsoil	90,000		$22,500
Cutoff key excavation		9,500	$17,100
Clay fill - Cutoff key		9,500	$38,950
- waste dump batters 0.45 m thick layer		94,000	$197,400
- waste dump batters 0.9 m thick layer		11,500	$34,500
- waste dump surfaces 0.3 m thick layer	24,000	7,200	$48,000
- waste dump surfaces 0.6 m thick layer	30,000	18,000	$75,000
Rock fill - waste dump batters 0.45 m thick layer	30,000	13,500	$63,000
- waste dump surfaces 0.3 m thick layer	24,000	7,200	$36,000
- waste dump surfaces 0.45 m thick layer	103,540	46,593	$207,080
Spill channels - excavate		1,960	$11,760
- rock fill		1,960	$5,880
Hardstand - excavate		51,200	$204,800
Content WRD			
Clearing dump surfaces	53,100		$1,858
Clay fill - waste dump surfaces 0.6 m thick layer	38,000	21,600	$76,000
- waste dump surfaces 0.45 m thick layer	15,100	6,795	$37,750

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	Surface area - m^2	Volume of material moved - m^3	Cost
Rock fill - waste dump batters 0.45 m thick layer	14,150	6,368	$28,300
- waste dump surfaces 0.45 m thick layer	38,000	17,100	$57,000
Spill channels - excavate		955	$5,730
- rock fill		955	$2,865
Hardstand - excavate		44,950	$179,800
Slaughteryard Creek - excavate		16,093	$48,279
Surface diversion & pond (SW 5)			$8,710
Backfill drillholes			$1,400
Backfill shafts			$3,050
Extra drainage works - east of Golden Butterfly WRD			$2,365
True Blue - reclaim rock containing arsenopyrite			$11,025
Additional clean up - Content			$446
Construct haulroads			$16,000
Mobilisation/demobilisation			$125,000
TOTAL		**386,932**	**$1,576,077**

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REVEGETATION

The revegetation programme was carried out between the 16th and 24th of January 1997. Direct seeding was used, sowing a selection of native tree species broadly representative of those found in the surrounding undisturbed woodlands. Seed was sourced from two commercial suppliers; Top End Seeds and Queensland Tree Seeds. Wherever possible seeds of local provenance were used. The Australian Trust for Conservation Volunteers provided volunteers to undertake the hand seeding programme.

The revegetation programme was designed by FMRS and based on proven techniques developed by them on other minesites.

Immediately prior to seeding all areas were ripped along contour by a Caterpillar D6H dozer using triple shank rippers to a depth of 250 to 300 mm. Some of the flat areas adjacent to the Content Waste Rock Dump were ripped using a Caterpillar 12H equivalent grader. The actual seeding took place over four days between the 20th and the 23rd of January. All ripped and seeded areas were aerial topdressed with an NPK fertiliser on the at a rate of 500 kg/ha on the 23rd of January.

SAFETY

Set out following are the safety statistics for the earthworks and revegetation programmes:

Earthworks

Estimated hours worked: 17,200

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Lost time injuries: Nil

First aid treatments: Nil

Notifiable incidents: Nil

One written direction regarding safety was made by the DME Mines Inspector during the project, this related to the inadequacy of the safety bund height on the tip-head into Golden Butterfly open pit. This occurred at the start of the project and was immediately rectified.

Revegetation

Estimated hours worked: 500

Lost time injuries: Nil

First aid treatments: Nil

Notifiable incidents: Nil

I have included as an appendix to this report a copy of the results of the test-work undertaken by Earthtech Laboratories (NQ) on this project. I have previously provided to CTPI 49-Sch4 a copy of the map showing the sample locations and test results for Golden Butterfly WRD, unfortunately the map showing test locations for Content WRD has been lost in the intervening years.

I confirm that all works during the rehabilitation programme were undertaken and completed in a professional and competent manner and that they complied with the specifications set out in the contract.

Yours sincerely,

CTPI 49-Sch4

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APPENDIX 2

Release

The following table is a summary of the status of Commitment Compliance at ML 5248.

COMMITMENT	COMPLIANCE STATUS	COMMENTS
Identify background landholder requirements regarding rehabilitation of ML 5248.	In compliance	Completed - detailed in the Decommissioning Plan.
Prepare and implement an upgraded and enhanced site environmental monitoring program.	In compliance	The environmental monitoring program is implemented.
Review environmental monitoring program annually in consultation with the DME to ensure the continued effectiveness of the program.	In compliance	Completed.
Golden Butterfly Waste Dump - Clay fill covering and rock fill surface protection of the entire waste dump surface and construction of a cut-off key around the dump perimeter.	In compliance	Completed November 1996.
Content Waste Dump - Reprofile batter slopes (other than western batter). Clay fill covering and rock fill surface protection of the entire waste dump surface.	In compliance	Completed November 1996.
Identify, remove and dispose of potentially acid producing material from the Golden Butterfly hardstand area.	In compliance	Completed November 1996.
Identify, remove and dispose of contaminated sediments in Slaughteryard Creek adjacent to the Golden Butterfly waste dump.	In compliance	Completed November 1996.
Revegetate waste dump surfaces, former hardstand areas and other disturbed areas with native woodland tree species.	In compliance	Seed planting completed January 1997.

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COMMITMENT	COMPLIANCE STATUS	COMMENTS
Revegetation performance will be monitored on an annual basis.	In compliance	First monitoring completed May 1997 and will continue to be monitored late in the dry season (November) of each year.
Generation of sediment will be limited by: (i) diversion of upstream runoff and, (ii) sediment traps will be constructed where necessary.	In compliance	Some works completed in 1993, remainder completed November 1996.
The effectiveness of sediment control measures will be monitored on a regular basis.	In compliance	Being inspected regularly by local representative.
Erosion monitoring on the waste dump surfaces will be undertaken on a regular basis.	In compliance	First monitoring completed May 1997 and monitoring continues late in the dry season (November) of each year.
Water monitoring of creek sites will be undertaken at the locations and on the frequencies detailed in the Water Monitoring Schedule for ML 5248.	In compliance	Monitoring has been undertaken close to the correct date since the sampling schedule was introduced.
Water quality at monitoring sites SW1, (Golden Butterfly catchment) & SW5 (Content/Lady Isabella catchment) will comply with ANZECC (1992) Water Quality Guidelines for livestock watering (cattle), or not exceed 115% of background whichever is greater. Background will be measured at sites SW3 & SW4.	Substantially in compliance ***[Note that this statement as included in the 1996 (Amended) Decommissioning Plan table is not consistent with statements in the text of the document]***	Water quality at SW1 was in compliance, however, many cadmium concentrations at SW5 were above the relinquishment criteria during the monitoring period. Note that the text of the 1996 Decommissioning Report specifies that SW1 is the nominated compliance point but that compliance is aimed at for SW2 and SW5.
Water quality monitoring within open pits will be undertaken at the locations and on the frequencies detailed in the Water Monitoring Schedule for ML 5248.	Substantially in compliance	Quarterly samples were not always collected at the beginning of the specified months, however, this has improved since the sampling schedule was introduced.

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COMMITMENT	COMPLIANCE STATUS	COMMENTS
Pit water quality monitoring data will be reviewed annually, with any deterioration analysed and possible related impacts assessed.	In compliance	Review undertaken in the Annual Monitoring Report.
Groundwater quality monitoring will be undertaken at the locations and on the frequencies detailed in the Water Monitoring Schedule for ML 5248.	Substantially in compliance	Samples were not always collected at the beginning of the specified months.
GBMB series groundwater monitoring bores - maintain water quality within the range of water quality data collected for these bores over the period 1990 to 1993.	Not in compliance	Some GBMB bores have continual exceedances of the relinquishment criteria. However, the stated criteria are very strict and the water has no beneficial use.
BH series groundwater monitoring bores - water quality monitoring data will be reviewed annually, with any deterioration analysed and possible related impacts assessed.	In compliance	Review undertaken in the Annual Monitoring Report.
Monitoring data will be collated, interpreted and reported to the DME on an annual basis together with an audit of compliance status against commitments.	In compliance	Annual Monitoring Report
An annual lease inspection will be carried out by Goldfields	In compliance	The last lease inspection was undertaken in December 2000 by Goldfields staff.
Where practicable runoff water will be diverted away from voids via diversion bunds.	In compliance	Completed.
Safety bunding and fencing will be erected around open pits.	In compliance	Completed.

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COMMITMENT	COMPLIANCE STATUS	COMMENTS
Warning signs will be placed in strategic sites around the lease.	In compliance	Completed.
Abandoned shafts will be identified and backfilled.	In compliance	Completed November 1996.
Exploration drill holes will be located, plugged and covered over.	In compliance	Completed November 1996.
The lease will be monitored for the outbreak of noxious weeds, any outbreaks will be controlled by DPI recommended methods.	In compliance	Regular inspections are being carried out by Fawcett Mine Rehabilitation Services and Jim Willis.
Submit to the DME a Final Rehabilitation Report.	In compliance	This document is the Final Rehabilitation Report.

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APPENDIX 3

Release

The complete set of relinquishment criteria for ML 5248 is provided in the table below.

Category	Location	Parameters	Relinquishment Criteria
Surface Water	SW Series	pH, TDS, EC, Calcium, Magnesium, Sodium, Sulphate, Arsenic, Cadmium Copper, Iron, Lead, Manganese, Nickel, Zinc	Livestock watering guidelines - beef cattle (ANZECC, 1992) or 115% of background surface water quality.
	Open pits	pH, TDS, EC, Calcium, Magnesium, Sodium, Sulphate, Arsenic, Cadmium Copper, Iron, Lead, Manganese, Nickel, Zinc	No criteria
Groundwater	GBMB Series Bores	pH, TDS, EC, Calcium, Magnesium, Potassium, Sodium, Sulphate, Chloride, Arsenic, Cadmium, Copper, Iron, Lead, Manganese, Nickel, Zinc	Maintain existing water quality measured during the period 1990 to 1993.
	BH Series Bores	pH, TDS, EC, Sulphate, Iron	No criteria
Vegetation	Golden Butterfly and Content Waste Dumps and adjacent revegetated areas	• Landscape Function Analysis (LFA)	• Capture and decomposition of leaf litter is occurring • Vegetation structural complexity trending towards control sites • Vegetation compositional complexity trending towards control sites • Habitat complexity trending towards control sites
		• Vegetation Measures – Species richness – Species frequency – Species density – Growth rate	• No criteria
Erosion	Golden Butterfly and Content Waste Dumps	• LFA SSCC – surface stability – infiltration – nutrient cycling	• trending towards control site
		• Integrity of bank and trough systems on waste dump sloping	• Maintained
		• Erosion stability and depth	• Erosion depth not > 300 mm

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The following table is part of the relinquishment criteria for the SW Series.

Summary of ANZECC (1992) Livestock Watering Guidelines

PARAMETER	SYMBOL	UNIT	CRITERION
pH	pH	-	NGR
Electrical Conductivity	EC	µS/cm	NGR
Total Dissolved Solids	TDS	mg/L	4000
Sodium	Na	mg/L	NGR
Calcium	Ca	mg/L	1000
Magnesium	Mg	mg/L	600
Sulphate	SO_4	mg/L	1000
Arsenic	As	mg/L	0.5
Cadmium	Cd	mg/L	0.01
Copper	Cu	mg/L	5
Iron	Fe	mg/L	NGR
Lead	Pb	mg/L	0.1
Manganese	Mn	mg/L	NGR
Nickel	Ni	mg/L	1.0
Zinc	Zn	mg/L	20

Notes:
NGR = No guideline recommended

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The following table is the lease relinquishment criteria for groundwater (GBMB Series bores only).

GBMB Series Bore Monitoring 1990 to 1993

PARAMETER	UNITS	GBMB1	GBMB2	GBMB3	GBMB4	GBMB5	GBMB6
pH	-	3.6-6.15	7.3 - 8.15	6.65-7.25	5.95-6.5	5.6-6.95	5.85-6.85
Total Dissolved Solids (TDS)	mg/L	390-520	1290-2040	280-500	150-240	40-100	110-150
Electrical Conductivity (EC)	µS/cm	590-610	1970-2040	410-445	190-225	68-73	98-305
Sodium	mg/L	17-91	350-400	72-76	27-31	9.3-11	7-14
Sulphate	mg/L	170-240	500-580	11-110	11-65	0.8-7.9	2.8-22
Chloride	mg/L	7-55	190-370	107-130	13-42	11-30	16-26
Arsenic	mg/L	0.01-0.06	0.03-0.07	0.01-0.04	0.02	0.01-0.02	0.01-0.06
Cadmium	mg/L	<0.01-0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	mg/L	0.01-0.05	<0.01	0.01	<0.01	<0.01	<0.01
Iron	mg/L	2.1-6.2	1-1.8	1.8-3.7	2.2-2.6	1.3-3.6	1.7-2.9
Lead	mg/L	0.08-0.23	0.12-0.70	0.02-0.54	0.07-0.16	0.12-0.24	0.05-0.18
Manganese	mg/L	0.45-0.55	0.44-0.68	0.05-1.3	<0.01 -0.04	<0.01 -0.04	<0.01 -0.03
Zinc	mg/L	0.04-0.34	0.02-0.15	<0.01 -0.24	<0.01 -0.45	0.05-0.19	0.03-0.18

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APPENDIX 4

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Analyte	Units	28-Jan-1996	6-Dec-1996	31-Dec-1996	28-Feb-1997	1-Dec-1997	31-Dec-1997	15-Jan-1998	31-Jan-1998	15-Feb-1998	1-Mar-1998	15-Mar-1998
GENERAL												
Electrical Conductivity	uS/cm				370	110	260	140	250	160	150	180
pH	units	3.9	5.1	6.3	5	7.9	6.1	6.8	7	6.7	6.6	6.9
TDS	mg/L	300	110	100	200	150	180	100	150	140	110	130
MAJOR-IONS												
Calcium	mg/L	6.8	3.7	3.4	12	4.3	9.3	4.3	4.4	4.7	3.4	3
Magnesium	mg/L	7.4	2	1.8	7	1.9	4.1	2.8	2.7	2.8	2.1	2.4
Nitrate as N	mg/L	0.58	1.8	0.39								
Nitrite as N	mg/L	<0.002	0.017	0.28								
Oxidised Nitrogen	mg/L		1.8	0.67								
Sodium	mg/L				40	8.6	29	14	32	18	18	22
Sulphate	mg/L	200	33	17	190	27	76	32	62	43	36	44
METALS												
Arsenic	mg/L	<0.02	<0.02	<0.02	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.0051	<0.0005	0.0024	0.0019	<0.0005	0.0009	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper	mg/L	0.38	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	1.9	5	3.5	0.08	2.5	0.13	1.5	0.68	2.2	0.64	0.97
Lead	mg/L	<0.005	0.022	0.013	<0.002	0.015	<0.002	0.005	<0.002	0.007	0.003	0.003
Manganese	mg/L		0.37	0.14	0.92	0.09	0.58	<0.05	<0.05	0.09	0.09	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005								
Molybdenum	mg/L	<0.1	<0.05	<0.05								
Nickel	mg/L	0.13	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.45	0.08	<0.05	0.28	<0.05	0.15	0.05	<0.05	0.06	<0.05	<0.05

Analyte	Units	1-Jan-1999	15-Jan-1999	15-Feb-1999	1-Mar-1999	15-Jan-2000	15-Feb-2000	29-Feb-2000	15-Dec-2000	4-Jan-2001	15-Feb-2001	1-Mar-2001	15-Mar-2001	1-Apr-2001
GENERAL														
Electrical Conductivity	uS/cm	110	100	320	150	190	170	200	140	180	190	200	140	160
pH	units	6.8	6.8	7.2	6.8	6.5	6.7	6.8	6.2	7.5	7.3	7.5	7.2	7.5
TDS	mg/L	98	100	220	120	160	140	170	170	220	140	170	100	140
MAJOR-IONS														
Calcium	mg/L	3.3	1.9	7.4	2.6	3.5	1.9	4.6	2.9	4.1	3.8	3.8	2.7	2.2
Magnesium	mg/L	1.7	1.4	4.2	1.8	2.3	1.4	2.7	1.7	2.7	2.6	3	2	1.8
Nitrate as N	mg/L													
Nitrite as N	mg/L													
Oxidised Nitrogen	mg/L													
Sodium	mg/L	12	12	39	18	21	17	29	17	30	27	30	21	21
Sulphate	mg/L	22	25	79	33	50	32	48	32	44	46	44	28	27
METALS														
Arsenic	mg/L	0.008	<0.005	0.008	0.007	0.005	0.008	0.012	0.007	0.026	0.029	0.033	0.021	0.019
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	2.3	0.4	1.2	0.72	1.4	1.6	1.2	0.77	1.3	2.7	1.9	1.7	1.8
Lead	mg/L	0.004	0.004	<0.001	0.004	0.003	0.003	0.002	0.005	0.002	0.003	0.002	0.003	0.002
Manganese	mg/L	0.11	<0.05	0.31	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	0.06	<0.05	0.07	<0.05
Mercury	mg/L													
Molybdenum	mg/L													
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.034	0.02	0.065	0.016	0.029	0.01	<0.005	0.034	0.009	0.024	0.013	0.013	0.009

Values shaded [ ] are above the completion criterion but less than twice the value

Values shaded [ ] are more than twice the completion criterion

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Analyte	Units	28-Jan-1996	5-Mar-1996	6-Nov-1996	6-Dec-1996	31-Dec-1996	28-Feb-1997	31-Dec-1997	15-Jan-1998	31-Jan-1998	15-Feb-1998	1-Mar-1998	15-Mar-1998
GENERAL													
Electrical Conductivity	uS/cm						1000	520	240	420	190	250	190
pH	units	2.8	3.8	6.2	3.9	4	4	4.2	4.2	4.3	5.2	4.6	4.8
TDS	mg/L	1040	9300	900	490	350	690	340	100	260	150	160	130
MAJOR-IONS													
Calcium	mg/L	13.1	78	34	23	21	33	21	10	15	6.9	8.7	8.6
Magnesium	mg/L	27	224	14	19	11	29	12	5.8	8.6	3.7	4.7	3
Nitrate as N	mg/L	0.94	0.06	1.2	1.6	1.3							
Nitrite as N	mg/L	<0.002	0.021	0.024	<0.002	0.014							
Oxidised Nitrogen	mg/L		0.08	1.2	1.6	1.3							
Sodium	mg/L						78	46	15	37	16	21	15
Sulphate	mg/L	950	9600	620	340	220	570	220	76	170	57	75	66
METALS													
Arsenic	mg/L	0.05	0.5	<0.02	<0.02	<0.02	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.024	0.18	0.0045	0.0051	0.0076	0.01	0.0042	0.0028	0.0023	0.0014	0.0016	0.0009
Copper	mg/L	2.06	22	<0.05	0.31	0.13	0.45	0.09	0.1	0.09	<0.05	0.05	<0.05
Iron	mg/L	23	197	<0.05	0.6	<0.05	0.12	<0.05	0.12	0.12	0.19	0.12	0.08
Lead	mg/L	<0.005	<0.1	<0.005	<0.005	<0.005	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese	mg/L			1.7	3.1	2	4.8	2	0.72	0.88	0.61	0.78	0.33
Mercury	mg/L	<0.0005	0.001	<0.0005	<0.0005	<0.0005							
Molybdenum	mg/L	<0.1	<0.1	<0.05	<0.05	<0.05							
Nickel	mg/L	0.66	7.2	0.07	0.27	0.14	0.29	0.1	0.06	<0.05	<0.05	0.05	<0.05
Zinc	mg/L	2.2	19	<0.05	0.7	0.44	1.3	0.69	0.62	0.56	0.25	0.45	0.4

Analyte	Units	1-Jan-1999	15-Jan-1999	15-Feb-1999	1-Mar-1999	15-Mar-1999	15-Feb-2000	29-Feb-2000	15-Dec-2000	15-Feb-2001	1-Mar-2001	15-Mar-2001	1-Apr-2001
GENERAL													
Electrical Conductivity	uS/cm	400	180	570	360	310	170	190	200	110	110	100	140
pH	units	4.7	6.8	4.4	4.6	6.5	6.8	6.6	6.4	6.7	7.2	7.3	6.9
TDS	mg/L	260	130	400	240	220	260	170	300	200	150	120	130
MAJOR-IONS													
Calcium	mg/L	17	3.9	22	11	12	3.2	4.9	4.3	2.3	5.2	2.6	2.6
Magnesium	mg/L	7.4	2.8	12	7	6.4	2.5	3.3	2.9	1.4	3.3	1.8	1.8
Nitrate as N	mg/L												
Nitrite as N	mg/L												
Oxidised Nitrogen	mg/L												
Sodium	mg/L	45	22	51	32	33	21	25	30	15	20	16	17
Sulphate	mg/L	140	49	260	140	120	51	68	63	42	58	32	42
METALS													
Arsenic	mg/L	<0.005	<0.005	0.008	<0.005	0.005	0.01	0.006	0.009	0.015	0.014	0.016	0.015
Cadmium	mg/L	0.0018	0.0003	0.0045	0.0044	0.0005	<0.0002	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	0.2	0.13	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.13	0.14	0.63	0.23	0.19	0.76	0.51	1.8	0.55	0.71	1	1.2
Lead	mg/L	<0.001	<0.001	<0.001	<0.002	<0.002	0.003	<0.002	0.005	0.004	<0.002	0.003	<0.002
Manganese	mg/L	1.3	0.36	3.1	1.7	0.82	0.19	0.23	0.06	0.06	<0.05	<0.05	<0.05
Mercury	mg/L												
Molybdenum	mg/L												
Nickel	mg/L	0.08	<0.05	0.16	0.11	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.31	0.024	0.98	0.67	0.12	0.031	0.031	0.046	0.033	0.027	0.027	0.016

Values shaded [ ] are above but less than twice the completion criterion

Values shaded [ ] are more than twice the completion criterion

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Analyte	Units	28-Jan-1996	5-Mar-1996	6-Dec-1996	31-Dec-1996	28-Feb-1997	31-Dec-1997	15-Jan-1998	31-Jan-1998	15-Feb-1998	1-Mar-1998	15-Mar-1998	1-Apr-1998
GENERAL													
Electrical Conductivity	uS/cm					120	150	78	92	100	90	69	100
pH	units	6.6	6.5	6	6.5	6.4	6.6	6.3	8.7	7.1	6.6	7.8	6.9
TDS	mg/L	130	140	130	150	80	200	83	64	120	81	72	90
MAJOR-IONS													
Calcium	mg/L	2.5	4.3	2.4	3.7	2.4	4.6	2.7	2.5	2.4	1.8	<0.5	2.7
Magnesium	mg/L	1.9	1.9	1.5	1.7	1.9	2.4	2.2	1.1	1.4	1.2	<0.5	1
Nitrate as N	mg/L	1.4	0.98	0.82	0.34								
Nitrite as N	mg/L	0.009	0.016	0.017	0.037								
Oxidised Nitrogen	mg/L		1	0.84	0.38								
Sodium	mg/L					16	18	8.1	11	13	11	10	12
Sulphate	mg/L	35	53	20	36	39	40	15	16	22	26	13	21
METALS													
Arsenic	mg/L	<0.02	<0.02	<0.02	<0.02	<0.01	<0.005	0.007	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.0006	<0.0005	<0.0005	0.0008	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.84	1.53	6.5	1.5	0.2	0.92	0.94	2.2	2.6	1.3	0.88	0.31
Lead	mg/L	<0.005	<0.1	0.006	0.006	<0.002	0.004	<0.002	<0.002	0.002	<0.002	<0.002	<0.002
Manganese	mg/L			<0.05	0.09	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005								
Molybdenum	mg/L	<0.1	<0.1	<0.05	<0.05								
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Analyte	Units	1-Jan-1999	15-Jan-1999	15-Feb-1999	1-Mar-1999	15-Feb-2000	29-Feb-2000	15-Dec-2000	1-Mar-2001	15-Mar-2001
GENERAL										
Electrical Conductivity	uS/cm	61	57	170	100	240	120	66	100	84
pH	units	6.5	6.7	7.2	6.9	6.7	6.9	6.4	7.6	7.5
TDS	mg/L	89	110	210	140	240	130	130	130	110
MAJOR-IONS										
Calcium	mg/L	0.97	0.91	2.1	1.2	5.5	2.3	1	2.4	2.1
Magnesium	mg/L	0.92	0.72	1.5	0.98	4.9	2	0.7	1.5	1.5
Nitrate as N	mg/L									
Nitrite as N	mg/L									
Oxidised Nitrogen	mg/L									
Sodium	mg/L	7.8	7	25	14	26	15	8.7	16	17
Sulphate	mg/L	14	15	36	27	76	36	22	21	21
METALS										
Arsenic	mg/L	<0.005	<0.005	0.023	<0.005	<0.005	<0.005	<0.005	0.009	0.012
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.69	0.49	4.6	1.6	0.26	0.95	0.63	1.9	3.2
Lead	mg/L	0.003	0.003	0.001	0.002	<0.002	<0.002	0.008	0.002	<0.002
Manganese	mg/L	<0.05	<0.05	<0.05	<0.05	0.28	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L									
Molybdenum	mg/L									
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.014	0.017	0.017	<0.005	0.007	<0.005	0.02	0.008	0.008

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Croydon Monitoring
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Table A4-4: Site SW3A

Analyte	Units	28-Jan-1996	5-Mar-1996	30-Mar-1996	3-May-1996	6-Dec-1996	28-Feb-1997	15-Jan-1998	1-Mar-1998	15-Jan-1999	15-Feb-1999	15-Feb-2000
GENERAL												
Electrical Conductivity	uS/cm						1400	830	710	460	2300	86
pH	units	2.5	2.8	2	1.7	4	4.2	4.3	4.5	5.4	4.3	6.9
TDS	mg/L	1570	11300	26000	120000	560	1100	560	510	320	2100	100
MAJOR-IONS												
Calcium	mg/L	11	41	45	4250	29	45	29	21	16	100	0.5
Magnesium	mg/L	25	184	350	3400	27	60	27	25	15	93	0.8
Nitrate as N	mg/L	0.19	0.52	0.43	0.22	1.5						
Nitrite as N	mg/L	0.002	0.015	0.02	0.044	0.014						
Oxidised Nitrogen	mg/L		0.54	0.45	0.26	1.5						
Sodium	mg/L						120	79	69	50	280	12
Sulphate	mg/L	1450	10600	18200	240	420	880	370	280	190	1300	22
METALS												
Arsenic	mg/L	0.4	5.4	12.5	80	<0.02	<0.01	<0.005	<0.005	<0.005	0.005	0.005
Cadmium	mg/L	0.037	0.18	0.295	4.4	0.0063	0.017	0.0079	0.005	0.0034	0.035	<0.0002
Copper	mg/L	3.66	26	56	340	0.23	0.49	0.11	0.17	<0.05	0.34	<0.05
Iron	mg/L	90	630	1100	4850	0.52	<0.05	0.09	0.12	<0.05	0.14	0.56
Lead	mg/L	<0.005	<0.1	<0.05	<0.05	0.005	0.004	<0.002	<0.002	<0.001	0.004	<0.002
Manganese	mg/L				380	3.6	8.1	2.7	2.6	1.3	10	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005						
Molybdenum	mg/L	<0.1	<0.1	<0.1	<0.1	<0.05						
Nickel	mg/L	0.91	6.3	13	80	0.29	0.4	0.19	0.19	<0.05	0.49	<0.05
Zinc	mg/L	2.7	18	42	235	0.58	0.96	0.36	0.44	0.06	0.89	0.007

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Analyte	Units	3-May-1996	30-Jun-1996	1-Aug-1996	2-Sep-1996	30-Oct-1996	30-Nov-1996	31-Dec-1996	28-Feb-1997	31-Mar-1997	4-Oct-1997	1-Dec-1997	15-Dec-1997	31-Dec-1997	15-Jan-1998	31-Jan-1998	15-Feb-1998	1-Mar-1998	15-Mar-1998	1-Apr-1998
GENERAL																				
Electrical Conductivity	uS/cm								150	160	820	330	300	120	56	99	79	82	84	100
pH	units	7.3	7.8	7.6	8.3	7.5	7	6.8	6.6	6.8	7.9	7.5	7.5	6.7	6.2	7.3	7	6.6	7.1	7.1
TDS	mg/L	190	210	270	410	530	300	290	170	190	600	430	440	250	83	70	120	89	78	91
MAJOR-IONS																				
Calcium	mg/L	6.7	9.5	10	15	22	12	7.9	4.3	4.3	18	6.6	6.5	4.2	2.6	2.8	2.8	2	1.7	3.5
Magnesium	mg/L	3.5	4.3	5	6.8	8.6	5	3.4	3.1	2.2	8.9	3.3	3.2	1.7	2	1.7	1.5	1.4	1	1.7
Nitrate as N	mg/L	0.23	0.05	<0.05	<0.05	0.05	0.76	0.57												
Nitrite as N	mg/L	0.037	0.016	0.002	<0.005	0.013	0.04	0.12												
Oxidised Nitrogen	mg/L	0.27	0.07	<0.05	<0.05	0.06	0.8	0.69												
Sodium	mg/L								19	23	130	45	38	16	5.4	11	9	10	10	12
Sulphate	mg/L	58	76	72	78	170	140	68	66	73	260	88	72	36	14	20	20	22	19	21
METALS																				
Arsenic	mg/L	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	<0.01	<0.01	0.01	<0.005	0.007	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	0.005
Cadmium	mg/L	<0.0005	<0.0005	<0.0005	0.0008	<0.0005	<0.0005	0.003	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.8	0.87	0.15	0.5	1.3	0.76	2.7	0.38	0.5	1.5	1.1	0.98	0.41	0.47	1.5	1.9	0.92	0.34	0.34
Lead	mg/L	<0.05	<0.05	<0.05	<0.05	<0.005	<0.05	0.006	0.002	0.003	0.003	0.008	0.008	0.004	0.005	0.002	0.007	0.002	<0.002	<0.002
Manganese	mg/L	<0.05	<0.05	0.05	<0.05	0.13	0.18	0.12	<0.05	<0.05	0.58	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005												
Molybdenum	mg/L	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.05												
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.14	<0.05	0.08	<0.05	0.16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Analyte	Units	21-Sep-1998	1-Dec-1998	1-Jan-1999	15-Jan-1999	31-Jan-1999	15-Feb-1999	1-Mar-1999	15-Mar-1999	1-Apr-1999	15-Apr-1999	1-Jan-2000	15-Jan-2000	1-Feb-2000	15-Feb-2000	29-Feb-2000	15-Mar-2000
GENERAL																	
Electrical Conductivity	uS/cm	420	410	160	93	110	130	120	140	140	150	130	100	120	130	120	130
pH	units	8.4	8.5	7.3	7.1	7.2	7.3	6.9	9.2	8.9	7.9	6.7	7	9.3	7	7	7.9
TDS	mg/L	270	400	220	150	190	180	140	140	140	130	220	190	190	170	130	130
MAJOR-IONS																	
Calcium	mg/L	12	10	3	1.7	1.7	2.8	2	2.2	2.5	3.1	2.7	1.2	1.8	2.3	2.8	2.4
Magnesium	mg/L	5	5.2	2	1.3	1.5	1.3	1.4	1.4	1.8	2	1.7	1.3	1	1.5	1.5	1.8
Nitrate as N	mg/L																
Nitrite as N	mg/L																
Oxidised Nitrogen	mg/L																
Sodium	mg/L	60	71	24	14	14	17	16	18	20	22	20	13	17	18	16	18
Sulphate	mg/L	73	96	31	22	24	30	27	36	36	39	30	28	33	33	35	27
METALS																	
Arsenic	mg/L	0.011	0.016	0.005	<0.005	0.01	0.012	<0.005	0.012	0.017	0.014	0.006	0.007	0.014	0.015	<0.005	0.011
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.52	1.3	1.3	0.69	3.8	2.2	0.8	0.59	0.76	1.1	1	1.2	0.72	0.69	0.66	0.81
Lead	mg/L	<0.001	0.003	0.005	0.003	0.003	0.001	<0.002	0.006	0.004	0.004	0.003	0.003	0.002	<0.002	<0.002	<0.002
Manganese	mg/L	<0.05	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07	<0.05	<0.05	<0.05
Mercury	mg/L																
Molybdenum	mg/L																
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.007	0.013	0.03	0.015	0.2	0.013	0.005	0.009	0.006	0.012	0.022	0.037	0.016	0.01	<0.005	0.028

Analyte	Units	1-Apr-2000	1-Dec-2000	15-Dec-2000	4-Jan-2001	15-Jan-2001	1-Feb-2001	15-Feb-2001	1-Mar-2001	15-Mar-2001	1-Apr-2001	15-Apr-2001
GENERAL												
Electrical Conductivity	uS/cm	150	390	160	120	170	170	73	86	88	100	110
pH	units	8.6	7.2	6.5	6.8	8.6	8.3	7.1	7.3	7.5	7.4	7.4
TDS	mg/L	140	660	320	270	260	230	140	130	110	130	140
MAJOR-IONS												
Calcium	mg/L	2.7	7.9	3.2	2.8	3.1	3.3	1.5	2.5	2	1.4	1.5
Magnesium	mg/L	1.9	5.2	2.2	1.8	2	2.1	0.9	1.8	1.5	1	1.3
Nitrate as N	mg/L											
Nitrite as N	mg/L											
Oxidised Nitrogen	mg/L											
Sodium	mg/L	21	65	25	21	28	28	10	14	15	14	14
Sulphate	mg/L	32	110	45	43	43	43	23	25	22	20	23
METALS												
Arsenic	mg/L	0.017	0.018	0.008	0.01	0.013	0.013	0.01	0.01	0.011	0.009	0.01
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.63	6.4	2.4	1.6	1.6	1.6	0.55	1.1	0.96	1.2	1.7
Lead	mg/L	<0.002	0.008	0.006	0.003	0.002	<0.002	0.002	0.003	0.003	0.003	0.002
Manganese	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05
Mercury	mg/L											
Molybdenum	mg/L											
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.024	0.02	0.01	0.01	0.031	0.006	0.014	0.014	0.032	0.026	<0.005

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Croydon Monitoring
Water Quality Results

Analyte	Units	6-Dec-1996	31-Dec-1996	28-Feb-1997	31-Mar-1997	1-Dec-1997	15-Dec-1997	31-Dec-1997	15-Jan-1998	31-Jan-1998	15-Feb-1998	1-Mar-1998	15-Mar-1998	1-Apr-1998
GENERAL														
Electrical Conductivity	uS/cm			130	650	140	150	440	400	990	890	790	1700	2800
pH	units	6	6	5.7	5.4	7.1	6.7	4.4	4	3.9	3.8	3.6	3.2	3.2
TDS	mg/L	180	180	120	440	150	160	310	250	800	840	670	1800	3000
MAJOR-IONS														
Calcium	mg/L	4	6.3	3.3	24	5.3	4.4	13	9.5	31	26	15	23	45
Magnesium	mg/L	2.8	2.5	2	20	2.2	2.8	17	16	45	32	29	66	120
Nitrate as N	mg/L	0.3	0.4											
Nitrite as N	mg/L	0.034	0.043											
Oxidised Nitrogen	mg/L	0.33	0.44											
Sodium	mg/L			16	57	13	12	30	16	44	24	23	39	71
Sulphate	mg/L	24	42	50	420	47	39	190	170	500	560	400	1300	2200
METALS														
Arsenic	mg/L	<0.02	<0.02	<0.01	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005	0.056	<0.005	<0.005	<0.01
Cadmium	mg/L	<0.0005	0.0012	<0.0005	0.0046	<0.0005	<0.0005	0.014	0.046	0.14	0.15	0.1	0.21	0.35
Copper	mg/L	0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.11	0.37	0.86	1.9	1.3	4.3	6.3
Iron	mg/L	6.2	4	0.3	<0.05	0.28	2.7	0.07	0.19	0.12	0.62	0.67	2.4	0.87
Lead	mg/L	0.024	0.023	0.003	<0.001	0.005	0.007	<0.002	0.003	0.005	0.007	0.005	0.016	0.05
Manganese	mg/L	0.22	0.51	0.12	1.9	0.51	0.15	2.1	1.6	7.6	6.1	3.8	8.1	22
Mercury	mg/L	<0.0005	<0.0005											
Molybdenum	mg/L	<0.05	<0.05											
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.11	0.16	0.47	0.63	0.45	1.1	2
Zinc	mg/L	<0.05	0.05	<0.05	0.2	<0.05	<0.05	0.6	0.92	2.5	2.6	2.1	4	8.5

Analyte	Units	1-Jan-1999	15-Jan-1999	31-Jan-1999	15-Feb-1999	1-Mar-1999	15-Mar-1999	1-Apr-1999	15-Apr-1999	1-Jan-2000	15-Jan-2000	1-Feb-2000	15-Feb-2000	29-Feb-2000	15-Mar-2000	1-Apr-2000
GENERAL																
Electrical Conductivity	uS/cm	170	260	860	320	340	740	640	1000	280	400	430	130	480	780	1200
pH	units	4.6	4.2	3.8	4.2	4	3.8	3.8	4.2	4	4.2	4.1	4.4	3.8	3.7	3.5
TDS	mg/L	110	190	660	220	210	580	480	990	180	250	330	92	380	620	940
MAJOR-IONS																
Calcium	mg/L	6.6	8.3	25	14	8.3	20	23	48	8.4	13	16	4.3	11	20	36
Magnesium	mg/L	3.2	6.9	32	8.9	11	34	25	54	8.6	11	14	2.8	19	35	58
Nitrate as N	mg/L															
Nitrite as N	mg/L															
Oxidised Nitrogen	mg/L															
Sodium	mg/L	13	9	40	14	15	30	26	54	17	18	27	5.8	22	38	61
Sulphate	mg/L	61	120	450	140	140	400	330	660	110	180	200	43	210	390	610
METALS																
Arsenic	mg/L	<0.005	<0.005	0.014	<0.005	<0.005	<0.005	<0.005	0.026	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	0.01
Cadmium	mg/L	0.0043	0.013	0.054	0.012	0.016	0.042	0.033	0.061	0.011	0.018	0.014	0.0038	0.046	0.046	0.069
Copper	mg/L	0.05	0.24	0.57	0.21	0.22	0.73	0.49	0.82	0.15	0.21	0.18	0.05	0.43	0.53	0.69
Iron	mg/L	<0.05	<0.05	0.36	0.29	0.16	0.28	0.13	0.15	0.08	0.07	<0.05	<0.05	0.27	0.1	0.1
Lead	mg/L	<0.001	<0.001	0.004	<0.001	<0.002	0.009	0.004	0.007	<0.002	<0.002	<0.002	<0.002	0.004	0.005	0.005
Manganese	mg/L	0.84	2.1	6.9	2.3	2.7	5.5	5.3	12	2.1	2.4	3.2	0.84	3.2	5.6	9.8
Mercury	mg/L															
Molybdenum	mg/L															
Nickel	mg/L	0.06	0.09	0.36	0.08	0.15	0.35	0.3	0.58	0.11	0.14	0.18	<0.05	0.22	0.37	0.57
Zinc	mg/L	0.17	0.41	1.3	0.46	0.54	1.3	0.92	1.9	0.37	0.49	0.58	0.12	0.83	1.2	1.9

Values shaded [ ] are above but less than twice the completion criterion

Values shaded [ ] are more than twice the completion criterion

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Croydon Monitoring
Water Quality Results

Analyte	Units	1-Dec-2000	15-Dec-2000	4-Jan-2001	15-Jan-2001	1-Feb-2001	15-Feb-2001	1-Mar-2001	15-Mar-2001	1-Apr-2001	15-Apr-2001
GENERAL											
Electrical Conductivity	uS/cm	260	170	300	440	480	310	640	350	530	670
pH	units	4.1	4	4	4	4	4.2	3.9	4.3	3.9	3.9
TDS	mg/L	170	100	240	300	340	220	520	260	400	520
MAJOR-IONS											
Calcium	mg/L	8	3.9	7.2	12	13	12	17	9.6	13	19
Magnesium	mg/L	6.4	3.4	11	16	17	12	25	13	19	26
Nitrate as N	mg/L										
Nitrite as N	mg/L										
Oxidised Nitrogen	mg/L										
Sodium	mg/L	12	8.4	15	26	30	15	25	15	20	27
Sulphate	mg/L	96	56	120	170	190	130	330	160	250	330
METALS											
Arsenic	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.0099	0.0044	0.017	0.024	0.024	0.018	0.046	0.021	0.022	0.029
Copper	mg/L	0.12	0.1	0.11	0.19	0.19	0.23	0.62	0.25	0.38	0.44
Iron	mg/L	<0.05	<0.05	<0.05	0.07	0.05	0.08	0.22	0.18	0.24	0.19
Lead	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	0.004	0.003	0.003	0.003
Manganese	mg/L	2.2	1	1.8	2.9	3.6	1.8	4.4	2.6	4.4	6.8
Mercury	mg/L										
Molybdenum	mg/L										
Nickel	mg/L	0.08	0.06	0.12	0.18	0.19	0.13	0.35	0.19	0.32	0.44
Zinc	mg/L	0.37	0.2	0.55	0.69	0.68	0.65	1.4	0.68	0.94	1.2

Values shaded [ ] are above but less than twice the completion criterion

Values shaded [ ] are more than twice the completion criterion

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Analyte	Units	7-Jun-1998	1-Jan-1999	15-Jan-1999	15-Feb-1999	1-Mar-1999	1-Apr-1999	1-Jan-2000	15-Jan-2000	1-Feb-2000	15-Feb-2000	29-Feb-2000	15-Mar-2000	1-Apr-2000
GENERAL														
Electrical Conductivity	uS/cm	76	120	85	46	98	89	110	110	110	93	84	80	88
pH	units	7.5	7.7	6.5	6.1	6.9	6.8	7.2	7.2	9	6.6	6.6	7.8	7.2
TDS	mg/L	400	580	130	76	390	370	700	880	780	300	280	470	370
MAJOR-IONS														
Calcium	mg/L	1.2	3	3	1.4	2.6	2.1	3.7	3.5	3.7	2.1	3	2	1.9
Magnesium	mg/L	1.3	1.6	2	0.59	1.9	1.5	1.9	5.1	1.5	3.4	1.6	1.2	1.2
Nitrate as N	mg/L													
Nitrite as N	mg/L													
Oxidised Nitrogen	mg/L													
Sodium	mg/L	15	26	8.3	5.2	14	13	24	21	24	14	14	16	18
Sulphate	mg/L	8	2	26	13	23	18	16	4	25	24	25	5	6
METALS														
Arsenic	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	<0.0005	<0.0002	0.0014	<0.0002	0.0007	0.0005	<0.0002	<0.0002	<0.0002	0.0004	0.0003	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	1.1	2	0.59	0.63	1.9	1	2.9	3.5	1.4	2	0.74	0.96	0.65
Lead	mg/L	0.009	0.019	<0.001	<0.001	0.005	0.004	0.004	0.007	0.006	0.004	0.003	0.013	0.006
Manganese	mg/L	<0.05	0.06	0.34	0.14	0.21	<0.05	<0.05	0.08	0.13	0.19	0.05	<0.05	<0.05
Mercury	mg/L													
Molybdenum	mg/L													
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	<0.05	0.058	0.054	0.019	0.03	0.039	0.049	0.047	0.042	0.042	0.026	0.027	0.024

Analyte	Units	15-Dec-2000	4-Jan-2001	15-Jan-2001	1-Feb-2001	15-Feb-2001	1-Mar-2001	15-Mar-2001	1-Apr-2001	15-Apr-2001
GENERAL										
Electrical Conductivity	uS/cm	56	100	100	110	63	66	50	68	88
pH	units	5.3	7.1	7.4	7.8	7.2	7	7.4	7.2	7.5
TDS	mg/L	81	690	750	750	360	430	400	410	580
MAJOR-IONS										
Calcium	mg/L	1.7	2.7	2.9	2.8	1.7	1.9	1.8	1.2	2
Magnesium	mg/L	1.1	1.9	2	2	1	1.2	1.1	1.7	1.7
Nitrate as N	mg/L									
Nitrite as N	mg/L									
Oxidised Nitrogen	mg/L									
Sodium	mg/L	50	21	25	25	12	13	13	11	15
Sulphate	mg/L	19	25	26	27	20	19	16	15	12
METALS										
Arsenic	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.009	0.011
Cadmium	mg/L	0.0003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.29	4	3.8	3.7	0.66	0.95	0.76	2.9	3.8
Lead	mg/L	<0.002	0.007	0.007	0.007	0.003	0.003	0.004	0.004	0.008
Manganese	mg/L	<0.05	0.08	<0.05	<0.05	<0.05	<0.05	0.07	0.07	0.1
Mercury	mg/L									
Molybdenum	mg/L									
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.024	0.014	0.009	0.006	0.012	0.016	0.021	0.006	0.012

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Analyte	Units	5-Mar-1996	30-Mar-1996	3-May-1996	30-Jun-1996	1-Aug-1996	2-Sep-1996	30-Oct-1996	30-Nov-1996	31-Dec-1996	31-Mar-1997	24-Jun-1997	4-Oct-1997	1-Dec-1997	15-Mar-1998	7-Jun-1998
GENERAL																
Electrical Conductivity	uS/cm										6700	7100	7400	7500	4500	6000
pH	units	3.4	2.1	2.2	2.3	2.2	2.1	2.1	2.2	2.3	2.3	2.5	2.2	2.5	2.3	2.3
TDS	mg/L	8200	8500	9700	9900	9700	8700	11000	11000	10000	9400	12000	11000	11000	5200	7500
MAJOR-IONS																
Calcium	mg/L	241	205	260	250	250	300	250	250	280	180	360	370	340	99	140
Magnesium	mg/L	136	140	165	175	165	180	190	200	190	180	200	210	220	100	140
Nitrate as N	mg/L	0.06	0.03	<0.5	<0.05	<0.05	<0.05	0.02	<0.5	0.01						
Nitrite as N	mg/L	0.046	0.033	0.03	0.014	0.43	0.067	0.069	0.2	0.068						
Oxidised Nitrogen	mg/L	0.11	0.06	<0.5	<0.05	0.43	0.08	0.09	<0.5	0.08						
Sodium	mg/L										160	160	160	150	87	110
Sulphate	mg/L	8000	6840	6600	5500	7600	7400	7900	8400	7900	7400	670	7400	8300	3500	5100
METALS																
Arsenic	mg/L	1.75	2.1	2.9	4.5	48	3.5	4.4	3.4	3.1	3.2	2.6	3	1.6	1.4	2.9
Cadmium	mg/L	0.19	0.21	0.275	0.6	0.3	0.32	0.32	0.33	0.16	0.27	0.31	0.32	0.32	0.41	0.21
Copper	mg/L	24.4	26	32	33.8	34	34	34	35	31	26	30	30	33	14	22
Iron	mg/L	640	680	840	1100	1000	860	940	890	760	67	820	840	780	320	500
Lead	mg/L	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.025	<0.05	<0.005	<0.01	0.003	<0.01	<0.005	<0.002	<0.005
Manganese	mg/L			140	82	7.8	69	88	89	79	67	79	93	81	34	54
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005						
Molybdenum	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.05						
Nickel	mg/L	5.6	5.8	6.8	7.7	7.8	7.2	8.7	8.5	8.1	4.4	7.6	8.4	8.3	3.4	5.2
Zinc	mg/L	21	22.4	27.8	27	28	30	30	29	28	22	28	30	32	12	20

Analyte	Units	21-Sep-1998	1-Dec-1998	1-Mar-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	4-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL													
Electrical Conductivity	uS/cm	6900	6900	5500	6300	6800	5600	5400	6300	6700	6100	5500	6400
pH	units	2.3	2.4	2.3	2.3	2.3	2.3	2.3	2.4	2.4	2.3	2.6	2.4
TDS	mg/L	9700	11000	6800	11000	10000	7600	7400	9900	10000	8700	8300	9000
MAJOR-IONS													
Calcium	mg/L	280	150	240	290	340	260	240	330	290	280	220	320
Magnesium	mg/L	190	190	130	200	200	150	150	190	190	160	150	180
Nitrate as N	mg/L												
Nitrite as N	mg/L												
Oxidised Nitrogen	mg/L												
Sodium	mg/L	140	160	100	140	150	110	120	150	150	140	130	150
Sulphate	mg/L	6200	7400	5000	7200	6600	5300	4800	6700	7000	5600	5200	6400
METALS													
Arsenic	mg/L	2.4	2.6	1	1.8	1.8	1.5	1.1	1.7	1.6	1.3	1	1.3
Cadmium	mg/L	0.25	0.27	0.18	0.27	0.29	0.21	0.21	0.26	0.27	0.23	0.21	0.24
Copper	mg/L	28	30	18	27	28	19	18	24	24	20	18	21
Iron	mg/L	630	630	400	700	710	450	400	520	500	440	370	450
Lead	mg/L	<0.005	<0.005	<0.004	<0.002	<0.002	<0.005	<0.002	<0.01	<0.004	<0.004	<0.005	<0.002
Manganese	mg/L	73	85	54	78	84	65	56	74	76	74	56	72
Mercury	mg/L												
Molybdenum	mg/L												
Nickel	mg/L	7.1	7.9	5.2	7.6	7.6	5.2	5	7.1	7.2	6.3	6.5	6.9
Zinc	mg/L	27	29	19	29	31	17	18	26	27	23	19	23

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Analyte	Units	5-Mar-1996	30-Mar-1996	3-May-1996	30-Jun-1996	1-Aug-1996	2-Sep-1996	30-Oct-1996	30-Nov-1996	31-Dec-1996	31-Mar-1997	24-Jun-1997	4-Oct-1997
GENERAL													
Electrical Conductivity	uS/cm										270	290	350
Oxidised Nitrogen	mg/L	<0.05	0.02	0.17	0.08	<0.05	<0.05	<0.05	<0.05	0.3			
pH	units	8.2	7.7	7.2	7.6	8	7.9	7.6	7.7	7.2	7.3	8.2	8.3
TDS	mg/L	190	185	200	210	220	280	250	240	250	170	190	230
MAJOR-IONS													
Calcium	mg/L	21.3	21	21.8	22.5	22	20	25	23	20	12	14	15
Magnesium	mg/L	3.4	3.6	3.1	4.5	3.9	4.4	4.6	4.2	4.4	3.7	4.1	4.5
Nitrate as N	mg/L	<0.05	0.02	0.12	<0.05	<0.05	<0.05	<0.05	<0.05	0.3			
Nitrite as N	mg/L	<0.002	<0.002	<0.002	0.05	<0.002	<0.005	<0.005	<0.02	0.004			
Sodium	mg/L										34	37	38
Sulphate	mg/L	72	69	57	64	60	67	72	72	59	68	56	59
METALS													
Arsenic	mg/L	0.04	0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.01	<0.005	<0.005
Cadmium	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0087	<0.0005	<0.0005	<0.0005
Copper	mg/L	<0.05	0.11	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.13	0.12	0.14	0.13	0.05	<0.05	<0.05	0.1	0.52	<0.05	<0.05	<0.05
Lead	mg/L	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.005	<0.05	<0.005	<0.001	<0.002	<0.002
Manganese	mg/L			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.29	<0.05	<0.05	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005			
Molybdenum	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.05			
Nickel	mg/L	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	<0.05	<0.05	0.1	<0.05	0.07	<0.05	0.07	0.22	<0.05	<0.05	<0.05	<0.05

Analyte	Units	1-Dec-1997	15-Mar-1998	7-Jun-1998	21-Sep-1998	1-Dec-1998	1-Mar-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	4-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL																
Electrical Conductivity	uS/cm	360	220	250	250	230	230	230	250	250	230	260	260	260	230	250
Oxidised Nitrogen	mg/L															
pH	units	7.2	8	7.6	7.9	8.1	7.6	7.7	6.3	6.9	5.8	5.9	7.2	7.2	7.7	7
TDS	mg/L	200	130	130	140	160	130	140	150	170	150	150	170	220	150	160
MAJOR-IONS																
Calcium	mg/L	16	7.9	8.2	10	8.9	7.4	8.9	9.7	8.6	7.2	8.3	8.9	8.2	8.2	8.1
Magnesium	mg/L	4.9	2.9	3.4	3.3	3.5	3.7	4.3	4.6	4.3	3.7	4.6	4.7	4.7	4.3	4.5
Nitrate as N	mg/L															
Nitrite as N	mg/L															
Sodium	mg/L	42	26	28	29	30	25	30	32	32	29	30	32	31	30	29
Sulphate	mg/L	64	39	39	40	55	47	45	59	56	61	60	64	62	59	66
METALS																
Arsenic	mg/L	<0.005	0.01	0.017	0.009	0.006	0.006	0.014	0.006	0.008	<0.005	0.007	0.006	<0.005	<0.005	0.01
Cadmium	mg/L	<0.0005	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.2	<0.05	<0.05	<0.05	0.1	0.16	<0.05	<0.05	0.24	<0.05	0.11	<0.05	0.07	0.18	<0.05
Lead	mg/L	<0.005	<0.002	<0.001	<0.001	<0.001	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.25	0.11	<0.05	<0.05	0.14
Mercury	mg/L															
Molybdenum	mg/L															
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	<0.05	<0.05	<0.05	0.007	0.008	<0.005	0.006	0.01	0.012	<0.005	0.01	0.006	<0.005	0.007	<0.005

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Analyte	Units	5-Mar-1996	30-Mar-1996	3-May-1996	30-Jun-1996	1-Aug-1996	2-Sep-1996	30-Oct-1996	30-Nov-1996	31-Dec-1996	31-Mar-1997	24-Jun-1997	4-Oct-1997	1-Dec-1997
GENERAL														
Electrical Conductivity	uS/cm										1700	1700	1800	1900
Oxidised Nitrogen	mg/L	1.2	0.16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05				
pH	none	4.2	3	3.1	3.2	3.1	3.1	2.9	3	3.1	3.3	3.3	3.1	3.3
TDS	mg/L	1200	1200	1320	1200	1300	1300	1400	1400	1300	1300	1300	1400	1400
MAJOR-IONS														
Calcium	mg/L	73	69	78	70	72	77	81	73	80	64	75	72	83
Magnesium	mg/L	38.7	41	42.5	42	42	44	46	41	42	40	42	42	46
Nitrate as N	mg/L	1.2	0.16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05				
Nitrite as N	mg/L	<0.002	<0.002	<0.002	<0.002	0.003	<0.005	<0.005	0.02	<0.002				
Sodium	mg/L										140	150	160	170
Sulphate	mg/L	870	850	1000	850	770	840	960	960	1000	1000	810	890	890
METALS														
Arsenic	mg/L	0.03	<0.02	0.05	0.11	0.08	0.05	<0.02	0.03	0.02	<0.01	0.12	0.09	0.23
Cadmium	mg/L	0.019	0.044	0.045	0.0275	0.025	0.025	0.026	0.03	0.024	0.018	0.017	0.026	0.022
Copper	mg/L	0.86	0.83	0.78	0.75	0.8	0.76	0.93	0.9	0.82	0.6	0.55	0.52	0.59
Iron	mg/L	2.04	1.83	4.82	6.6	4.1	4.4	4.3	4.2	3.8	4.3	6.3	5.9	3.8
Lead	mg/L	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.005	<0.05	<0.005	0.003	0.002	<0.002	<0.005
Manganese	mg/L			5	5.2	5.3	5.1	6.2	6.2	5.8	6	5.2	5.1	5.5
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005				
Molybdenum	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.05				
Nickel	mg/L	0.48	0.48	0.46	0.46	0.5	0.45	0.54	0.59	0.55	0.38	0.46	0.48	0.47
Zinc	mg/L	1.66	1.61	1.65	1.6	1.7	1.9	1.9	1.9	1.8	1.5	1.6	1.6	1.8

Analyte	Units	15-Mar-1998	7-Jun-1998	21-Sep-1998	1-Dec-1998	1-Mar-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	4-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL															
Electrical Conductivity	uS/cm	1300	1400	1400	1400	1700	1300	1400	1400	1300	1300	1300	1300	1200	1200
Oxidised Nitrogen	mg/L														
pH	none	3.3	3.2	3.3	3.4	3.3	3.4	3.4	3.3	3.3	3.5	3.5	3.4	3.7	3.6
TDS	mg/L	930	980	1000	1100	1000	1000	1000	1100	1000	1000	1000	1100	960	970
MAJOR-IONS															
Calcium	mg/L	47	53	55	58	57	52	60	59	50	51	53	50	46	48
Magnesium	mg/L	32	32	35	36	34	36	37	36	34	34	35	34	31	32
Nitrate as N	mg/L														
Nitrite as N	mg/L														
Sodium	mg/L	110	110	120	130	110	120	130	130	130	130	130	130	130	130
Sulphate	mg/L	540	570	570	660	640	610	570	600	560	590	600	550	540	560
METALS															
Arsenic	mg/L	0.015	0.013	0.039	0.017	0.019	0.086	0.024	0.029	0.011	0.058	0.031	0.012	0.022	0.038
Cadmium	mg/L	0.0085	0.011	0.011	0.013	0.013	0.0097	0.011	0.013	0.023	0.0086	0.0072	0.011	0.009	0.0089
Copper	mg/L	0.31	0.33	0.42	0.45	0.33	0.29	0.29	0.28	0.26	0.23	0.22	0.21	0.2	0.17
Iron	mg/L	1.8	1.9	1.4	1.2	0.8	1.5	1.6	1.3	1.1	1.2	1.2	0.78	1.2	0.79
Lead	mg/L	<0.002	<0.001	<0.001	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese	mg/L	3.3	3.3	4.2	4.2	3.8	3.8	3.9	3.8	3.6	3.6	3.9	3.8	3.6	3.6
Mercury	mg/L														
Molybdenum	mg/L														
Nickel	mg/L	0.27	0.31	0.34	0.33	0.35	0.34	0.29	0.29	0.26	0.27	0.26	0.27	0.27	0.25
Zinc	mg/L	0.92	0.99	1.1	1.2	1.1	0.99	0.99	0.89	0.9	0.93	0.89	0.86	0.85	0.78

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Analyte	Units	5-Mar-1996	30-Mar-1996	3-May-1996	30-Jun-1996	1-Aug-1996	2-Sep-1996	30-Oct-1996	30-Nov-1996	31-Dec-1996	31-Mar-1997	24-Jun-1997	4-Oct-1997	1-Dec-1997	15-Mar-1998	7-Jun-1998
GENERAL																
Electrical Conductivity	uS/cm										990	1000	1100	1100	730	750
pH	units	4.3	3.4	3.4	3.5	3.3	3.4	3.2	3.3	3.4	3.5	3.6	3.4	3.5	3.5	3.5
TDS	mg/L	930	930	940	930	960	940	1000	970	910	850	820	900	860	540	560
MAJOR-IONS																
Calcium	mg/L	59	55	57	61	62	69	70	57	60	43	52	50	55	29	33
Magnesium	mg/L	28.2	40.5	28	33	33	36	36	32	31	26	27	26	29	18	18
Nitrate as N	mg/L	0.57	0.66	0.59	0.51	0.41	0.29	0.39	0.35	0.34						
Nitrite as N	mg/L	<0.002	<0.002	0.002	0.008	0.002	<0.005	<0.005	<0.02	<0.002						
Oxidised Nitrogen	mg/L	0.57	0.66	0.59	0.51	0.41	0.29	0.39	0.35	0.34						
Sodium	mg/L										60	58	62	62	38	41
Sulphate	mg/L	680	660	670	550	490	480	660	600	520	580	450	490	530	280	270
METALS																
Arsenic	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.155	0.185	0.365	0.19	0.15	0.09	0.22	0.21	0.02	0.16	0.16	0.15	0.17	0.091	0.11
Copper	mg/L	1.36	1.38	1.45	1.53	1.58	1.6	1.7	1.5	1.4	1	1.1	1	1.2	0.7	0.77
Iron	mg/L	0.76	0.62	0.32	0.31	0.3	0.23	0.92	0.91	1.3	0.46	0.32	0.48	0.3	0.29	0.17
Lead	mg/L	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.005	<0.05	<0.005	0.005	0.005	0.004	0.004	0.002	0.002
Manganese	mg/L			5.5	6.4	5.6	7.1	6.7	6.1	5.5	4.2	4.5	4.5	4.8	2.4	2.5
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005						
Molybdenum	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.05						
Nickel	mg/L	0.6	0.59	0.57	0.64	0.6	0.64	0.74	0.73	0.67	0.43	0.53	0.53	0.57	0.29	0.34
Zinc	mg/L	4.5	4.6	4.99	4.7	4.85	5.9	6.9	6.6	4.8	3.5	3.9	3.8	4.4	2.3	2.6

Analyte	Units	21-Sep-1998	1-Dec-1998	1-Mar-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	4-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL													
Electrical Conductivity	uS/cm	810	790	790	800	850	890	830	830	890	890	650	640
pH	units	3.5	3.7	3.5	3.5	3.5	3.5	3.4	3.6	3.6	3.5	3.8	3.6
TDS	mg/L	570	660	610	660	690	710	690	680	740	740	660	680
MAJOR-IONS													
Calcium	mg/L	36	36	36	41	44	45	40	40	43	42	38	41
Magnesium	mg/L	20	21	18	22	23	24	22	21	24	23	20	22
Nitrate as N	mg/L												
Nitrite as N	mg/L												
Oxidised Nitrogen	mg/L												
Sodium	mg/L	42	47	44	48	52	52	49	48	52	56	49	50
Sulphate	mg/L	310	360	330	330	340	370	330	360	380	350	330	360
METALS													
Arsenic	mg/L	0.005	0.008	<0.005	<0.005	<0.005	0.013	<0.005	0.008	0.005	<0.005	<0.005	0.006
Cadmium	mg/L	0.094	0.11	0.1	0.011	0.11	0.11	0.12	0.1	0.12	0.11	0.1	0.1
Copper	mg/L	0.91	0.97	0.85	0.95	1	0.98	0.9	0.92	0.96	0.95	0.88	0.89
Iron	mg/L	0.11	0.18	0.11	0.12	0.12	0.11	0.06	0.24	0.1	0.1	0.23	0.15
Lead	mg/L	0.003	0.002	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004
Manganese	mg/L	3.2	3.2	2.9	3.3	3.5	3.5	3.2	3.3	3.7	3.6	3.3	3.4
Mercury	mg/L												
Molybdenum	mg/L												
Nickel	mg/L	0.37	0.41	0.41	0.45	0.44	0.44	0.4	0.42	0.43	0.44	0.44	0.45
Zinc	mg/L	3.1	3.4	3.1	3.2	3.6	3.1	3.2	3.3	3.3	3.3	3.4	3.1

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Water Quality Results

Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	7-Jun-1998
GENERAL										
Electrical Conductivity	uS/cm	805	1045	800	760	810	770	810	860	790
pH	units	7.8	7.4	6.6	6.5	6.9	6.6	6.6	6.7	6.4
TDS	mg/L	570	560	560	580	540	570	630	580	580
MAJOR-IONS										
Calcium	mg/L					11	14	14	14	13
Chloride	mg/L	35	48	53	46	37	37	36	35	37
Magnesium	mg/L	8.5	8.5	8.4	8.5	8.8	9.8	9.7	9.5	9.6
Nitrite as N	mg/L	0.012	0.061	0.006	0.59					
Sodium	mg/L	130	119	220	120	120	120	120	120	410
Sulphate	mg/L	200	180	240	220	200	190	240	220	220
METALS										
Arsenic	mg/L	<0.02	0.03	<0.02	<0.02	<0.01	<0.005	0.025	0.022	0.024
Cadmium	mg/L	0.0005	0.0013	0.0009	<0.0005	<0.0005	<0.0005	0.0051	<0.0005	0.0041
Copper	mg/L	<0.05	0.08	<0.05	0.15	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	1.96	0.86	11	3.9	1.6	2.5	3.4	2.8	3.6
Lead	mg/L	0.9	<0.05	1.4	0.13	0.018	0.051	0.21	0.008	0.13
Manganese	mg/L					1	1.6	1.8	1.6	1.6
Mercury	mg/L	0.0006	<0.0005	<0.0005	<0.0005					
Zinc	mg/L	0.15	0.05	0.24	0.09	<0.05	<0.05	0.08	<0.05	<0.05

Analyte	Units	21-Sep-1998	6-Dec-1998	28-Jun-1999	20-Sep-1999	1-Jan-2000	28-Jun-2000	29-Sep-2000
GENERAL								
Electrical Conductivity	uS/cm	760	700	710	710	720	690	700
pH	units	6.6	6.8	6.6	6.3	6.3	6.6	6.6
TDS	mg/L	580	590	580	590	590	590	580
MAJOR-IONS								
Calcium	mg/L	13	12	11	11	10	9.6	10
Chloride	mg/L	37	35	34	34	35	35	39
Magnesium	mg/L	7.8	8	8.4	7.7	7.2	7.2	6.6
Nitrite as N	mg/L							
Sodium	mg/L	110	120	110	120	110	110	120
Sulphate	mg/L	230	260	230	210	240	250	190
METALS								
Arsenic	mg/L	0.013	0.007	0.005	<0.005	0.019	<0.01	0.006
Cadmium	mg/L	0.005	0.0091	0.0045	0.0023	0.0069	0.0042	0.0038
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.16	0.14	0.2	0.63	3.8	3.5	1.2
Lead	mg/L	0.008	0.006	0.013	0.006	0.035	0.05	0.12
Manganese	mg/L	1.6	1.6	1.6	1.1	1.8	1.7	1.4
Mercury	mg/L							
Zinc	mg/L	0.042	0.045	0.019	0.011	0.031	0.012	0.016

Values shaded [ ] are above but less than twice the completion criterion

Values shaded [ ] are more than twice the completion criterion

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Water Quality Results

Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	7-Jun-1998
GENERAL										
Electrical Conductivity	uS/cm	1620	2220	2000	1900	2100	2100	2400	2700	2400
pH	units	8.3	7.5	7.3	7.2	7.2	7.8	6.9	6.9	7
TDS	mg/L	1400	1400	1400	1500	1400	1600	1700	1800	1700
MAJOR-IONS										
Calcium	mg/L					63	64	71	73	72
Chloride	mg/L	200	200	220	210	200	210	240	250	240
Magnesium	mg/L	15.2	13.6	17	18	19	18	19	20	20
Nitrite as N	mg/L	0.003	<0.002	<0.002	0.27					
Sodium	mg/L	370	370	370	350	370	380	440	470	420
Sulphate	mg/L	730	680	640	660	800	600	680	670	680
METALS										
Arsenic	mg/L	<0.02	<0.02	<0.02	<0.02	<0.01	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	<0.0005	0.0082	0.0012	0.0005	<0.0005	0.0013	<0.0005	<0.0005	<0.0005
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	1.53	0.06	0.19	0.53	0.2	0.16	2.8	0.82	0.16
Lead	mg/L	0.3	<0.05	<0.05	0.022	0.014	0.01	0.022	0.003	<0.001
Manganese	mg/L					0.07	<0.05	1.3	1	0.69
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005					
Zinc	mg/L	0.11	<0.05	0.07	<0.05	<0.05	<0.05	0.07	0.07	0.17

Analyte	Units	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	11-Jun-2001
GENERAL												
Electrical Conductivity	uS/cm	4000	2300	2400	2300	2400	2400	2300	2200	2300	2400	2400
pH	units	7.2	7.2	6.8	7	6.8	7	6.8	7.2	7.2	7.5	7.4
TDS	mg/L	1700	1700	1700	1700	1700	1700	1700	1700	1700	1900	1700
MAJOR-IONS												
Calcium	mg/L	73	69	74	71	74	72	72	72	68	68	69
Chloride	mg/L	250	250	240	250	250	250	250	250	240	250	250
Magnesium	mg/L	21	19	20	21	21	21	20	20	20	19	20
Nitrite as N	mg/L											
Sodium	mg/L	410	430	410	430	460	450	450	450	440	440	450
Sulphate	mg/L	670	780	680	720	690	690	580	820	720	730	740
METALS												
Arsenic	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.09	<0.05	0.1	<0.05	0.13	<0.05	<0.05	0.1	<0.05	<0.05	<0.05
Lead	mg/L	0.002	<0.001	<0.002	<0.002	<0.002	0.004	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese	mg/L	0.58	0.38	0.37	0.43	1.5	1.4	1.3	1.2	1.1	1.2	1
Mercury	mg/L											
Zinc	mg/L	0.28	0.085	0.078	0.12	0.019	0.018	0.007	0.047	0.01	0.025	0.011

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Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	17-Mar-1998	7-Jun-1998
GENERAL											
Electrical Conductivity	uS/cm	58	78	70	88	89	89	150	160	38	150
pH	units	6.3	5.8	5.3	5.6	6	6.2	6	6.3	5.7	5.5
TDS	mg/L	77	74	76	250	250	180	680	1600	69	79
MAJOR-IONS											
Calcium	mg/L					2.6	1.2	6.4	3.1	<0.5	1.1
Chloride	mg/L	11	11	16	14	12	12	17	13	6	10
Magnesium	mg/L	<0.5	<0.5	<0.5	1.4	1.5	0.6	2.5	2.7	<0.5	1.2
Nitrite as N	mg/L	0.003	0.003	0.002	0.033						
Sodium	mg/L	12.8	11.3	10	15	14	14	22	20	5.5	8.3
Sulphate	mg/L	<5	<5	<5	<5	27	12	23	13	3	2
METALS											
Arsenic	mg/L	<0.02	<0.02	<0.02	<0.02	<0.01	<0.005	0.016	0.008	<0.005	<0.005
Cadmium	mg/L	<0.0005	0.0016	<0.0005	0.0005	<0.0005	<0.0005	0.0011	0.0007	<0.0005	<0.0005
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	8	0.13	2.4	5.8	3.3	2.4	3.8	1.5	1.7	1.2
Lead	mg/L	0.1	<0.05	<0.05	0.07	0.041	0.029	0.043	0.018	0.014	0.018
Manganese	mg/L					<0.05	<0.05	0.28	0.15	<0.05	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005						
Zinc	mg/L	<0.05	<0.05	<0.05	0.15	<0.05	<0.05	0.11	0.11	<0.05	0.15

Analyte	Units	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL													
Electrical Conductivity	uS/cm	71	83	68	71	82	120	82	66	65	83	72	69
pH	units	5.6	5.9	5.2	5.7	5.7	5.9	5.8	5.8	5.8	6.4	5.9	5.7
TDS	mg/L	110	220	150	160	180	250	180	150	170	220	140	160
MAJOR-IONS													
Calcium	mg/L	0.21	0.45	<0.05	0.9	1.4	2	0.8	0.6	<0.5	1	0.7	<0.5
Chloride	mg/L	12	16	12	14	15	19	16	13	12	15	14	13
Magnesium	mg/L	0.25	0.63	<0.05	0.9	0.8	1.2	<0.5	0.6	<0.5	0.6	0.5	<0.5
Nitrite as N	mg/L												
Sodium	mg/L	12	15	11	12	14	19	13	10	11	13	14	11
Sulphate	mg/L	4	11	4	6	13	13	16	13	16	11	8	7
METALS													
Arsenic	mg/L	0.018	0.022	0.016	0.013	0.018	0.011	0.006	<0.01	0.008	0.009	0.01	0.012
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	1.4	1.9	1.5	2.2	3.1	3	2	2.3	2.1	2.2	3	1.6
Lead	mg/L	0.017	0.012	0.037	0.012	0.008	0.013	0.013	0.014	0.006	0.014	0.008	0.006
Manganese	mg/L	<0.05	0.08	<0.05	<0.05	<0.05	0.16	0.05	0.05	0.05	0.14	0.09	<0.05
Mercury	mg/L												
Zinc	mg/L	0.12	0.13	0.19	0.11	0.1	0.044	0.071	0.13	0.11	0.11	0.094	0.048

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Croydon Monitoring
Water Quality Results

Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	17-Mar-1998	7-Jun-1998
GENERAL											
Electrical Conductivity	uS/cm	185	251	230	220	240	240	270	280	260	520
pH	units	7.1	5.9	5.4	5.5	5.8	6	5.7	5.9	6	5.6
TDS	mg/L	210	200	220	250	240	210	260	310	230	230
MAJOR-IONS											
Calcium	mg/L					2.3	2	3.2	1.8	2.2	2
Chloride	mg/L	39	37	41	50	43	46	39	40	43	44
Magnesium	mg/L	1	1	1.3	1.9	1.5	1.1	1.8	1.8	1.6	2.2
Nitrite as N	mg/L	0.002	<0.002	<0.002	0.011						
Sodium	mg/L	33.3	23	35	35	34	33	38	35	38	38
Sulphate	mg/L	32	23	27	29	34	26	35	33	29	31
METALS											
Arsenic	mg/L	0.02	<0.02	<0.02	<0.02	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.0005	0.0042	0.0007	<0.0005	0.0005	0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	2.15	<0.05	0.52	1.1	0.22	0.31	0.72	0.1	<0.05	<0.05
Lead	mg/L	0.3	<0.05	0.05	0.045	0.028	0.029	0.031	0.005	0.002	<0.001
Manganese	mg/L					<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005						
Zinc	mg/L	0.06	0.06	0.09	0.06	<0.05	<0.05	0.09	0.32	0.05	0.11

Analyte	Units	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL													
Electrical Conductivity	uS/cm	290	270	280	280	290	290	280	280	280	290	270	290
pH	units	5.8	5.9	5.6	6	5.9	5.9	6.2	5.9	5.9	6	6.4	6.1
TDS	mg/L	120	250	240	240	250	250	240	250	250	340	230	240
MAJOR-IONS													
Calcium	mg/L	1.8	1.7	2.1	2.3	2.9	2.5	1.5	2.1	1.9	2.3	2.1	1.4
Chloride	mg/L	45	44	44	46	47	47	46	47	47	45	45	47
Magnesium	mg/L	1.7	1.8	1.9	2.4	2.3	2	1.7	2.2	1.9	2	2	1.7
Nitrite as N	mg/L												
Sodium	mg/L	38	40	39	40	42	42	42	39	41	41	42	41
Sulphate	mg/L	33	42	34	37	37	35	43	39	43	38	35	38
METALS													
Arsenic	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0003	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	6.6	<0.05
Lead	mg/L	<0.001	<0.001	0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.008	<0.002
Manganese	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L												
Zinc	mg/L	0.63	0.15	0.48	0.12	0.1	0.1	0.076	0.25	0.12	0.18	0.079	0.05

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Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	17-Mar-1998	7-Jun-1998
GENERAL											
Electrical Conductivity	uS/cm	78	88	75	68	71	73	88	84	77	130
pH	units	7.8	5.8	5.2	5.3	5.9	5.8	5.7	5.9	6.4	5.5
TDS	mg/L	120	90	80	82	74	88	110	96	93	94
MAJOR-IONS											
Calcium	mg/L					1	0.7	1.8	<0.5	0.6	<0.5
Chloride	mg/L	11	19	23	21	14	18	14	15	16	16
Magnesium	mg/L	<0.5	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.1
Nitrite as N	mg/L	0.002	0.002	<0.002	0.005						
Sodium	mg/L	14	11.4	12	10	11	11	11	9.6	12	11
Sulphate	mg/L	5	<5	<5	<5	<5	<5	<5	<5	<2	2
METALS											
Arsenic	mg/L	0.03	0.02	<0.02	<0.02	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	<0.0005	0.0029	0.0008	<0.0005	0.0006	<0.0005	0.0009	<0.0005	<0.0005	<0.0005
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.65	<0.05	0.19	0.32	<0.05	0.1	0.44	0.18	<0.05	<0.05
Lead	mg/L	0.1	<0.05	<0.05	0.009	0.011	0.006	0.1	0.005	0.002	<0.001
Manganese	mg/L					<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L	0.0005	<0.0005	<0.0005	<0.0005						
Zinc	mg/L	<0.05	<0.05	<0.05	0.07	<0.05	<0.05	0.29	0.13	0.1	0.1

Analyte	Units	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL													
Electrical Conductivity	uS/cm	80	74	77	77	78	78	78	80	79	80	80	78
pH	units	5.6	5.7	5.4	5.7	5.6	5.6	6.1	5.8	5.7	5.9	6	6
TDS	mg/L	80	100	88	110	97	96	96	96	95	140	120	94
MAJOR-IONS													
Calcium	mg/L	0.2	0.08	<0.05	<0.5	1	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chloride	mg/L	15	15	15	16	16	16	16	16	15	16	15	16
Magnesium	mg/L	0.2	0.29	<0.05	0.7	0.7	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	<0.5
Nitrite as N	mg/L												
Sodium	mg/L	9.8	11	11	11	12	12	12	11	11	11	13	10
Sulphate	mg/L	<2	4	2	4	<2	3	3	<2	8	4	3	2
METALS													
Arsenic	mg/L	<0.005	<0.005	0.006	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	<0.05	<0.05	<0.05	<0.05	0.11	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead	mg/L	<0.001	<0.001	0.008	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.002
Manganese	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L												
Zinc	mg/L	0.41	0.11	0.067	0.046	0.061	0.019	0.047	0.11	0.07	0.087	0.075	0.07

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Release

Croydon Monitoring
Water Quality Results

Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	17-Mar-1998	7-Jun-1998
GENERAL											
Electrical Conductivity	uS/cm	75	102	90	80	80	85	84	79	69	120
pH	units	6.6	5.8	5.2	5.3	5.7	5.8	5.4	5.5	6.1	5.7
TDS	mg/L	110	120	110	120	100	110	120	87	91	100
MAJOR-IONS											
Calcium	mg/L					1.1	1.1	1.4	<0.5	<0.5	<0.5
Chloride	mg/L	12	12	19	18	14	14	13	13	13	14
Magnesium	mg/L	<0.5	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.8
Nitrite as N	mg/L	0.002	<0.002	<0.002	0.006						
Sodium	mg/L	13.5	12.5	14	12	12	12	11	10	11	12
Sulphate	mg/L	<5	<5	<5	<5	<5	<5	<5	<5	<2	2
METALS											
Arsenic	mg/L	<0.02	0.02	<0.02	<0.02	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	<0.0005	0.042	0.0008	<0.0005	0.0013	0.0026	<0.0005	<0.0005	<0.0005	<0.0005
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.1	<0.05	0.2	0.42	<0.05	0.18	0.16	0.16	<0.05	<0.05
Lead	mg/L	<0.1	<0.05	<0.05	0.011	0.016	0.034	0.049	0.003	<0.002	<0.001
Manganese	mg/L					<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005						
Zinc	mg/L	<0.05	0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.37

Analyte	Units	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL													
Electrical Conductivity	uS/cm	80	78	79	76	82	100	140	150	90	92	90	85
pH	units	5.6	5.8	5.5	5.7	5.8	5.8	6	6.1	5.9	6	6.2	6
TDS	mg/L	80	110	100	110	110	120	140	150	110	170	110	110
MAJOR-IONS													
Calcium	mg/L	0.26	0.11	<0.05	<0.5	1	1.2	0.9	2.7	<0.5	<0.5	<0.5	0.9
Chloride	mg/L	14	12	12	13	11	14	21	22	12	12	11	11
Magnesium	mg/L	0.21	0.31	<0.05	0.7	0.7	0.7	0.6	1.3	<0.5	<0.5	<0.5	<0.5
Nitrite as N	mg/L												
Sodium	mg/L	11	12	12	12	14	16	22	22	14	13	16	13
Sulphate	mg/L	3	6	3	4	2	8	20	19	9	7	5	3
METALS													
Arsenic	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.005	0.005	0.006
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead	mg/L	<0.001	<0.001	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L												
Zinc	mg/L	0.2	0.081	0.051	0.024	0.045	0.023	0.051	0.26	0.06	0.055	0.091	0.029

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Release

Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	18-Mar-1998	7-Jun-1998	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999
GENERAL															
Electrical Conductivity	uS/cm	985	1195	1100	1000	1100	1100	1300	1500	1300	1300	1300	1200	1300	1200
pH	none	7.9	7.2	7	7	7.4	7.5	6.9	6.9	7.5	6.9	7.2	7.2	6.9	7.4
TDS	mg/L	910	840	850	840	870	630	1000	1100	1000	970	960	1000	1000	980
MAJOR-IONS															
Chloride	mg/L	18	12	31	21										
Magnesium	mg/L	20	17.7	20	22										
Nitrite as N	mg/L	0.004	0.002	<0.002	0.52										
Sodium	mg/L	140	88	130	120										
Sulphate	mg/L	520	430	350	370	410	310	440	480	430	430	420	470	490	460
METALS															
Arsenic	mg/L	0.08	0.04	<0.02	<0.02										
Cadmium	mg/L	<0.0005	0.0008	<0.0005	<0.0005										
Copper	mg/L	<0.05	<0.05	<0.05	<0.05										
Iron	mg/L	1.08	<0.05	0.6	0.32	0.16	<0.05	2	3.2	0.4	<0.05	0.14	0.12	0.13	0.19
Lead	mg/L	<0.1	<0.05	0.08	0.065										
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005										
Zinc	mg/L	0.1	<0.05	0.05	0.07										

Analyte	Units	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL									
Electrical Conductivity	uS/cm	1200	1300	1300	1300	1300	1400	1300	1300
pH	none	6.9	7.2	7.4	7.2	7.3	7.5	7.8	7.4
TDS	mg/L	970	1000	1100	1100	1100	1100	1100	1000
MAJOR-IONS									
Chloride	mg/L								
Magnesium	mg/L								
Nitrite as N	mg/L								
Sodium	mg/L								
Sulphate	mg/L	430	440	460	470	470	450	450	480
METALS									
Arsenic	mg/L								
Cadmium	mg/L								
Copper	mg/L								
Iron	mg/L	0.11	0.07	<0.05	0.13	<0.05	<0.05	2	0.08
Lead	mg/L								
Mercury	mg/L								
Zinc	mg/L								

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Release

Croydon Monitoring
Water Quality Data

Analyte	Units	1-Mar-1996	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	18-Mar-1998	7-Jun-1998
GENERAL											
Electrical Conductivity	uS/cm	797	1082	950	900	1300	970	1200	1200	1300	1300
pH	none	4.2	3.3	3.1	3.3	3.4	3.5	3.4	3.4	3.3	3.3
TDS	mg/L	720	680	700	660	1000	720	880	880	1000	990
MAJOR-IONS											
Chloride	mg/L	19	18	35	21						
Magnesium	mg/L	12.3	13.8	13	13						
Nitrite as N	mg/L	0.003	<0.002	0.002	1.1						
Sodium	mg/L	110	98	120	98						
Sulphate	mg/L	520	460	370	420	850	370	480	480	570	550
METALS											
Arsenic	mg/L	0.07	<0.02	0.03	0.12						
Cadmium	mg/L	<0.0005	0.0028	<0.0005	<0.0005						
Copper	mg/L	<0.05	<0.05	<0.05	<0.05						
Iron	mg/L	12	0.95	17	27	2.8	1	11	0.54	1.3	1.3
Lead	mg/L	0.4	0.06	<0.05	0.022						
Mercury	mg/L	<0.0005	<0.0005	<0.0005	<0.0005						
Zinc	mg/L	0.34	0.37	0.23	0.27						

Analyte	Units	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL													
Electrical Conductivity	uS/cm	1100	1100	1200	1200	1000	920	1100	980	1100	1000	1200	1200
pH	none	3.3	3.8	3.5	3.5	3.7	3.8	3.5	3.8	3.6	3.5	3.7	3.5
TDS	mg/L	810	880	910	1000	830	730	890	800	870	820	1000	930
MAJOR-IONS													
Chloride	mg/L												
Magnesium	mg/L												
Nitrite as N	mg/L												
Sodium	mg/L												
Sulphate	mg/L	430	500	620	540	440	380	480	440	490	400	540	520
METALS													
Arsenic	mg/L												
Cadmium	mg/L												
Copper	mg/L												
Iron	mg/L	0.5	6.9	6.5	0.19	12	11	0.73	8.9	3.3	6.9	0.47	0.3
Lead	mg/L												
Mercury	mg/L												
Zinc	mg/L												

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Analyte	Units	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	18-Mar-1998	7-Jun-1998	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999
GENERAL														
Electrical Conductivity	uS/cm	928	3000	170	210	300	730	820	1100	960	1200	1400	270	310
pH	none	7.2	6.8	5.6	6.1	6.4	6.6	7.1	5.9	6	6.6	6.9	5.8	6.4
TDS	mg/L	570	2100	240	160	220	470	510	880	680	830	1000	230	260
MAJOR-IONS														
Chloride	mg/L	62	310	18										
Magnesium	mg/L	2.6	18	1.4										
Nitrite as N	mg/L	0.006	<0.005	0.024										
Sodium	mg/L	169	620	31										
Sulphate	mg/L	260	990	54	66	79	180	210	310	260	330	420	84	95
METALS														
Arsenic	mg/L	0.03	0.03	<0.02										
Cadmium	mg/L	0.0009	<0.0005	<0.0005										
Copper	mg/L	<0.05	<0.05	<0.05										
Iron	mg/L	1.75	0.3	0.82	0.36	0.38	0.54	0.5	<0.05	<0.05	<0.05	<0.05	0.16	0.44
Lead	mg/L	<0.05	<0.05	0.072										
Mercury	mg/L	<0.0005	<0.0005	<0.0005										
Zinc	mg/L	<0.05	<0.05	0.09										

Analyte	Units	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL									
Electrical Conductivity	uS/cm	800	180	130	230	360	110	120	270
pH	none	6.9	5.5	5.8	6.2	6.9	5.9	6.3	6.7
TDS	mg/L	500	150	130	250	270	160	160	320
MAJOR-IONS									
Chloride	mg/L								
Magnesium	mg/L								
Nitrite as N	mg/L								
Sodium	mg/L								
Sulphate	mg/L	210	47	47	76	100	220	63	73
METALS									
Arsenic	mg/L								
Cadmium	mg/L								
Copper	mg/L								
Iron	mg/L	0.13	0.16	<0.05	0.47	0.18	0.54	0.22	0.86
Lead	mg/L								
Mercury	mg/L								
Zinc	mg/L								

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Analyte	Units	31-May-1996	23-Sep-1996	2-Jan-1997	31-Mar-1997	24-Jun-1997	4-Oct-1997	5-Dec-1997	18-Mar-1998	7-Jun-1998	21-Sep-1998	6-Dec-1998	1-Apr-1999	28-Jun-1999
GENERAL														
Electrical Conductivity	uS/cm	6530	6000	6100	7400	6700	7100	7600	6600	7100	7500	7600	7500	7300
pH	units	6.3	6.2	6	6.1	6.3	6.3	6.6	7.4	6.9	6.7	6.5	6.4	6.6
TDS	mg/L	4500	4600	5000	5400	4900	5600	5200	5000	5100	11000	12000	5700	5600
MAJOR-IONS														
Chloride	mg/L	1200	1300	1400										
Magnesium	mg/L	132	120	160										
Nitrite as N	mg/L	<0.002	<0.002	0.096										
Sodium	mg/L	200	880	1100										
Sulphate	mg/L	2000	350	1900	2300	1600	2000	1900	1700	1900	1900	2300	2000	1900
METALS														
Arsenic	mg/L	0.1	<0.1	<0.02										
Cadmium	mg/L	0.0016	<0.003	0.0014										
Copper	mg/L	<0.05	<0.05	<0.05										
Iron	mg/L	<0.05	0.52	0.82	<0.05	<0.05	0.24	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead	mg/L	<0.05	<0.05	0.056										
Mercury	mg/L	<0.0005	<0.0005	<0.0005										
Zinc	mg/L	0.07	<0.05	0.16										

Analyte	Units	20-Sep-1999	1-Jan-2000	1-Mar-2000	28-Jun-2000	29-Sep-2000	7-Jan-2001	15-Mar-2001	11-Jun-2001
GENERAL									
Electrical Conductivity	uS/cm	7500	7500	7800	7600	8000	8000	7900	8300
pH	units	6.6	6.4	6.4	6.6	6.6	6.8	7	6.7
TDS	mg/L	5700	5800	6000	6100	6400	6600	6200	6400
MAJOR-IONS									
Chloride	mg/L								
Magnesium	mg/L								
Nitrite as N	mg/L								
Sodium	mg/L								
Sulphate	mg/L	2000	780	2000	2300	2300	2200	2200	2300
METALS									
Arsenic	mg/L								
Cadmium	mg/L								
Copper	mg/L								
Iron	mg/L	0.14	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	<0.05
Lead	mg/L								
Mercury	mg/L								
Zinc	mg/L								

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APPENDIX 5

Release

Water Level Analysis of Golden Butterfly Pit Croydon Gold Mine

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Prepared for

Goldfields Limited
PO Box R986
Royal Exchange Post Office
NSW 1225

HLA-Envirosciences Project No 1715-3

by

CTPI 49-Sch4 BSc(CivEng) MSc(EnvEng) CPEng
Principal Civil/Environmental Engineer

CTPI 49-Sch4 BSc
Principal Hydrogeologist

15 May 2001

This document was prepared for the sole use of Goldfields Limited and the regulatory agencies that are directly involved in this project, the only intended beneficiaries of our work. No other party should rely on the information contained herein without the prior written consent of HLA-Envirosciences Pty Limited and Goldfields Limited.

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3.0 GROUNDWATER 2

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1.0 INTRODUCTION

Goldfields Limited requested HLA-Envirosciences review the available meteorology and groundwater data for the area around the Golden Butterfly Pit and Waste Dump at the Croydon Mine in Northwest Queensland. The purpose of the review was to determine the likelihood of the pit overflowing in extreme weather conditions.

Goldfields Kalgoorlie Limited (formerly Pancontinental Mining Limited) is holder of ML 5248, just west of Croydon township in Northwest Queensland. ML 5248 was mined between 1987 to 1990. In 1993 a Decommissioning Plan was accepted by the Department of Minerals and Energy and decommissioning commenced.

The data reviewed for this study included the following:

- Rainfall and Evaporation data from Bureau of Meteorology Station 029012 – Croydon Township. Rainfall data commenced in 1889 and evaporation data commenced in 1972.
- Groundwater levels from two monitoring wells for 19 monitoring events from March 1996 through January 2001.

2.0 PRECIPITATION AND EVAPORATION

2.1 Average Monthly Precipitation and Evaporation

The Croydon Mine is located in Northwest Queensland, which is subject to very distinct monsoonal wet and dry seasons. **Table 1** shows that on average, 85% of the rainfall falls from December to March, but the evaporation is spread relatively evenly throughout the year.

Table 1 – Average monthly Precipitation and Evaporation

Month	Rainfall (mm/month)	Evap (mm/month)
Jan	218.8	202
Feb	177.0	158
Mar	115.0	189
Apr	23.1	195
May	8.2	177
Jun	8.5	147
Jul	3.4	161
Aug	2.8	198
Sep	5.7	243
Oct	14.0	279
Nov	44.5	267
Dec	111.4	248
12 Month Total	732.4	2464
Dec to Mar Total	622.2	797
Dec to Mar %	85%	31%
Apr to Nov Total	110.2	1667

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Table 1 also shows that between December and March average rainfall exceeds average evaporation by only 175 mm. In a wet year, rainfall will exceed evaporation as described in the next section. During the dry months, April to November evaporation exceeds precipitation by about 1.5 metres. This means that there is no real significance to a sequence of wet or dry years. Each year will have a wet season and a dry season. In a sequence of wet years, the dry season would still cause evaporation to exceed rainfall. For this reason there is no reason to analyse a series of wet years.

2.2 Wet Season Rainfall

Table 2 – Ranked Rainfall from December to March, Croydon

Wet Year	rank / 112	Year	Rainfall Dec-Mar (mm)
Wettest	1/112	1974	1611
90%	11/112	1922	942.2
80%	22/112	2001	823.8
50%	56/112	1927	647.7
20%	90/112	1926	431.3
10%	101/112	1978	378.8
Driest	112/112	1952	192.6
Average Wet Season Evaporation			797

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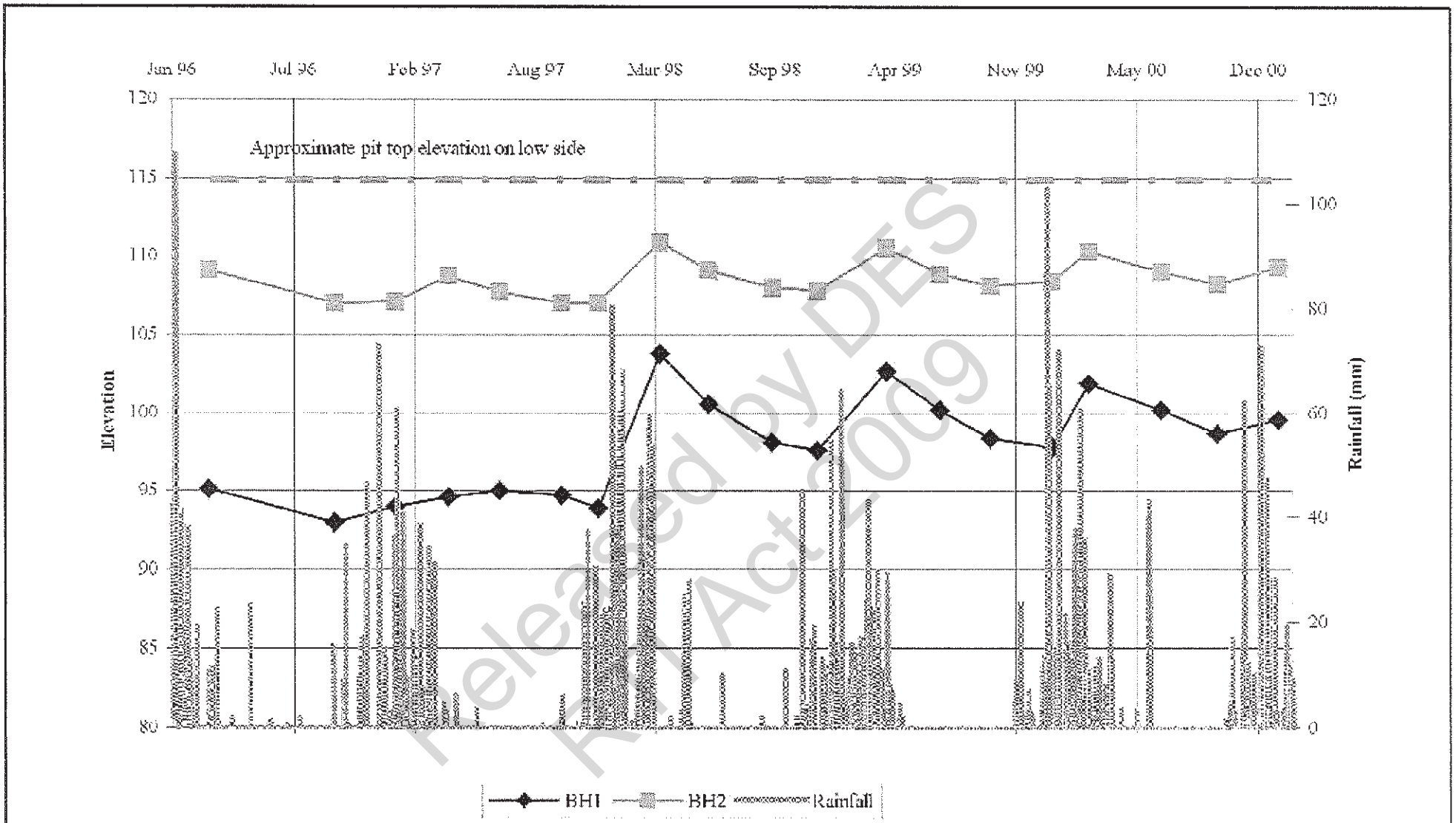
The rainfall records at Croydon Met Station have been recorded for 112 years. **Table 2** shows that during the 80 percentile or wetter year there will be more rainfall than the average evaporation in the wet season from December to March (as shown in **Table 1**). The net additional rainfall is very small (between 0 and 0.8 m) compared to the evaporation during the dry months, when a net loss of water on the order of 1.5 metres of water is likely.

3.0 GROUNDWATER

Groundwater levels for two monitoring wells located adjacent to the Golden Butterfly Pit were evaluated for change over time and magnitude of change with rainfall. Monitoring Well BH1 is located approximately 60 metres northeast of the pit and BH2 is located approximately 50 metres southwest of the pit. The water level dataset includes 19 monitoring events from March 1996 through January 2001.

Figure 1 presents a plot of water levels in BH1 and BH2 over time, as well as daily rainfall for the period (March 1996 through January 2001). The data show a good correlation with rainfall. Water levels show a marked increase in 1998, which was the 8th wettest year on record over a 112 year period. The overall trend in groundwater levels appears to be increasing very slightly over this 5 year period. It is possible that the increase is cyclical and related to series of wet years. The rainfall in the years following 1998 were also above the mean (1999 – 0.2%; 2000 – 7.4%). The plot also shows that the equivalent water elevation in BH1 ranges from 7 to 14 metres deeper than in BH2, even though BH1 is considered to be the up gradient well.



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GROUNDWATER ELEVATION PLOT
GOLDEN BUTTERFLY PIT
Goldfields Limited
Croydon Gold Mine, QLD

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Figure 2 presents a southwest to northeast cross section through the pit and the monitoring wells. It shows the relative difference between the water levels in BH1 and BH2. Because the depth of the pit and the water level in the pit are not known, it is not possible to quantify the effect of the change in the pit water level has on the monitoring well levels, hence the groundwater levels surrounding the pit.

As discussed above, the historic rainfall and evaporation data indicate a relatively large deficit because of the high evaporation during 7 to 8 months of the year. Assuming that the bund surrounding the pit does not allow surface run off to enter the pit and that groundwater flows into and out of the pit at the same rate, direct rainfall would be the only source of water into the pit. There is also the possibility that the pit could be acting as a groundwater sink due to the surrounding geology and the significant amounts of water removed by evaporation. **Table 3** shows the impact of rainfall and evaporation in the wet and dry seasons and how the pit level and freeboard in the pit is affected.

Table 3 – Summary of Estimated Pit levels and Freeboard under wet and dry conditions

Wet Year	mm added by Rainfall	mm removed by Evap	Change in Pit Level	Approx Free-board#	mm added by Rainfall	mm removed by Evap	Change in Pit Level	Approx Free-board#
	December to March			1st Apr	April to November			1st Dec
90%	942mm	563mm	+0.4m	3.7m	84mm	1424mm	-1.3m	5.0m
50%	648mm	662mm	0.0m	4.1m	57mm	1381mm	-1.3m	5.4m
10%	379mm	1011mm	-0.6m	4.7m	56mm	1841mm	-1.8m	6.5m

- assumes starting pit water level of RL110.9 (worst case of all readings, BH2 18 march 1998) and lowest pit top level of RL115.0 (based on Woodward-Clyde Plan dated July 1996)

Table 3 shows that even in a very wet year the pit water level will drop by 0.9m without any inflow of groundwater, assuming that runoff from surrounding catchments is kept out of the pit.

Although it would be useful if the data used to make the conclusions were more complete, the existing data points very strongly toward the conclusion that the net evaporation can only decrease the pit level, as long as surface runoff is kept out of the pit. If pit levels increase, then there would have to be inflow from groundwater. No water levels for the pit have been recorded, so it will be difficult to test this theory with data over a long period. No construction details are available for the wells, so there may be some inconsistencies in the way that the wells can accept groundwater from all the strata over the full depth of the well. Wellhead elevations were estimated based on a drawing entitled "Golden Butterfly Pit and Waste Dump Plan of Existing Layout" by Woodward-Clyde, dated July 1996.

Additional monitoring wells are located adjacent to Slaughteryard Creek to the southwest of the pit. Water levels in these wells were not evaluated due to their proximity to the creek. It is considered that the

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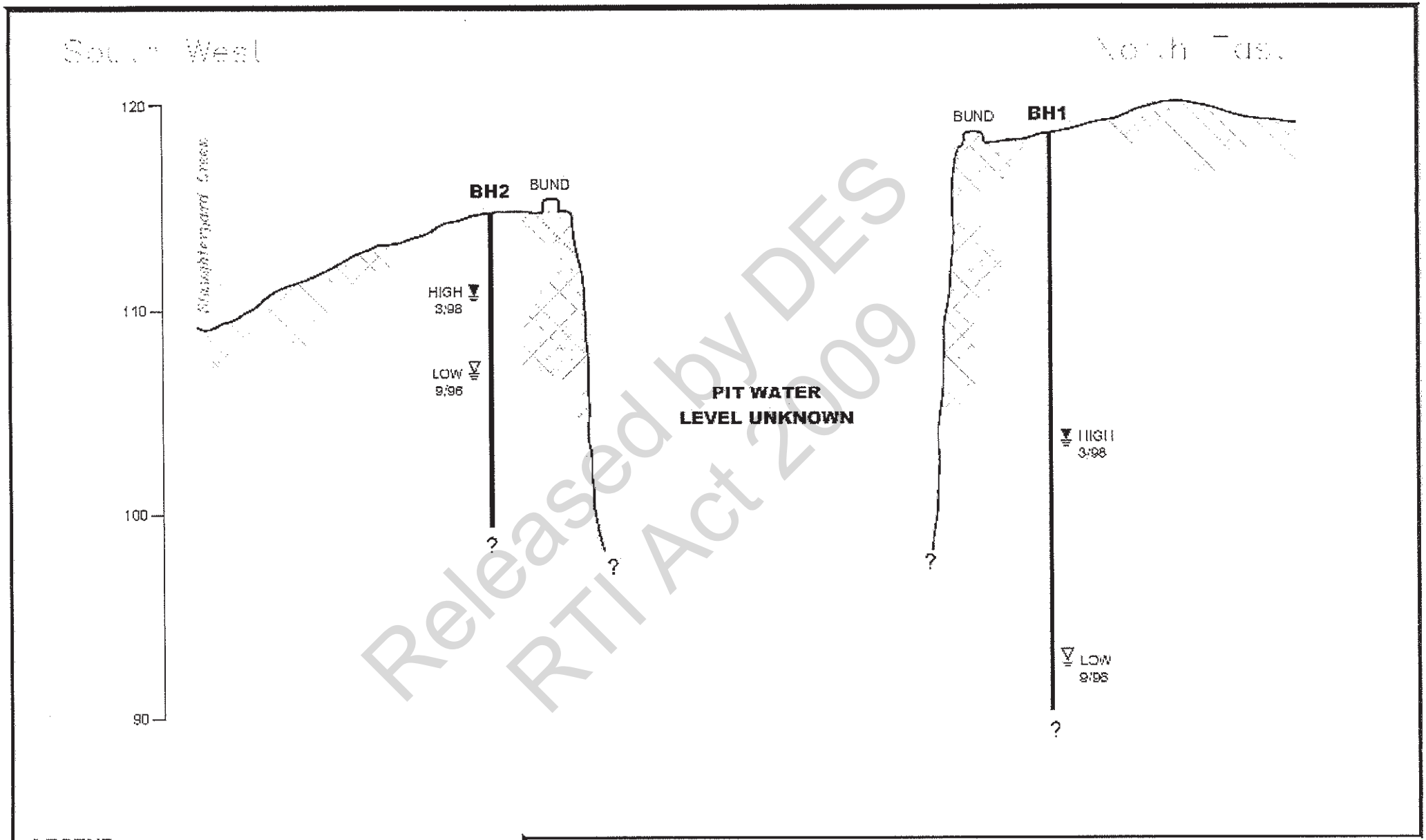

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LEGEND

- HIGHEST WATER LEVEL DURING MONITORING PERIOD
- LOWEST WATER LEVEL DURING MONITORING PERIOD

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CROSS SECTION THROUGH GOLDEN BUTTERFLY PIT
Goldfields Limited
Croydon Gold Mine, QLD

FIGURE
2

DRAWN	PROJECT # - NAME	APPROVED	DATE	REVISED DATE
LJE	F1715-001		May 2001	

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levels in these wells would be affected to a larger degree by the creek and not by a change in the pit water level.

4.0 CONCLUSIONS

Based on the above assumptions and calculations, it is unlikely that the pit would be overtopped in even the wettest year on record. The available data shows that without groundwater inflow, the pit would lose water even in a wet year. The only conditions that may cause the pit to overtop would be a rise in the groundwater levels, equivalent to the top of the pit. In that case there would be water on the ground at other locations before it got to the top of the pit. Taking the worst case scenario that the pit water level will recover to the highest level recorded in the two boreholes, there would still be 3.7 metres of freeboard in the pit at the end of a 90 percentile wet season. All of these assumptions are based on the continued maintenance and integrity of the bunds around the pit ensuring that no surface runoff from the surrounding catchments can enter the pit.

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Water Level Analysis
of Golden Butterfly Pit
Croydon Gold Mine

15 May 2001

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Managing Director

Quality Control Reviewer

CTPI 49-Sch4
Principal Environmental Scientist (Mining)

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Enquiries Alex Apostol
Telephone (07) 4744 7814
Your reference
Our reference CNS5741/CR52682

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Queensland Government

Department of
Environment and Resource Management

11 November 2011

Rp 48382546012

Mark Kelleher
Chief Executive Officer
Carpentaria Shire Council
P.O. Box 31
Normanton QLD 4890

Dear Sir,

Water Quality Update - Belmore Creek

I refer to your letter received by the Department of Environment & Resource Management (the department) on 24 October 2011 highlighting concerns over elevated levels of heavy metals, most notably arsenic (As) in Belmore Creek.

DERM recently conducted an inspection of the Barrick Croydon Gold Mine located to the immediate west of the Croydon Township. The inspection involved monitoring of the onsite water storages/pits and the receiving environment of Belmore Creek. Results of monitoring indicated that both water and sediment samples did not exceed the licence limits for As, as shown in the table below.

Water & Sediment Sampling Results for Arsenic

Croydon Gold Mine & Belmore Creek, 22 August 2011

Monitoring Point	Matrix	Result	Trigger Level	As Contaminant Limit
Onsite Water Storages				
Golden Butterfly Pit	Water	0.004 mg/L	N/A	0.5 mg/L[1]
Golden Butterfly North Pit	Water	0.009 mg/L		
Content Pit	Water	0.003 mg/L		
Lady Isabella Pit	Water	<0.001 mg/L		
Receiving Environment (Belmore Creek)				
Belmore Creek & Stock Dam "Confluence"	Sediment	<5 mg/kg	20 mg/kg[2] or 80th percentile of reference, whichever is higher	70 mg/kg[3] or twice the reference value, whichever is higher
Reference Site SW7 on Belmore Creek Upstream	Sediment	<5 mg/kg		

[1] *Contaminant limit based on ANZECC (2000) stock water quality guidelines;*
[2] *ANZECC (2000) Interim Sediment Quality Guidelines – low value based on total sediments;*
[3] *ANZECC (2000) Interim Sediment Quality Guidelines – high value based on total sediments.*

Should the receiving waters and/or sediments exceed the contaminant trigger levels, the department will require Barrick Australia Pacific Ltd, owner of the Barrick Croydon Gold

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Queensland 4825 Australia
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Website www.derm.qld.gov.au
ABN 46 640 294 485

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Mine, to complete an investigation in accordance with the *Australia & New Zealand Environment and Conservation Council (ANZECC) 2000* methodology into the potential for environmental harm and where required, implement measures to prevent environmental harm from occurring.

The department is committed to continually monitoring the Barrick Corydon Gold mine through the wet season. If a release of contaminated water from the open pits to Belmore Creek should occur, this release will be investigated by the department.

Croydon Water Supply

During the inspection on 22 August 2011 the Croydon water supply was not sampled for metal concentrations. With regards to concerns the Croydon water supply may not be suitable for human consumption due to elevated levels of metals, the department suggests that you contact either the Croydon Shire Council or Queensland Health for further information on this issue.

If you have any queries in relation to this matter please contact Alex Apostol on (07) 4744 7814.

Yours sincerely,

CTPI 49-Sch4

Richard Kidston
A/Manager
Mining and Heavy industry
North Region
Department of Environment and Resource Management

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Cc: Croydon Shire Council
PO Box 17
Croydon QLD 4871

Brad McCullough
Director, Queensland Heath
19 Alpine Street
CAIRNS QLD 4870

APPENDIX E POST MINE LANDUSE PLAN

Appendix A

POST MINE LANDUSE PLAN

CROYDON GOLD MINE

POST MINE LANDUSE PLAN

DECEMBER 2011

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Attachment B Grazing Management Plan

1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring, investigations and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Barrick holds Environmental Authority No. MIN100401906 (EA) for the Project.

This Post Mine Landuse Plan (PMLP) has been prepared in accordance with EA Condition C2 1:

(C2-1) A Post Mine Land Use Plan for the licensed place must be developed and implemented for a nominal period of:

(a) at least thirty (30) years following the cessation of mining activities on the licensed place; or

(b) a shorter period if the licensed place is proven to be geo-technically and geo-chemically stable and it can be demonstrated to the satisfaction of the administering authority that no release of contaminants from the site will result in environmental harm and be prepared at least 18 months prior to cessation of mining activities on the licensed place.

In addition, EA Condition C2 2 outlines the components of the PMLP (Table 1). A summary of where the components of the PMLP are addressed in this report is also provided in Table 1.

In accordance with EA Condition C2 2, this PMLP will be included in the Project Plan of Operations and will be updated with each subsequent Plan of Operations.

The remainder of this PMLP is structured as follows:

Section 2: Describes the rehabilitation concepts for the Project.

Section 3: Provides a description of the Geotechnical Assessment.

Section 4: Provides a description of the Geochemical Assessment.

Section 5: Describes the Hydrology and Hydrogeology of the Project.

Section 6: Describes the Rehabilitation Monitoring Program.

Section 7: Details the Grazing Management Plan.

Section 8: Identifies the Completion Criteria for the Project.

Section 9: Outlines the Research Programs for the Project.

Section 10: Describes the review process for this PMLP.

Section 11: Lists the references cited in this PMLP.

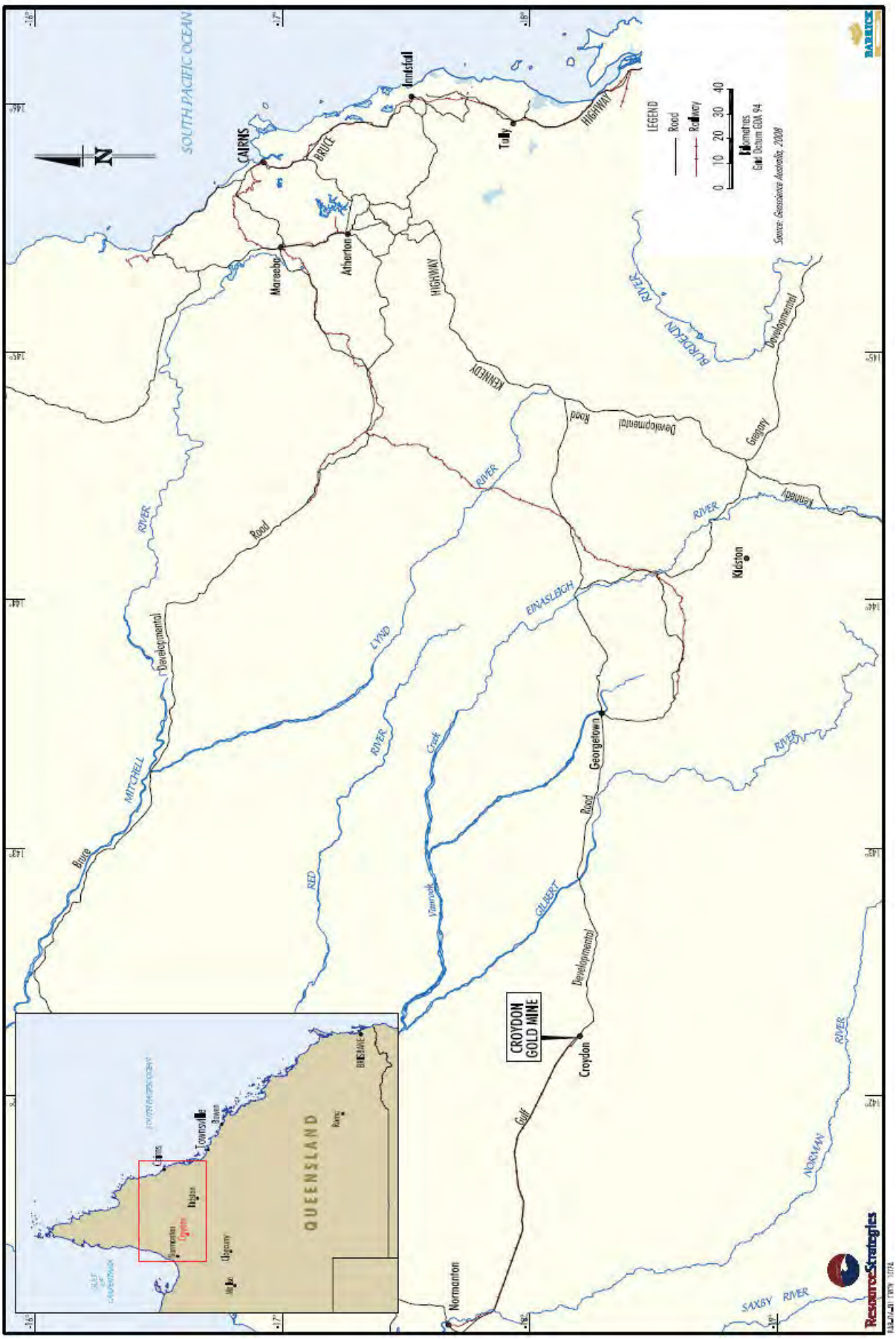

Figure 1: Regional Location

Table 1: Components of the Post Mine Landuse Plan

Component of PMLP		Section of this Report
C2-2	*The Post Mine Land Use Plan must be included in the Plan of Operations and updated with each subsequent Plan of Operations, describing how the rehabilitation objectives in Schedule C – Table 1 will be achieved. The Post Mine Land Use Plan must include:*	
(a)	*schematic representation of final land form inclusive of drainage features;*	Section 2.2
(b)	*slope designs;*	Section 2.3
(c)	*cover design;* *including a report on the effectiveness of existing cover systems;*	Section 2.3 Section 2.3.1
(d)	*drainage design;*	Section 2.4
(e)	*erosion controls on reformed land;*	Section 2.5
(f)	*description of experimental design for monitoring of analogue and rehabilitated areas inclusive of statistical design;*	Section 6
(g)	*proposed revegetation criteria including:* *(i) species diversity, abundance and composition;* *(ii) projective cover;* *(iii) dry matter production; and* *(iv) stocking rates to ensure self sustaining vegetation is maintained;*	Section 8.2
(h)	*proposed revegetation methods inclusive of plant species selection, re-profiling, respreading soil, soil ameliorants/amendments, surface preparation and method of propagation;*	Section 2.1
(i)	*materials balance including available top soil; and* *low permeability encapsulation media for capping;*	Section 2.6 Section 2.3
(j)	*research program and associated milestones;*	Section 9
(k)	*geotechnical;* *geochemical; and* *hydrological studies;*	Section 3 Section 4 Section 5
(l)	*chemical, physical and biological properties of soil; and* *chemical, physical and biological properties of water;*	Sections 2.3.2 and 4 Section 5
(m)	*measurable completion criteria for each rehabilitation indicator that enables determination of rehabilitation success for each disturbance type;*	Section 8
(n)	*rehabilitation monitoring program, including the monitoring of:* *(i) surface water quality;* *(ii) groundwater quality;* *(iii) erosion rates;* *(iv) integrity and effectiveness of final cover of final cover systems; and* *(v) health and resilience of vegetative cover;*	Section 6 and Attachment A
(o)	*grazing management plan;*	Section 7 and Attachment B
(p)	*operation and maintenance of:* *(i) the surface water management system;* *(ii) groundwater monitoring network;* *(iii) final cover systems; and* *(iv) vegetative cover.*	 Section 2.4 Section 5.2.1 Section 2.3.1 Section 2.3.1

2 REHABILITATION CONCEPTS

The rehabilitation concepts for the Project provide for the re establishment of a stable and sustainable ecosystem which is consistent with the proposed post mine landuse of low intensity grazing/disturbed native habitat, with exception of the open pits (Section 2.2). This section provides a description of the revegetation, final landforms, slope and cover design, effectiveness of the cover system, soil properties, drainage design, erosion and sediment control and the materials balance at the Project. Any additional rehabilitation works required at the Project will be conducted utilising similar rehabilitation concepts described in this section.

2.1 REVEGETATION

The revegetation methods undertaken in the 1996 Rehabilitation Program are outlined below. The rehabilitation works conducted in 1996 are fully reported in Fawcett (2001) and HLA Enviroscience (2001a). In the event additional rehabilitation works are required at the Project, similar revegetation methods to those described below will be implemented.

Selection of Plant Species

Sixteen tree and shrub species were included in the seed mix used during the 1996 revegetation program. Additional tree and shrub species have been recorded at the revegetation monitoring transects most likely self seeding from the adjacent vegetation. HLA Enviroscience (2001a) reported 19 species at the vegetation monitoring sites, including seven species of *Acacias*, seven species of *Eucalypts* and five species belonging to other genera including *Melaleuca*, *Atalaya*, *Erythrophleum* and *Hakea*.

Any additional rehabilitation works required at the Project will utilise a similar selection of plant species in the seed mix as mentioned above.

Re-profiling, Soil Respreading and Surface Preparation

Minor re profiling on both waste rock dumps was conducted to remove surface irregularities. Soil was respread with appropriate earth moving equipment (e.g. grader). Immediately prior to seeding all areas were ripped along contour to a depth of 250 millimetres (mm) to 300 mm. All ripped areas were aerial topdressed with an NPK fertiliser at a rate of 500 kilograms per hectare (Fawcett, 2001).

Any additional rehabilitation works required at the Project will conduct appropriate re profiling and utilise similar soil respreading and surface preparation methods as mentioned above.

Method of Propagation and Soil Ameliorant

An aerial application of DAP fertiliser to the rehabilitation sites in 2004 has markedly improved the phosphorus status of the soil but has had no lasting impact on the nitrogen status. It is considered that the most practical method of improving soil nitrogen status in the long term is to sow groundcover legumes, such as Seca stylo (*Stylosanthes scabra*) and Verano stylo (*S. hamata*) which are well adapted to the Gulf country area (Landline Consulting, 2007).

Any additional rehabilitation works required at the Project will utilise similar propagation and soil ameliorant methods as mentioned above.

Weed Management

A weed control program was initiated in 1996 to control isolated Calotrope (*Calotropis procera*) plants observed around the southern end of the Golden Butterfly waste rock dump (Fawcett, 2001). This weed species is ubiquitous in the Croydon area. Where necessary, a similar weed management program to that initiated in 1996 will be conducted at the Project.

2.2 FINAL LANDFORMS

The mining related landforms on ML 5248 comprise of waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps.

Specifically they include (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Golden Butterfly waste rock dump;
- Content Pit;
- Content waste rock dump;
- Lady Isabella Pit;
- abandonment bunds across the access ramps of the four open pits;
- hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps;
- water diversion bunds and sediment dams adjacent to the Content and Golden Butterfly waste rock dumps; and
- roads and tracks.

The final landform concept is to achieve a stable post mining landform that is able to meet the identified post mining landuse and rehabilitation objectives. The post mining land descriptions and rehabilitation objectives are specified in Schedule C – Table 1 of the EA, which is reproduced in Table 2.

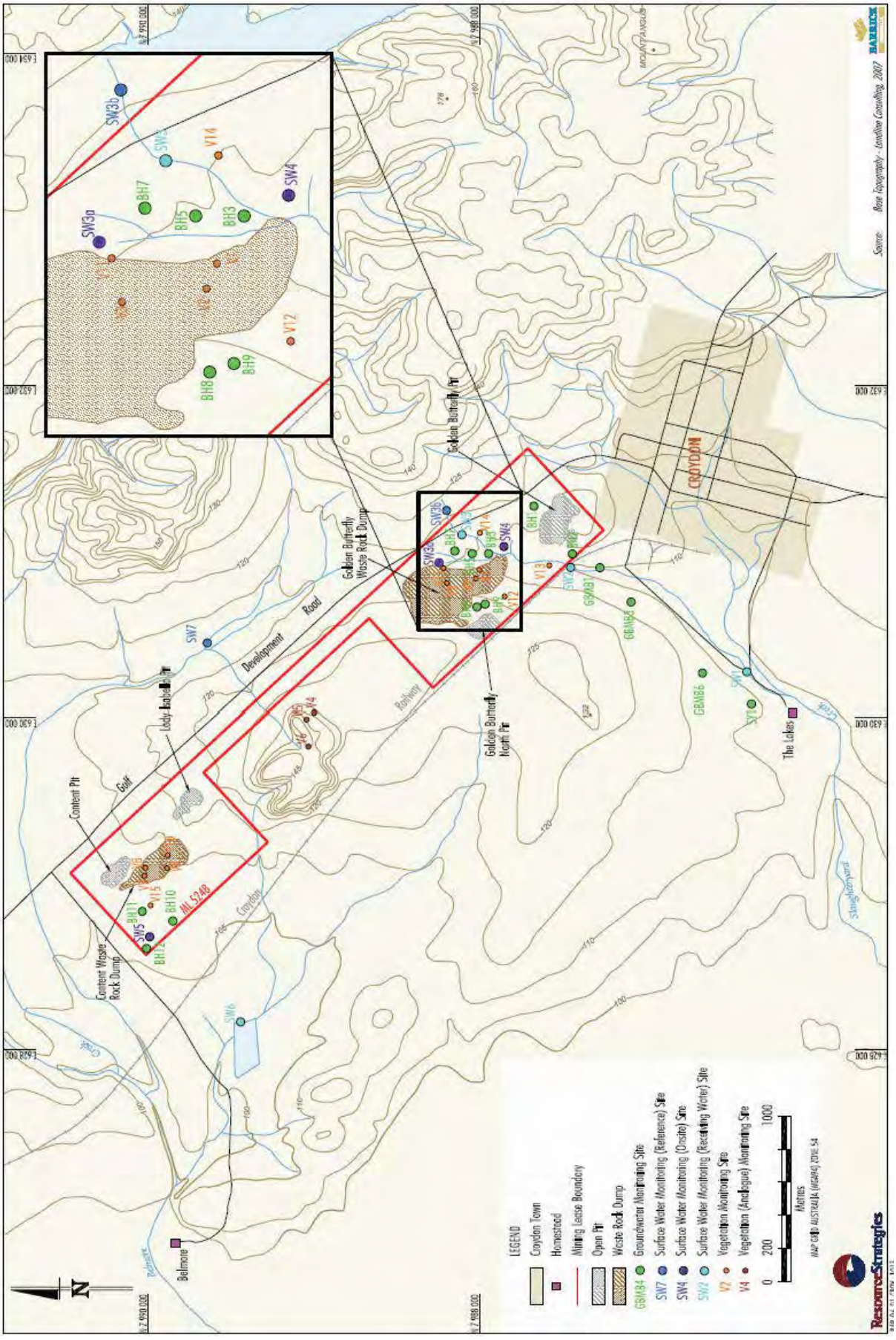

Figure 2: Site Location and Location of Environmental Monitoring Stations

Table 2:Post-Mining Land Description and Rehabilitation Objectives

Landform (refer Schedule H – Map 1)	Surface area (hectares)	Rehabilitation Objectives		
		Post-mine land description	Land classification[1]	Analogue site identification
Golden Butterfly North Pit	1.6	Non beneficial land use	Class VIII	Sites to be rehabilitated to a standard nominated in the rehabilitation program developed in accordance with Condition C2 1 based on analogue sites.
Golden Butterfly Pit	5.1	Non beneficial land use	Class VIII	
Lady Isabella Pit	1.7	Non beneficial land use	Class VIII	
Content Pit	2.1	Non beneficial land use	Class VIII	
Content Dump	6.3	L.I.G.[2]/disturbed native habitat	Class VI or better	
Golden Butterfly Dump	15.2	L.I.G.[2]/disturbed native habitat	Class VI or better	
Content Hardstand	2.0	L.I.G.[2]/disturbed native habitat	Class VI or better	
Golden Butterfly Hardstand	0.5	L.I.G.[2]/disturbed native habitat	Class VI or better	
Sediment Dams	1.5	L.I.G.[2]/disturbed native habitat	Class VI or better	
Roads / Tracks	3.5	L.I.G.[2]/disturbed native habitat	Class VI or better	

[1] QLD department of Minerals and Energy (2008).

[2] L.I.G. (Low Intensity Grazing) defined by criteria listed in Land Use Acceptance Criteria.

The final landforms were constructed when the Project was decommissioned/ closed in 1993 and additional rehabilitation works were substantially completed in 1996/1997. The final landforms on ML 5248 are dominated by low hills (i.e. waste rock dumps) which are compatible with the surrounding topography in terms of elevation and slope and final voids.

Schematic diagrams of the final landforms, inclusive of drainage features, are provided in Figure 3.

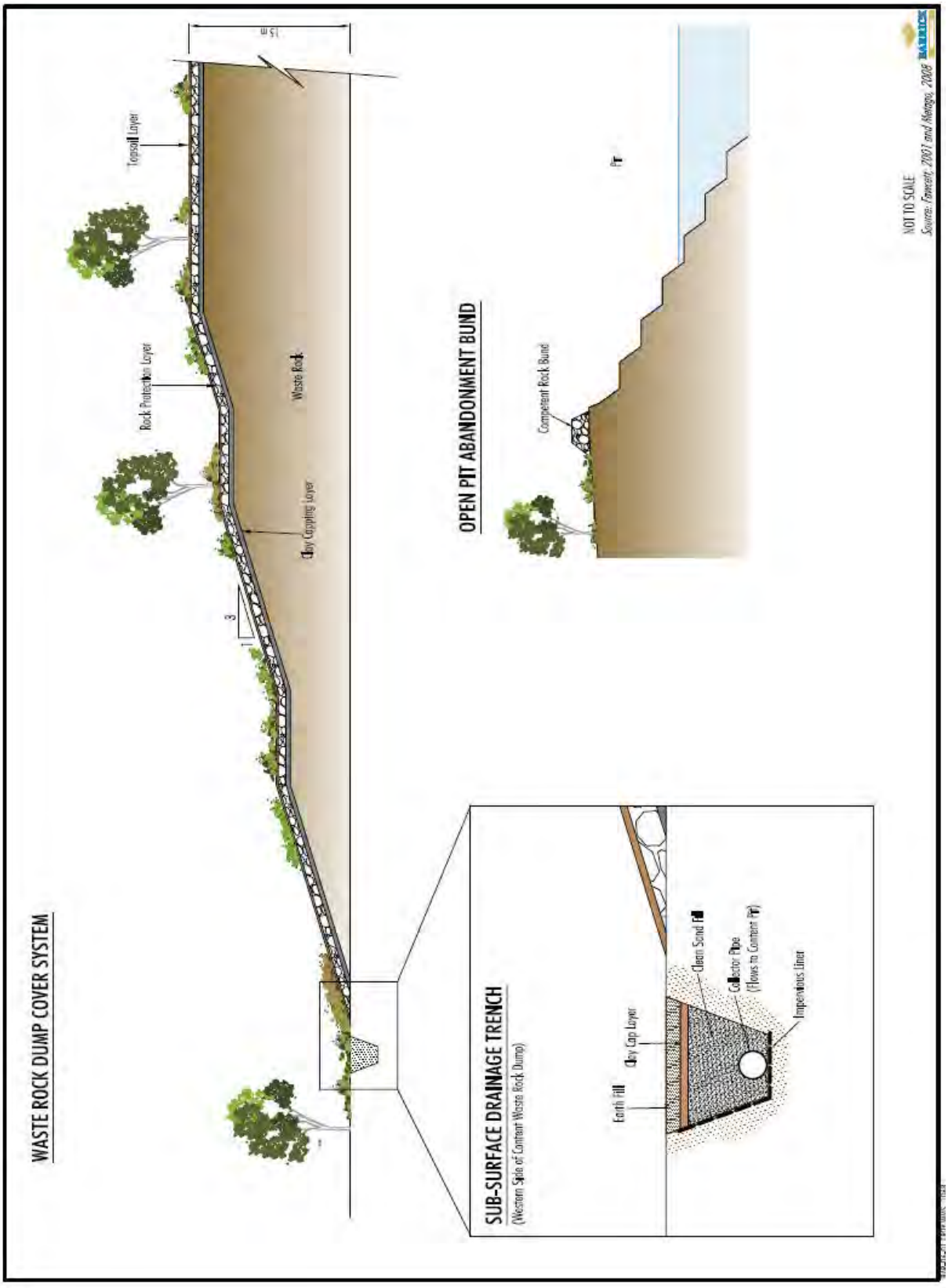

Figure 3: Waste Rock Dump Cover System and Open Pit Abandonment Bund Cross Section Schematics

2.3 SLOPE AND COVER DESIGN

Since the Project was decommissioned/ closed, reclamation works were conducted on the final landforms identified in Section 2.2. Full details of the reclamation works are reported in Fawcett (2001) and HLA Enviroscience s (2001a) .

The slope and cover design of the waste rock dumps have been developed to provide low permeability encapsulation. The reclamation work in 1996/ 1997 on both the Golden Butterfly and Content waste rock dumps involved (Figure 3):

- battering of slopes to 3H:1V minimum, with benches of 5 metres (m) width provided at a maximum of 5 m[1] vertical spacing; and
- construction of an engineered cover system consisting of a clay capping layer, a rock fill surface protection layer and a layer of topsoil.

Following preparation of the engineered cover system, all areas were sown with a seed mix of native tree and shrub species broadly representative of species found in the surrounding undisturbed woodlands .

2.3.1 Effectiveness of Cover System

The performance of the final cover system at the Project is monitored indirectly via erosion, vegetation and water monitoring. These monitoring parameters provide an indirect indication of the integrity of the final cover system. Details of the final cover system monitoring program are provided in the Rehabilitation Monitoring Program (Attachment A).

Golden Butterfly Waste Rock Dump Cover System

Monitoring indicates that the cover system on the Golden Butterfly waste rock dump is effective. The following monitoring sites provide an indication of the effectiveness of the cover system of the Golden Butterfly waste rock dump (Figure 2):

- on site surface water monitoring sites, SW3a and SW4;
- receiving water monitoring sites, SW1, SW2 and SW3, downstream of the Golden Butterfly waste rock dump; and
- vegetation monitoring sites, V1, V2, V3 and V11, on the surface of the Golden Butterfly waste rock dump.

On-site Surface Water Monitoring

On site surface water monitoring site SW3a (i.e. Golden Butterfly waste rock dump toe drain) (Figure 2) is consistently of good quality and records no exceedances of the contaminant limits specified in Schedule F – Table 8 of the EA..

On site monitoring site SW4 (i.e. stock water dam) (Figure 2) recorded one aluminium EA contaminant limit (5 mg/L) exceedance of 11mg/L in February 2005 and one pH range contaminant limit (greater than 4 pH units and less than 9 pH units) exceedance of 9.3 pH units in January 2007 during the period 2001 to 2011. No contaminant limit exceedances have been recorded since the pH range exceedance in 2007 at site SW4.

[1] HLA Enviroscience s (2001a) stated the vertical spacing of the Golden Butterfly and Content waste rock dumps as 50 m. However, it is considered the correct vertical spacing elevation of the waste rock dumps is 5 m.

Receiving Waters Monitoring

Each receiving water monitoring site surrounding the Golden Butterfly waste rock dump (i.e. SW1, SW2 and SW3) (Figure 2) displayed low pH levels and elevated levels of electrical conductivity (EC), sulphate, arsenic, cadmium, iron, manganese, lead and zinc during the period 1994 and 1995 (Landline Consulting, 2007). Following the reclamation works and clay capping of the Golden Butterfly waste rock dump in 1996, water quality at each receiving water monitoring site has improved. Since 1996, only short term exceedances of the contaminant limits specified in Schedule F – Table 3 of the EA have been recorded at these receiving water monitoring sites. Schedule F – Table 3 is reproduced in Section 8.

During the period 2001 and 2011, receiving water monitoring site SW1 has recorded two pH range contaminant limit exceedances, recording 9.1 pH units in February 2006 and 9.2 pH units in April 2006. No contaminant limit exceedances have been recorded since these pH range exceedances in 2006 at monitoring site SW1.

At receiving water monitoring site SW2, pH and aluminium exceeded the contaminant limits specified in Schedule F – Table 3 of the EA during the period 2001 to 2011. The pH contaminant limit range was exceeded on one occasion reaching 9.1 pH units in April 2006. The aluminium contaminant limit (5 mg/L) was exceeded on one occasion to 18 mg/L in January 2007. No contaminant limit exceedances have been recorded since 2007 at site SW2.

No contaminant limit exceedances have been recorded at receiving water monitoring site SW3 during the period 2001 to 2011.

Vegetation Monitoring

The groundcover monitoring results at the vegetation monitoring sites V1, V2, V3 and V11, on the surface of the Golden Butterfly waste rock dump were recorded in 2010 and are provided in Table 3. Data show that the Golden Butterfly waste rock dump fell below the recommended success criteria of 75% of the appropriate analogue areas for ground cover. However a significant portion of this failure is a result of inadvertent sampling during the low point in the vegetative production cycle which compromised the ability to identify all grass species. Further complicating identification of grasses as well as the overall evaluation was over utilization of forage by horses illegally pastured on the Golden Butterfly Waste Dump. However, rock and litter are major components of the cover system on the Golden Butterfly and Content waste rock dumps. Rock cover is considered an effective cover system component for preventing soil erosion.

An additional component to ground cover monitoring, and a criterion for successful rehabilitation, is species diversity, which can be a measure of biodiversity. There are two optional success criteria for species diversity. The landform must either exhibit: 1) greater than three non exotic species with greater than 2% relative cover, or 2) 50% of the number of non exotic species with greater than 2% relative cover from the appropriate analogue area. The Golden Butterfly waste rock dump exceeded both of these optional success criteria based on the analogue areas.

The Golden Butterfly waste rock dump display good potential for adequate and diverse plant communities. However, illegal grazing is significantly impacting the landform in terms of vegetative cover and limiting the ability of the monitoring program to produce data to demonstrate achievement of success criteria. Despite this situation, the fact that the waste rock dump is a target for illegal grazing demonstrates vegetation performance and that the Golden Butterfly waste rock dump is effective.

Table 3: Groundcover Monitoring Results for Croydon Waste Rock Dump Vegetation Monitoring Sites

	Scientific Name	Area --> Common Name	Content Dump	Golden Butterfly	Boiler Analogue	V Analogues
Grasses						
P	*Aristida sp.*	Wire Grass	0.42	0.04	2.03	4.19
A	*Brachiaria sp.*	Armgrass	-	-	-	0.07
P	*Cymbopogon bombycinus*	Silky Oilgrass	-	-	-	0.28
P	*Cyperus sp.*	Sedge	0.57	-	-	-
A	*Eriachne armitii*	Longawn Wanderrie Grass	2.24	-	-	-
I	*Pennisetum ciliare*	Buffelgrass	-	0.58	-	-
P	*Sedge sp.*	Sedge	-	-	-	0.07
A	*Setaria surgens*	Pigeon Grass	-	-	-	0.07
	Unidentifiable	**Grazed beyond recognition**	11.70	4.90	11.68	-
Herbaceous						
P	*Anisomeles malabarica*	Chodhava	-	-	-	0.03
P	*Cheilanthes brownii*	Lip Fern	-	-	-	0.03
E	*Hyptis suaveolens*	Horehound	0.76	0.31	1.55	0.69
E	*Sida cordifolia*	Flannel Weed	0.04	-	-	-
A	*Striga curviflora*	Witchweed	-	-	-	0.17
I	*Stylosanthes scabra*	Shrubby Stylo	0.15	6.29	-	-
A	*Triumfetta pannosa*	Chinese Burr	-	-	-	0.45
Shrubs and Trees						
P	*Acacia eleocantha*	White Thorn	0.08	-	-	0.14
P	*Acacia holosericea*	Silver-leaved Wattle	0.38	0.49	-	-
P	*Acacia julifera*	Wattle	-	-	0.12	-
P	*Acacia leptostachya*	Slender Wattle	-	-	-	0.03
P	*Corymbia confertiflora*	Broad leaved Carbeen	0.04	-	0.12	-
P	*Corymbia gummifera*	Red Bloodwood	0.08	-	-	-
P	*Corymbia pocillum*	Bloodwood	-	0.13	-	-
P	*Corymbia polycarpa*	Long-fruited Bloodwood	-	0.09	-	-
P	*Corymbia setosa*	Rough-leaved Bloodwood	0.08	0.22	-	-
P	*Erythrophleum chlorostachys*	Red Ironwood	-	-	-	0.07
P	*Eucalyptus chartaboma*	Queensland Flaky-bark	-	-	-	0.10
P	*Eucalyptus polycarpa*	Long-fruited Bloodwood	0.04	-	-	-
Overstory Hits						
P	*Acacia eleocantha*	White Thorn	11.30	-	-	3.44
P	*Acacia holosericea*	Silver-leaved Wattle	1.85	1.10	-	-
P	*Acacia julifera*	Wattle	-	-	32.40	-
P	*Acacia leptostachya*	Slender Wattle	-	-	-	4.78
P	*Acacia shirleyi*	Lancewood	4.30	2.45	-	-
P	*Adenanthera abrosperma*	Red Sandalwood	-	-	-	2.22
P	*Alphitonia excelsa*	Red Ash	-	-	-	3.89
P	*Corymbia aparrerinja*	Ghost Gum	-	0.35	-	-
P	*Corymbia confertiflora*	Broad leaved Carbeen	0.10	-	7.10	-
P	*Corymbia gummifera*	Red Bloodwood	0.05	-	-	-
P	*Corymbia papuana*	Ghost Gum	0.60	0.20	-	-
P	*Corymbia pocillum*	Desert Gum	-	1.80	-	-
P	*Corymbia polycarpa*	Long-fruited Bloodwood	0.75	4.20	-	-
P	*Corymbia setosa*	Rough-leaved Bloodwood	1.05	-	0.60	-
P	*Erythrophleum chlorostachys*	Red Ironwood	-	-	-	1.89
P	*Erythroxylum ellipticum*	Kerosene Tree	-	-	0.20	0.22
P	*Eucalyptus chartaboma*	Queensland Flaky-bark	-	-	-	20.06
P	*Eucalyptus polycarpa*	Long-fruited Bloodwood	4.05	-	-	-
P	*Gardenia vilhelmii*	Gardenia	-	-	-	0.50
P	*Petalostigma banksii*	Quinine Bush	-	-	0.10	-
P	*Terminalia aridicola*	Brown Damson	-	-	-	0.61
		Understory Plant Cover	**16.56**	**13.08**	**15.50**	**6.41**
		Rock (> 5 mm)	19.33	23.78	12.04	17.05
		Litter	32.92	41.94	29.74	37.26
		Bare Ground	7.14	11.10	2.32	1.66
		Overstory Plant Cover	**24.05**	**10.10**	**40.40**	**37.61**
		Total Plant Cover	**40.61**	**23.18**	**55.90**	**44.02**
		Annual and Perennial Cover (excluding exotics and unidentifiables)	**28.11**	**17.97**	**42.66**	**43.33**

Source: Barrick 2011.

To maintain the revegetation performance at this eastern section of ML 5248 (i.e. Golden Butterfly mining area) it is proposed that controlled low intensity grazing by domesticated stock on the area surrounding the Golden Butterfly waste rock dump occur only during the dry season. No grazing is to occur on the waste rock dump. Further details of the grazing management measures for the Project are provided in the Grazing Management Plan (Attachment B).

It is considered from the on site surface waters, receiving waters and vegetation monitoring results provided above that the cover system of the Golden Butterfly waste rock dump is effective and no works are proposed.

Content Waste Rock Dump Cover System

Monitoring indicates that the cover system on the Content waste rock dump is effective, with the exception of the western side on the waste rock dump. During the reclamation works conducted in 1996, the rehabilitation performance on the western batter was considered adequate and the western batter was not capped with the engineered cover system identified in Section 2.3. Seepage has affected the hardstand area to the west of the Content waste rock dump and may be a source of elevated parameters at site SW 5 (i.e. Sediment Dam) at the north western corner of ML 5248.

The following monitoring sites provide an indication of the effectiveness of the cover system of the Content waste rock dump (Figure 2):

- on site surface water monitoring sites, SW5;
- receiving water monitoring sites, SW6; and
- vegetation monitoring sites, V7, V8, V9 and V10, on the surface of the Content waste rock dump.

On-site Surface Water Monitoring

During the period 2001 to 2011, water quality at monitoring site SW5 demonstrated consistently low pH levels and elevated levels of aluminium and arsenic exceeding the contaminant limits specified in Schedule F – Table 8 of the EA. Schedule F – Table 8 of the EA is reproduced in Section 8. In addition a single exceedance of the cadmium contaminant limit was recorded in April 2011, while the nickel contaminant limit (1 mg/L) was exceeded on four occasions since 2001, with the last exceedance occurring March 2010.

The proposed reclamation works to be conducted during the term of this Plan of Operations (Section 3.1 of the Plan of Operations [Barrick, 2011]) includes excavation of the Sediment Dam (i.e. SW5), sampling and characterisation of the excavated and residual material in the Sediment Dam and the installation of a subsurface drainage trench at the western foot of the Content waste rock dump. However, these proposed works are dependent upon the outcomes of the refinement of the Content Pit hydrological model. At the completion of the proposed reclamation works, monitoring at the Sediment Dam will continue to assess the effectiveness of the works.

Receiving Waters Monitoring

Monitoring commenced at receiving water monitoring site SW6 in 1999 in response to the deterioration of water quality at the on site monitoring site SW5. During the period 2001 to 2011, aluminium exceeded the contaminant limit (5 mg/L) on seven occasions. No other contaminants exceeded the contaminant limits specified in Schedule F – Table 3 during the period 2001 to 2011 at monitoring site SW6. Schedule F – Table 3 of the EA is reproduced in Section 8.

Vegetation Monitoring

The groundcover monitoring results at the vegetation monitoring sites V7, V8, V9 and V10, on the surface of the Content waste rock dump were recorded in 2010 and are provided in Table 3. Data show that the Content waste rock dump fell below the recommended success criteria of 75% of the appropriate analogue areas for ground cover. However a significant portion of this failure is a result of inadvertent sampling during the low point in the vegetative production cycle which compromised the ability to identify all grass species. However, rock and litter are major components of the cover system on the Golden Butterfly and Content waste rock dumps. Rock cover is considered an effective cover system component for preventing soil erosion.

An additional component to ground cover monitoring, and a criterion for successful rehabilitation, is species diversity, which can be a measure of biodiversity. There are two optional success criteria for species diversity. The landform must either exhibit: 1) greater than three non exotic species with greater than 2% relative cover, or 2) 50% of the number of non exotic species with greater than 2% relative cover from the appropriate analogue area. The Content waste rock dump exceeded both of these optional success criteria based on the analogue areas. Further, it was determined that soil stability results were closely tied to the vegetation cover results. All evaluated slopes of the Content Waste Dump passed the soil stability standard. It is considered from these results that the vegetation performance on the Content waste rock dump is effective.

It is proposed that domesticated stock be permanently excluded from the western section of ML 5248 (i.e. Content and Lady Isabella mining areas) to minimise the impact of grazing on the revegetation performance in this area. Further details of the grazing management measures for the Project are provided in the Grazing Management Plan (Attachment B).

It is considered from the on site surface waters, receiving waters and vegetation monitoring results provided above that the cover system of the Content waste rock dump is effective, except for the western batter. The proposed reclamation works for the Content waste rock dump are scheduled during the yearly dry season period when site access and working conditions are suitable. However, the exact timing of the proposed works is dependent upon the outcomes of the refinement of the Content Pit hydrological model. At completion of the proposed reclamation works (Section 3.1 of the Plan of Operations [Barrick, 2208a]), monitoring at the on site water, receiving water and vegetation monitoring sites identified above, will continue to assess the effectiveness of the proposed works.

As required by Condition C2 2 (c) of the EA a report on the effectiveness of the above works on the Content waste rock dump cover system will be finalised when the proposed reclamation works are completed and will include monitoring results from site SW5, SW6, and V7 to V10.

Operation and Maintenance of the Vegetation Cover and Final Cover Systems

If vegetation, erosion and water monitoring indicates poor final cover system performance, reclamation works will be conducted to maintain the integrity and effectiveness of the final cover systems and vegetation performance at the Project. As stated above a report on the effectiveness of the final cover systems will be finalised upon completion of the proposed reclamation works described in Section 3.1 of the Plan of Operations (Barrick, 2011).

2.4 DRAINAGE DESIGN

A Water Management Strategy (WMS) has been prepared in accordance with Condition F7.1 of the EA. The WMS includes details of the drainage management strategies for the Project and is included as Appendix D of the Plan of Operations (Barrick, 2011). A summary of the WMS is provided below.

Water Management Strategy Summary

The WMS provides a drainage review of the Project, including the general relief, surface hydrology and hydrogeology.

Drainage management strategies have been prepared for the final landforms on ML 5248 where required. The proposed strategies will include:

- excavating a subsurface trench at the western foot of the Content waste rock dump and installing a collector pipe to drain any contaminated seepage to the Content Pit (Figure 3);
- capping the trench with a clay layer to exclude any surface runoff;
- excavating the salted area to the west of the Content waste rock dump, sampling and characterising the excavated and residual material, placing the excavated material in the Content Pit, back filling the excavated area and re contouring to shed all surface runoff to the west of ML 5248; and

A monitoring program of the surface water and groundwater monitoring sites will be conducted in accordance with the Rehabilitation Monitoring Program (Attachment A). The results of the monitoring program will be included in the annual review of the WMS which will assist in assessing the effectiveness of the proposed drainage management strategies.

Operation and Maintenance of Surface Water Management System

Should surface water monitoring indicate poor performance of the surface water management system, further reclamation works will be conducted. A description of the proposed drainage management plan for the Project is provided in the WMS (Appendix D of the Plan of Operations [Barrick, 2011]).

2.5 EROSION AND SEDIMENT CONTROL

An Erosion and Sediment Control Plan (ESCP) has been prepared in accordance with Condition F5 1 of the EA. The ESCP details the erosion protection and sediment control measures implemented at the Project and is included as Appendix E of the Plan of Operations (Barrick, 2008a). A summary of the ESCP is provided below.

Erosion and Sediment Control Plan Summary

The ESCP provides a review of the status and sources of erosion and sediment on the Project. The principles that underpin the control measures are provided to justify the proposed erosion protection and sediment control works.

The proposed erosion protection and sediment control measures for the final landforms on ML 5248. will include:

- excavating the Sediment Dam (i.e. SW5) in the north west corner of ML 5248, sampling and characterising the excavated and residual material, placing the excavated material in the Content Pit and constructing a shallow sediment dam to capture any sediment transport off ML 5248; and
- maintenance works on existing drainage structures in the event of major damage due to extreme storm events (e.g. cyclones).

A monitoring program of the vegetation monitoring sites will be conducted in accordance with the Rehabilitation Monitoring Program (Attachment A). The results of the monitoring program will assist in assessing the effectiveness of the proposed erosion and sediment control measures and if necessary, the ESCP will be updated where required.

2.6 MATERIALS BALANCE

A materials investigation was conducted by Woodward Clyde (1996) at the Golden Butterfly and Content waste rock dumps and near surrounds during the reclamation works of 1996/1997. The materials characteristics from this investigation are identified in Section 4.

In addition to this investigation and in accordance with EA Condition C2 2 (i) a materials balance, including low permeability encapsulation media, has been prepared for the proposed reclamation works scheduled for the Content waste rock dump as described in Section 3.1 of the Plan of Operations (Barrick, 2011). The materials balance, including low permeability encapsulation media, for the proposed works is provided in Table 5.

Table 4: Materials Balance

Material Requirements/Sources	Volume (m^3)
Material Requirements	
Content hardstand area	
Rock mulch and soil	10,000
Sand	450
Clay	45
Material Sources	
Golden Butterfly waste rock dump - east haul ramp	
Rock mulch	6,000
External sources	
Rock mulch and soil	5,000
Sand	450
Clay	45

Note: m^3 = cubed metres

3 GEOTECHNICAL ASSESSMENT

There is no documentation available to indicate that any historical geotechnical investigations have been completed. A geotechnical investigation of the various landforms at the Croydon site was conducted by Allan Watson Associates in November 2009 based on the following scope of work:

- Data review of available information relating to the Project site and associated landforms.
- Site visit and geotechnical assessment, comprising a confirmation of general geological setting and a detailed visual inspection of each landform to identify key geotechnical issues /constraints.
- Geotechnical interpretation and analysis to further characterise the mining landforms and to isolate any geotechnical issues of significance.

The focus of this scope of work has been to inform a Project risk assessment conducted by Barrick, in compliance with the requirements of the EA No. MIN100401906.

3.1 MINING RELATED LANDFORMS

The mining related landforms on ML 5248 comprise waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads /tracks) surrounding the open pits and waste rock dumps. These landforms are located on Figure 2 and include the following:

- Golden Butterfly pit.
- Golden Butterfly North pit.
- Golden Butterfly waste rock dump.
- Content pit.
- Content waste rock dump.
- Lady Isabella pit.
- Hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps.
- Stormwater diversion bunds and sediment /stormwater dams adjacent to the Content and Golden Butterfly waste rock dumps.
- Roads and tracks.

No processing infrastructure (e.g. plant areas or tailings storage facility) was located within ML 5248. Furthermore, historic mine workings (e.g. shafts and mullock heaps are located near to the site but outside ML 5248.

3.2 SUMMARY OF GEOTECHNICAL ASSESSMENT

The geotechnical assessment identified areas of geotechnical significance. A summary of these areas is as follows:

- There is potential for a slip failure within the sandstone on the south western face of the Golden Butterfly North pit that would also include the overlying fill. Given the sub horizontal bedding of the sandstone, which precludes a block type failure, such a failure would likely occur by a circular failure mechanism within the mass of the pit wall. The circular failure mechanism could be initiated through saturation of tension cracking observed within the surface of the fill profile which would act as a surcharge to the pit wall. The adjacent Croydon Railway and surcharge from the abandonment bund could also be potential mechanisms for failure.
- The southern pit wall of the Golden Butterfly pit is surcharged by an area of fill material, with evidence of tension cracking within the surface of the fill profile. Whilst it is considered that the cracking occurred as a result of settlement immediately following placement, and not an indication of imminent failure, instability could occur with excessive water ingress within the fill material with the fractured surface being confined to the fill profile.

- Under cutting of the less competent alluvium below a ferricrete profile is possible on the north western face of the Content pit, being initiated by water level drawdown in the pit.
- Shear foliation noted in the granite in the south western face of the Lady Isabella pit may allow shallow translational or planar failures into the pit void. The scale of such a failure would be limited. No specific mechanism would exist to initiate such movement.
- With the exception of the potential slip failure of the south western face of the Golden Butterfly North pit, it is considered that a higher level of investigation is not warranted for the areas of geotechnical significance.

Given the potential consequence of a failure of the south western face of the Golden Butterfly North pit affecting the Croydon Railway, it is considered that additional investigations into this area of geotechnical significance are required. A slope stability has therefore been conducted and is and discussed in the following section.

3.3 GOLDEN BUTTERFLY NORTH PIT STABILITY ASSESSMENT

The stability analysis was completed using the Slope/W computer package, which uses limit equilibrium theory to solve for the factor of safety of earth and rock slopes. The model calculates a factor of safety for a modeled two dimensional section, satisfying both moment and force equilibrium. This software is widely used in the assessment of stability of landforms such as the Golden Butterfly North pit wall.

In the absence of a detailed intrusive investigation program (eg drilling and sampling of subsurface materials), no opportunity for geotechnical testing of pit wall material to identify strength parameters was available. Notwithstanding, an inspection of rock mass and structure was made at the south western pit face as part of the geotechnical assessment. Given the sub horizontal bedding of the Coffin Hill Member sandstone in the walls, with bedding struck into the face, any failure would occur through the rock mass rather than via structural lineation. Compressive strength of the sandstone rock, based on rock quality observed in the pit face has been estimated to be 10 to 50mPa. It has also been estimated that effective strength properties for intact rock, tested in direct shear, would be in the order of:

Fraction Angle (ϕ') 40 to 60 degrees
Effective Cohesion (c') up to 100 kPa

For the purpose of this assessment, the following unit weighting for fill and insitu sandstone were adopted:

Sandstone 21.0kN/m3
Fill 17.0kN/m3

No strength parameters for the fill profile were considered as it is considered that any localized failure within this material would be of low consequence (i.e. would not affect the Croydon Railway). All theoretical failure circles were therefore forced into the sandstone unit.

The stability model assumed that the sandstone profile was dry (i.e. assuming groundwater coincided with pit water level), although assumed that the tension crack was saturated as void recharge to the pit face. The overall assessment methodology adopted for the stability assessment overestimates the potential for pit wall failure and is therefore considered to be conservative.

The typical range of the calculated strength parameters for the sandstone mass based on the analysis was as follows:

Fraction Angle (ϕ') 45 degrees
Effective Cohesion (c') 60 kPa

This combination of strength parameters are within the estimated range of strength properties as outlined above and are at the lower bound for strength properties of intact rock. The sensitivity of the model to the applied line load representing the train (i.e. 10kN/m) was carried out. Line loads up to 30kN/m were applied with no change to the FoS for a failure encompassing the Croydon Railway. It is considered based on this analysis that the Golden Butterfly North pit wall (excluding minor failures which may occur within the granitic spoil) is stable and that failure of the pit face encompassing the railway line based on the assumed parameters has a FoS greater than 1.5.

4 GEOCHEMICAL ASSESSMENT

Woodward Clyde (1996) investigated the acid producing potential of various rock types within the waste rock dumps and surrounding areas (i.e. former hardstand and ore stockpile areas and drainage channels) including key mine related landforms and infrastructure areas (HLA Enviroscience s, 2001a). The Woodward Clyde (1996) investigation included the excavation of 49 test pits from the locations identified in Table 6. Materials recovered from each pit were geologically logged, and tested for pH and EC in the field. Representative samples of each identifiable waste rock unit were collected for laboratory analysis. Analysis for total sulphur and acid neutralising capacity was carried out on these samples for estimation of the maximum potential acidity and net acid producing potential. The characteristics of the materials are provided in Table 6.

Table 5: Materials Characteristics

Location	Materials Characteristics	Potential for Acid Production
Golden Butterfly Waste Rock Dump	• Surface soil layer of clay and red sand overlying grey granite waste. • White granite materials were encountered beneath the surface soils in some areas.	• Indeterminate • Indeterminate
Content Waste Rock Dump	• Brown sandy topsoil layer overlying grey granite waste. • Thin layers of red gravelly clay were encountered in some areas. • Grey granite was found on the dump surface in a number of locations.	• Potentially Acid Producing Grey Granite • Indeterminate • Potentially Acid Producing Grey Granite
Haul Road	• Mixture of granite, sand and red gravelly clay. • The mixed waste material was considered to be potentially acid producing, however due to the high level of compaction of the haul road, the materials were effectively encapsulated.	• Potentially Acid Producing Grey Granite • Potentially Acid Producing Grey Granite
Stockpile Area	• Surficial red sand/ sandstone overlying grey granite, similar to that found in Golden Butterfly waste rock dump.	• Potentially Acid Producing Grey Granite
Western Side of Content Pit	• Grey granite waste similar to Content waste rock dump.	• Potentially Acid Producing Grey Granite
Drainage Channel	• Red clay to brown sandy clay.	• Indeterminate
North of Golden Butterfly Pit	• Non acid producing natural soils.	• Non Acid Producing

Source: Woodward Clyde (1996)

The investigation resulted in the re profiling and capping of the Golden Butterfly and Content waste rock dumps and the removal of all potentially acid generating material from the Golden Butterfly and Content stockpile hardstand areas and the Slaughteryard Creek drainage channel. These works were conducted in 1996. No further geochemical work is considered necessary for the Project.

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5 HYDROLOGICAL AND HYDROGEOLOGICAL ASSESSMENTS

5.1 HYDROLOGICAL ASSESSMENT

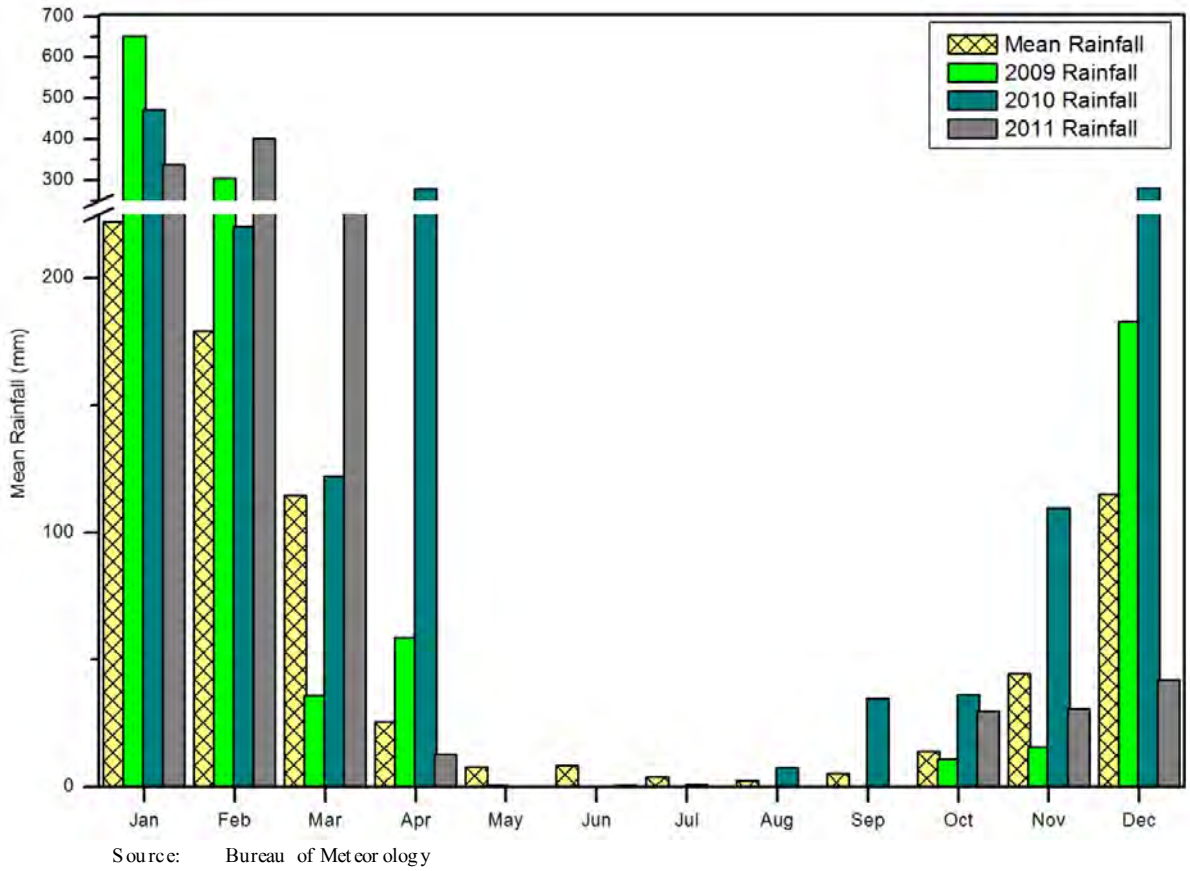
This section provides a description of the existing hydrological environment at the Project. The water management requirements and proposed drainage remediation works for the Project have been prepared and are included in the WMS (Appendix D of the Plan of Operations [Barrick, 2011]). The water quality from the surface water monitoring sites is analysed to provide an indication of the rehabilitation performance at the Project.

5.1.1 Existing Hydrological Environment

Rainfall

The Project experiences highly seasonal rainfall with an average annual rainfall of 747.9 mm (Table 7). This rainfall pattern is illustrated in Figure 4.

Figure 4: Average Monthly Rainfall Totals for Croydon Township



Source: Bureau of Meteorology

Flow Regime

The highly seasonal nature of rainfall means that all local creeks are ephemeral. The south eastern section ML 5248 (i.e. the Golden Butterfly mining area) is within the upper catchment of Slaughteryard Creek and the north western section of ML 5248 (i.e. the Content and Lady Isabella mining areas) lie within the Belmore Creek catchment.

There is no hydrological flow gauging records for ML 5248, however it is considered that surface water runoff in local creeks and drainage lines ceases relatively soon after storm events. Gradients are very low on much of ML 5248 which means that sheet flow is the dominant hydrological process during the short wet season.

Table 6: Croydon Township Weather Station Rainfall Data

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	
Mean rainfall (mm)	223	181	115.7	25.5	7.8	8.5	3.9	2.7	5.5	14	44.6	116.3	747.9	1889 2011
Highest rainfall (mm)	860.5	601.4	591.4	279.8	129.3	139.2	83.4	44.2	92.7	145	384.7	312	1565.8	
Date	1974	1964	1936	2010	1920	1990	2006	1924	1943	1975	1973	1942	2010	
Lowest rainfall (mm)	49.4	5.3	0	0	0	0	0	0	0	0	0	0.5	225.4	
Date	2003	1926	1988	2008	2011	2010	2011	2011	2011	2008	2003	1934	1952	
Decile 1 rainfall (mm)	73.2	43.5	16.5	0	0	0	0	0	0	0	5.8	36.2	438.6	
Decile 5 (median) rainfall (mm)	200.8	170.6	93.7	9.9	0.4	0.4	0	0	0	4.6	27.6	103.6	715.7	
Decile 9 rainfall (mm)	397	304.2	239.3	63.6	22.9	21.1	11.1	8.9	20	37	95.5	232.5	1038	
Highest daily rainfall (mm)	381	367.8	245.9	155.2	63.5	91	35	39.6	77.5	63.5	151.1	153	381	
Date	29 JAN 1908	05 FEB 1964	12 MAR 1936	06 APR 2010	07 MAY 1956	05 JUN 1990	15 JUL 2006	29 AUG 1924	04 SEP 1943	15 OCT 1964	27 NOV 1973	20 DEC 1976	29 JAN 1908	
Mean number of days of rain	12.8	12.3	8.3	2.1	1	1	0.6	0.4	0.6	1.8	4.5	8.3	53.7	
Mean number of days of rain ≥ 1 mm	11.9	11.3	7.3	1.8	0.8	0.8	0.5	0.3	0.5	1.4	3.8	7.6	48	
Mean number of days of rain ≥ 10 mm	6	5.5	3.3	0.6	0.3	0.2	0.1	0.1	0.2	0.5	1.3	3.4	21.5	
Mean number of days of rain ≥ 25 mm	2.8	2.2	1.4	0.3	0.1	0.1	0	0	0.1	0.1	0.5	1.4	9	
Monthly rainfall (mm)	338.8	401.6	241.6	13.2	0	0.6	0	0	0	30	36.4	42.2	1104.4	2011
Highest daily rainfall (mm)	77	142.4	53.2	12.4	0	0.6	0	0	0	17.8	25.8	14.8	77	
Number of days of rain	16	18	21	3	0	1	0	0	0	4	5	9	77	
Number of days of rain ≥ 1 mm	16	15	20	1	0	0	0	0	0	2	4	6	64	
Number of days of rain ≥ 10 mm	11	8	6	1	0	0	0	0	0	2	1	1	30	
Number of days of rain ≥ 25 mm	5	5	2	0	0	0	0	0	0	0	1	0	13	

Note: Data sourced from www.bom.gov.au (Croydon Station No 29012)

On-site Water Storages

The on site water storages on ML 5248 include the following (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Lady Isabella Pit;
- Content Pit;
- Golden Butterfly waste rock dump toe drain (i.e. SW3a);
- Stock water dam (i.e. SW4); and
- Sediment dam (i.e. SW5).

A summary of the most recent open pit water quality and surface water quality data (2000 to 2011) is provided in Table 8 and Table 9

Monitoring

In addition to the open pit and on site surface water monitoring sites identified above, the surface water monitoring program is inclusive of the following receiving water monitoring sites (Figure 2):

- SW1 (lower Slaughteryard Creek);
- SW2 (Slaughteryard west tributary at the boundary of ML 5248);
- SW3 (Slaughteryard Creek upstream of the Golden Butterfly waste rock dump);
- SW6 (Belmore Creek borrow pit/stock dam);
- SW3b (Reference site for Slaughteryard Creek); and
- SW7 (Reference site for Belmore Creek).

A summary of the most recent receiving water quality data (2000 to 2011) is provided in Table 9. No biological monitoring has been conducted at the Project. Given that no waste water treatment system is operating at the Project, it is considered that the monitoring of biological parameters in surface water is not required.

The monitoring program for the open pit waters, on site water storages and receiving waters is provided in the Rehabilitation Monitoring Program (Attachment A).

Open Pit Water Balance and Storage Capacity

An investigation conducted by HLA Enviroscience (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping. The consecutive unprecedented rainfall totals experienced since 2008/2009 support this conclusion in regards to the Golden Butterfly and Golden Butterfly North Pits. However, the overtopping and discharge from the Content Pit during early 2011 obviously shows that the conceptual hydrogeological model in terms of the Content Pit and Lady Isabella Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation.

Water Demand

As the Project is decommissioned/closed water would only be required for reclamation works. Water for these works would be sourced from the Golden Butterfly North Pit.

Table 7: Pit Lake Water Quality 2000-2011

Parameter	Sample Site							
	Golden Butterfly		Golden Butterfly North		Content		Lady Isabella	
	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	2.3 2.8	2.5	5.8 7.7	6.8	3.3 4.3	3.8	3.4 4.6	3.7
EC (µS/cm)	2910 12000	5971	60 370	270	737 1800	1135	491 1300	891
SO_4 (mg/L)	1910 8000	5130	11 92	69	300 780	483	180 610	372
Cu (mg/L)	3.3 24	14.1	<0.005 <0.05	<0.05*	0.048 0.28	0.12	0.13 1.4	0.69
Pb (mg/L)	<0.002 <0.005	<0.005*	<0.001 <0.002	<0.002*	<0.001 <0.002	<0.002*	0.002 0.007	0.003
Ni (mg/L)	1.56 8.5	5.10	<0.004 <0.05	<0.05*	0.087 0.32	0.18	0.14 0.77	0.39
Al (mg/L)	122 700	436	0.025 0.73	0.20	1.31 7.0	3.1	2.98 20	9.8
Zn (mg/L)	2.4 36	19.2	<0.005 0.05	0.011	0.23 1.1	0.58	0.82 5.8	2.98
Co (mg/L)	1.24 7.3	3.5	<0.005 <0.05	<0.05*	0.09 0.29	0.14	0.109 0.53	0.25
Cd (mg/L)	0.055 0.34	0.19	<0.0001 0.0002	<0.0002*	0.0021 0.023	0.006	0.013 0.19	0.08
Fe (mg/L)	240 450	356	<0.05 0.18	0.06*	0.69 1.5	0.95	<0.05 0.66	0.23*
Mn (mg/L)	56 110	79	<0.05 0.17	<0.05*	3.7 5.2	4.4	3.3 6.3	4.7
As (mg/L)	0.34 1.3	0.71	<0.005 0.01	<0.005*	<0.005 0.058	0.015	<0.003 0.013	0.004

Notes : * indicates median, below detection results have been replaced with half the relevant detection limit to calculate averages.

Table 8: Water Quality Summary of Surface Water Monitoring Sites 2000- 2011

Parameter	Sample Site													
	SW1		SW2		SW3		SW3b		SW4		SW5		SW6	
	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	6.2 9.2	7.20	5.7 9.1	6.78	6.2 8.00	6.96	5.3 6.76	6.16	6.4 9.3	7.45	3.5 6.75	4.3	5.3 9.0	7.4
EC (ȣS/cm)	77 610	245	64 301	144	38 450	116	17 97	54	38 770	159	32 1400	473	24 480	105
S04 (mg/L)	12 100	44	18 96	42	9 140	25.3	5 23	12.4	8 150	32	6 810	210	<1 43	12.6
Cu (mg/L)	0.004 0.063	0.019	<0.001 – 0.022	0.01	0.001 0.05	0.02	0.001 0.03	0.01	0.002 0.020	0.008	<0.001 2.5	0.38	0.001 0.158	0.018
Pb (mg/L)	<0.001 0.004	0.002*	0.001 0.01	<0.002*	<0.002 0.004	<0.002*	<0 .002 0.004	<0.002*	0.001 0.012	0.004	<0.002 0.006	<0.002*	<0.002 0.047	0.006*
Ni (mg/L)	<0.002 0.003	0.002	<0.001 – 0.011	0.004	<0.001 0.03	0.02	<0.001 0.03	0.01	<0.001 0.025	0.010	<0.001 1.0	0.20	<0.001 0.025	0.017
Al (mg/L)	0.06 2.7	0.55	0.01 18	1.08	<0.05 3.5	0.41	<0.01 0.62	0.12	0.03 11.0	0.93	0.11 77	9.8	0.025 350	9.1
Zn (mg/L)	0.008 0.03	0.018	<0.005 – 0.07	0.04	0.003 0.17	0.02	0.01 0.03	0.01	<0.005 0.110	0.020	<0.005 6.0	0.95	<0.005 0.073	0.019
Co (mg/L)	<0.005 <0.05	<0.05*	<0.001 0.003	0.002	<0.001 0.03	0.3	<0.001 0.03	0.01	<0.001 <0.05	<0.05*	<0.001 1.0	0.21	<0.001 0.025	0.020
Cd (mg/L)	<0.0002 0.0002 5	<0.0002*	<0.0001 0.0002	0.0001	<0.0001 0.0003	0.0001	<0.0001 0.0003	0.0001	<0.0001 0.0002	0.0001	<0.0001 0.24	0.036	<0.0001 0.0004	0.0001
Fe (mg/L)	0.33 2.7	1.19	0.27 1.2	0.69	0.73 5.2	2.05	0.33 1.2	0.77	0.42 5.1	1.30	0.08 0.39	0.24	0.57 13	2.6
Mn (mg/L)	<0.05 0.24	<0.05*	<0.05 0.014	0.08*	<0.05 1.9	<0.05*	<0.05 0 .07	<0.05*	<0.05 0 .14	<0.05*	0.31 10	3.69	<0.05 0.14	<0.05*
As (mg/L)	<0.005 0.033	0.010	<0.001 – 0.055	0.02	0.002 0.07	0.01	<0.001 0.018	0.004	0.003 0.04	0.01	0.002 0.02	0.004	<0.001 0.011	0.003

Notes : * indicates median, below detection results have been replaced with half the relevant detection limit to calculate averages .

Water Management Requirements

In accordance with Condition F7 1 of the EA a WMS is required. The WMS is provided as Appendix D in the Plan of Operations (Barrick, 2011). The WMS provides a drainage review of the Project, including the general relief, surface hydrology and hydrogeology. Drainage management strategies have been prepared for the final landforms on ML 5248. A brief description of the proposed drainage management strategies is provided in Section 2.4.

5.2 HYDROGEOLOGICAL ASSESSMENT

This section provides a description of the existing groundwater environment at the Project and provides a brief description of the conceptual hydrogeological model that was developed for the Project during the preparation of the Environmental Management Plan (Barrick, 2008b). The conceptual hydrogeological model was based on available hydrogeological and groundwater quality information.

5.2.1 Existing Groundwater Environment

It is expected that the area covered by ML 5248 is a 'hardrock' geological terrain with groundwater hosted in the upper weathered rock horizon and deeper fractured rock aquifers associated with the mineral deposit. This is supported by the limited use of groundwater in the surrounding region for stock watering. The aquifers are therefore not considered a potential resource. Groundwater quality is expected to reflect the mineralised nature of the country rock and bore yields are likely to be highly erratic due to the expected lack of hydrogeological interconnectivity between fractures. Regional groundwater levels are believed to be some 15 m below ground surface and any groundwater exploration would have to target geological structures.

The only known use of groundwater in the surrounding area is the decommissioned town borefield located some 2 km to the south west of ML 5248. The town borefield, which exploited an unconfined alluvial aquifer located along Slaughteryard Creek and deeper sedimentary bedrock aquifers, was decommissioned in 1995 when Lake Belmore was constructed as the permanent town water supply. Anecdotal evidence (Croydon Shire Council Engineer, pers. comm., 2008) indicates that many of the initial bores were dry and yields in the equipped bores rapidly decreased from an initial 1.3 litres per second (L/s) to 0.2 L/s at the time of decommissioning. Groundwater quality in this aquifer was fresh but several bores and the shallow wells had a high iron content. At the time unsuccessful attempts were made to implement a local artificial recharge scheme within the creek sands. Currently only two shallow wide diameter wells remain functional as a potential backup water supply for the town oval.

Fractured Rock Aquifers

Groundwater monitoring and pit lake recovery trends support the hypothesis that the deeper fractured rock aquifers are highly variable in water quality and have limited connectivity. Figure 5 shows the conceptualised hydrogeology in the Golden Butterfly Pit area. Groundwater levels on either side of the pit differ by up to 5 m and water qualities differ significantly (i.e. Bores BH1 and BH2) (Figure 6 and Table 9). It is suggested, based on the groundwater quality data (Table 9, Table 10, Table 11) that a major geological contact exists between bores GBMB2 and GBMB3 (Figure 5). This is borne out by the geology and the different water quality found in Golden Butterfly North Pit (Table 7). A summary of the groundwater quality from 2000 to 2011 is provided in Table 9, Table 10, and Table 11.

All four pits (i.e. Golden Butterfly, Golden Butterfly North, Content and Lady Isabella) now contain pit lakes largely as a result of groundwater inflow at depth from expected rock aquifers. The differing pit water qualities reflect country rock geology and varying mineralisation within the ore deposit through which the groundwater is moving prior to entering the pits. A summary of the water quality from 2000 to 2011 of the four open pits is provided in Table 7.

A hydrogeological study by HLA Enviroscience (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit (due to short wet season and high evaporation during most of the year) and that even in the wettest years there is no risk of the pit lakes overtopping. A simple water balance indicates that the pit lakes are expected to act as groundwater sinks and have limited capacity to influence groundwater quality much beyond the immediate footprint of the pit.

This hypothesis is supported by water quality monitoring results with a change in water quality occurring with increased distance from the Golden Butterfly Pit (shown in Table 9, Table 10, and Table 11). Despite these conclusions from the conceptual hydrogeological model the unprecedented rainfall totals experienced since 2008/2009 raised concerns about the model's robustness.

The 2008/2009 and 2009/2010 wet seasons resulted in extraordinary rainfall totals (Figure 4). In recognition of the possibility of a discharge from the Content Pit, Barrick had undertaken short term remediation works involving the transfer from water from the Content Pit to the Golden Butterfly Pit to minimise the risk of the Content Pit overtopping during the 2010/2011 wet season. The water level of the Content Pit was decreased by approximately four (4) meters during November and December 2010 (with a subsequent increase of one (1) meter in the Golden Butterfly Pit). Nevertheless, on the 29th March 2011 the Content Pit began discharging water which continued until the 13th April 2011 when no flow was observed to be entering receiving streams. This event obviously shows that the conceptual hydrogeological model in terms of the Content Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation.

A possible addition to the hydrogeological model for the Content Pit is the inclusion of a hydraulic connection with the Lady Isabella Pit. Figure 7 presents an aerial photograph of the area around the Content Pit overlaid with a contour map. The Lady Isabella Pit when full is approximately five meters higher in elevation that the Content Pit discharge level. This elevation difference provides a hydraulic driving force which with the relative close proximity of the Lady Isabella Pit to the Content Pit and possible connecting facture zones and or fault lines enabling water flow.

Unconfined Alluvial Aquifer – Slaughteryard Creek

The Slaughteryard Creek unconfined alluvial aquifer previously exploited by the original town water supply borefield is located off ML 5248 and some 2 km from the Golden Butterfly Pit (Figure 5). Although there are no bore logs for the town borefield, it is believed that it utilised the shallow unconfined alluvial aquifer associated with Slaughteryard Creek. It is expected that the unconfined alluvial aquifer is locally recharged by surface water flow within the creek. As previously stated the surface water recharge component that can be attributed to the Golden Butterfly Pit Lake is most unlikely. This has been confirmed by groundwater monitoring over the past ten years (Table 10, Table 11 and Table 12).

Groundwater Management Requirements

In addition to the groundwater monitoring network additional hydrogeological investigations are required by Condition F4 6 of the EA. A hydrogeological investigation/assessment was conducted in 2009 (Barrick, 2010) with the aim to confirm the conceptual hydrogeological model. In accordance with EA Condition F4 6 the hydrogeological investigation/assessment included:

- Obtaining additional geological information, regional groundwater use and bore water levels.
- Analysing groundwater quality data from the decommissioned town water supply bores.
- Surveying pit lake water levels and erection of water level gauges.
- Pit water level fluctuations and behaviour.

The 2009 hydrogeological investigation/assessment (Barrick, 2010) concluded the following:

- Groundwater is not considered a significant water resource within the mining lease and does not support or recharge any surface water drainage system. Some groundwater contamination has occurred below sections of the Content waste rock dump and around the mine pits. This contamination is highly localised and of no environmental concern, except along the western toe of Content Waste Rock Dump where remedial drainage measures are planned.

- There is no direct hydrogeological link between the Golden Butterfly Pit Lake and the Town Borefield or Lakes homestead bore and no possibility of this alluvial aquifer being contaminated by pit lake seepage water.
- The mine pits which have been considered hydrogeological sinks have until recently been slowly filling with rain and groundwater seepage. The two southern pits, namely, Golden Butterfly and Golden Butterfly North remain groundwater sinks and are likely to always be sinks if all stormwater runoff is diverted away from the surrounding area. Content and Lady Isabella Pits on the other hand have now filled with water to the extent that pit lake levels reflect local groundwater levels and hence currently represent hydrogeological flow through cells.
- The water quality in the pit lakes has improved over the past 20 years, and it is only Golden Butterfly Pit that currently has a true acid mine drainage problem. Access to this pit lake must be restricted at all times. The current water quality in the remaining pit lakes does not exclude their use for irrigation in the case of Golden Butterfly North and dust suppression (road construction) for Content and Lady Isabella. There is however an ongoing safety concern and issue that natural evapo concentration will continue in all pit lakes, particularly during low rainfall cycles. As such these facilities should not be considered as potential stock water supplies and all access restricted to avoid any unnecessary safety liabilities.
- Current water balance modelling and field observations suggests that the proposed surface drainage plan for the Golden Butterfly Pit area needs to be fully implemented before the next wet season. The relatively simple earth works proposed could significantly reduce seepage and groundwater recharge to the mine pits. It is also suggested that drainage measures be put in place to provide for potential managed discharge (spillage) from Content Pit lake. This is a precautionary measure that needs to be taken as this pit lake will at some stage briefly overtop and the excess water needs to be directed in a control manner to discharge into the adjacent Belmore Creek. Water quality is not considered an issue, should such a spill occur, particularly as it would only occur during extreme flood conditions.

All recommendations for earthworks and other physical changes to improve drainage measures and restrict access to the various pit lakes were implemented during 2009/ 2010.

In order to provide additional information to assist in refining the conceptual hydrological model, a series of water level monitoring stations have been installed during November 2011 in each of the pit lakes at Croydon (Figure 8). Each of these stations is fitted with a pressure sensor transducer connected to a data logger with solar powered battery supply. Additionally, in the event of a further discharge from the Content Pit, a measuring flume has been installed in the v drain which will direct any outflow from the Content Pit.

Operation and Maintenance of Groundwater Monitoring Network

The groundwater monitoring network for the Project includes the groundwater monitoring sites identified in Section 8 and is described in the Rehabilitation Monitoring Program (Attachment A).

The groundwater monitoring bores will be inspected during each monitoring event and maintenance would be conducted as required.

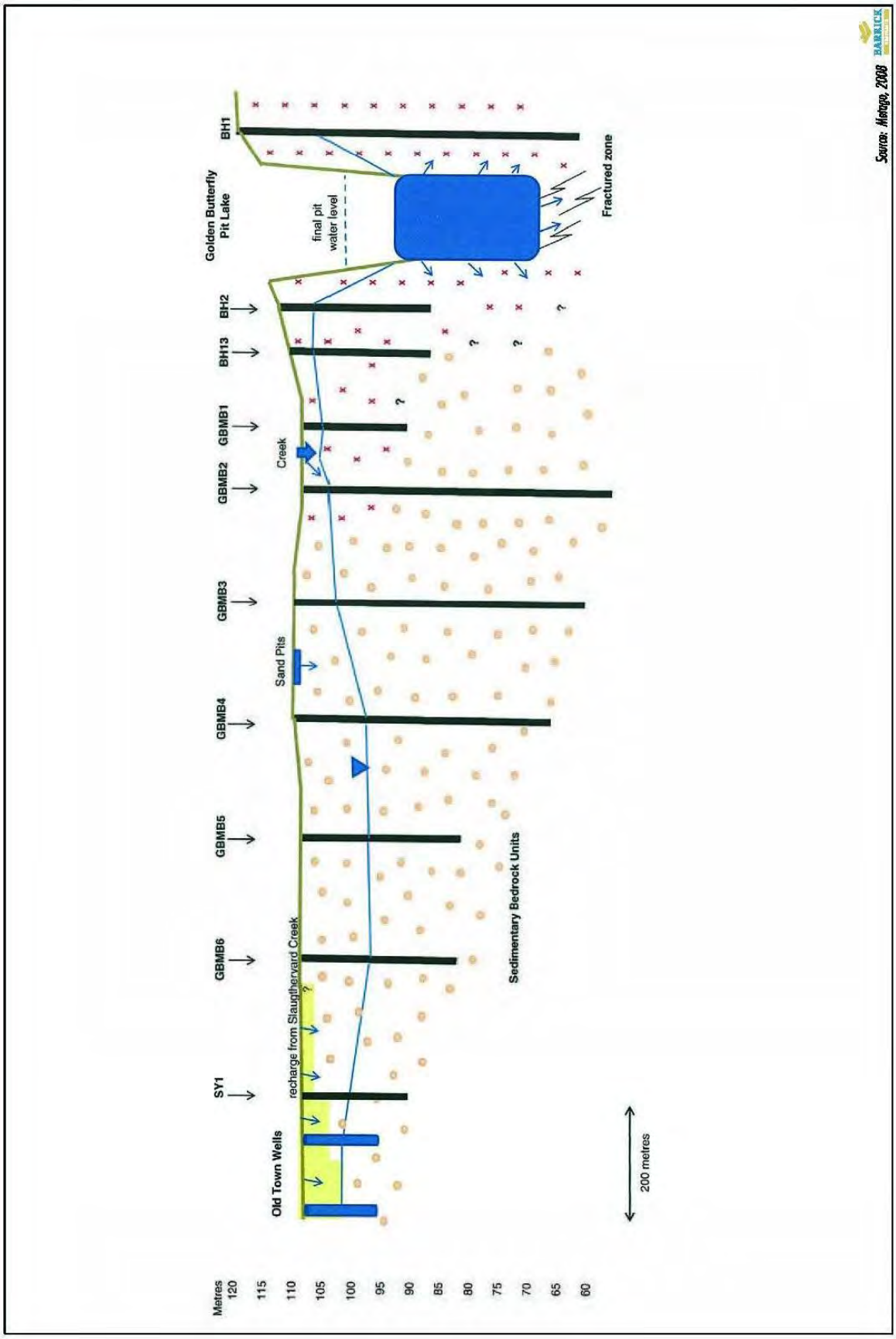


Figure 5: Conceptual Hydrogeological Model

Table 9: Groundwater Quality – Confined Fractured Rock Aquifer 1995 - 2009

Parameter	Sample Site																	
	BH1		BH2		BH3		BH4		BH5		BH6		BH7		GBMB1		GBMB2	
	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median
pH (pH units)	6.1 7.9 (42)	7.2 7.2	3.3 6.5 (41)	3.7 3.6	5.5 7.7 (35)	6.41 6.4	6.9 8.6	7.4	7.3 7.8 (13)	7.5 7.5	6.9 7.5	7.15	6.4 7.1	6.8	6.4 7	6.7	6.9 7.7	7.3
EC (µS/cm)	985 2260 (42)	1298 1300	740 1300 (41)	1016 980	110 3000 (35)	604 340	4800 7200	5611	4900 6800 (13)	5550 5600	480 2200	933	6400 8700	7472	160 760	591	2200 2700	2491
SO_4 (mg/L)	310 1160 (42)	471 460	260 850 (40)	442 435	20 990 (35)	172 100	1200 1800	1522	1400 2000 (13)	1733 1800	59 530	172	1400 2600	1950	36 190	120	630 790	703
Cu (mg/L)	<0.001 0.05 (16)	0.008 0.005	0.002 0.05 (15)	0.011 0.005	0.001 0.025 (13)	0.009 0.005	<0.001 <0.05	<0.01	<0.001 0.03 (13)	0.007 0.005	0.009 0.02	0.01	<0.003 0.03	<0.01	0.001 0.01	<0.01	<0.001 <0.05	<0.01
Pb (mg/L)	<0.001 0.35 (13)	0.031 0.001	<0.001 0.15 (13)	0.051 0.046	<0.001 0.072 (11)	0.013 0.001	<0.001 0.006	<0.002	<0.001 0.24 (11)	0.023 0.001	<0.002 0.056	0.009	<0.001 0.35	<0.002	<0.002 0.003	<0.002	<0.002 0.02	0.002
Ni (mg/L)	0.002 0.025 (16)	0.016 0.025	0.025 0.09 (15)	0.056 0.05	<0.001 0.025 (10)	0.014 0.0145	<0.002 <0.05	<0.05	<0.001 0.025 (13)	0.016 0.025	0.002 <0.05	<0.05	0.004 <0.05	<0.05	0.02 <0.05	<0.05	<0.002 <0.05	<0.05
Al (mg/L)	0.02 0.25 (15)	0.045 0.025	0.16 2.7 (14)	1.54 1.65	0.07 2.1 (10)	0.49 0.33	<0.05 0.37	<0.05	<0.01 0.29 (13)	0.049 0.025	0.14 6.8	2.35	<0.05 0.16	<0.05	<0.05 0.092	<0.05	<0.05 0.21	<0.05
Zn (mg/L)	0.01 0.18 (16)	0.053 0.038	0.043 1.06 (15)	0.40 0.36	<0.005 2.9 (13)	0.24 0.015	0.008 0.04	0.017	0.0025 0.032 (13)	0.0127 0.012	0.005 0.055	0.021	0.029 0.15	0.072	0.012 0.047	0.024	0.011 0.056	0.028
Co (mg/L)	<0.001 0.025 (11)	0.016 0.025	0.018 0.045 (11)	0.018 0.025	<0.001 0.025 (9)	0.015 0.025	<0.005 <0.05	<0.05	<0.001 <0.05	<0.05	<0.005 <0.05	<0.05	<0.005 0.07	<0.05	<0.05 <0.05	<0.05	<0.005 <0.05	<0.05
Cd (mg/L)	<0.0001 0.0025 (16)	0.0003 0.0001	<0.0001 0.0025 (15)	0.0007 0.0007	<0.0001 0.0009 (13)	0.0002 0.0001	<0.0001 0.0003	<0.0002	<0.0005 0.0004 (13)	<0.0005 0.0001	<0.0001 <0.0002	<0.0002	0.0002 0.002	0.00085	<0.0001 0.0067	0.0005	<0.0001 0.0003	<0.0002*
Fe (mg/L)	<0.05 3.2 (32)	0.436 0.1	0.025 27 (32)	4.54 1.3	0.025 1.75 (29)	0.33 0.25	<0.05 <0.05	<0.05	<0.05 0.09 (5)	<0.05	0.06 3.1	1.4	<0.05 0.27	<0.05	<0.05 0.08	<0.05	<0.05 <0.05	<0.05
Mn (mg/L)	<0.05 1.19 (8)	0.247 0.075	0.95 1.97 (8)	1.23 1.1	0.0025 0.025 (4)	0.019 0.025	<0.05 <0.05	<0.05	<0.05 0.06 (7)	0.034 0.025	<0.05 0.68	0.06	<0.05 1.9	<0.05	0.26 1.4	0.83	0.67 1.2	0.90
As (mg/L)	0.01 0.022 (16)	0.014 0.014	<0.001 0.09 (15)	0.008 0.025	<0.003 0.03 (13)	0.010 0.009	<0.005 0.003	<0.005	<0.05 0.009 (13)	0.012 0.007	0.013 0.048	0.026	<0.005 0.007	<0.005	0.007 0.034	0.02	<0.003 0.023	<0.005

* Below detection limit results have been substituted with a value of half of the detection limit

Table 10: Groundwater Quality – Unconfined Alluvial Aquifer 2001 - 2009

Parameter	Sample Site							
	GBMB3		GBMB4		GBMB5		GBMB6	
	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	5.7 6.8	6.2	5.9 6.5	6.1	5.6 7.1	6.0	5.7 7.1	6.2
EC (µS/cm)	52 110	79.4	260 350	308	68 490	114	66 580	152
SO_4 (mg/L)	3 13	6.3	17 38	28.8	2 13	4.4	3 19	7.1
Cu (mg/L)	0.001 0.01	<0.01*	<0.001 <0.05	<0.01*	<0.001 0.01	<0.01*	<0.001 <0.05	<0.01*
Pb (mg/L)	0.002 0.018	0.008	<0.001 0.008	<0.002*	<0.001 0.004	<0.002*	<0.001 0.31	<0.002*
Ni (mg/L)	<0.002 <0.05	<0.05*	<0.002 <0.05	<0.05*	<0.002 <0.05	<0.05*	<0.002 <0.05	<0.05*
Al (mg/L)	0.07 4.8	0.99	<0.05 0.29	<0.05*	<0.05 0.05	<0.05*	<0.05 0.69	<0.05*
Zn (mg/L)	0.017 0.11	0.052	0.006 0.18	0.043	0.01 .015	0.08	<0.005 0.092	0.025*
Co (mg/L)	<0.005 <0.05	<0.05*	<0.005 <0.05	<0.05*	<0.005 <0.05	<0.05*	<0.005 <0.05	<0.05*
Cd (mg/L)	<0.0002 <0.0002	<0.0002*	<0.0001 0.0018	<0.0002*	<0.0001 <0.0002	<0.0002*	<0.0001 <0.0002	<0.0002*
Fe (mg/L)	0.53 3	1.8	<0.05 6.6	0.18*	<0.05 <0.05	<0.05	<0.05 0.39	<0.05*
Mn (mg/L)	<0.05 0.15	0.05*	<0.05 .07	<0.05*	<0.05 0.26	<0.05*	<0.05 .037	<0.05*
As (mg/L)	0.003 0.012	<0.005*	<0.003 0.007	<0.005*	<0.003 0.091	<0.005*	<0.005 0.15	0.005

* indicates Median.

Table 11: Groundwater monitoring results 2010 – 2011

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH1	22/08/2011	8	1390	4	497	0.04	0.014	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.023
	20/09/2011	7.62	1410	3.7	476	<0.01	0.01	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.013
BH2	20/11/2010	3.69	940	0.8	374	0.99	0.001	<0.05	0.0001	<0.010	0.017	0.003	<0.0001	0.027	<0.01	0.204
	22/08/2011	3.7	934	1.4	383	0.96	<0.001	<0.05	0.0001	<0.001	0.016	0.01	<0.0001	0.026	<0.01	0.171
	20/09/2011	3.69	989	1.2	380	1.05	0.001	<0.05	0.0004	<0.001	0.019	0.015	<0.0001	0.034	<0.01	0.183
BH3	20/11/2010	8	746	3.6	148	0.43	0.01	<0.05	<0.0001	<0.010	<0.001	0.003	<0.0001	<0.001	<0.01	0.031
	23/08/2011	7.08	454	2.9	92	0.17	0.008	<0.05	<0.0001	<0.001	0.003	0.003	<0.0001	0.002	<0.01	0.007
	20/09/2011	7.09	499	3	95	0.23	0.031	<0.05	<0.0001	<0.001	0.006	0.002	<0.0001	0.002	<0.01	0.007
BH5	20/11/2010	8.37	5500	6.6	1930	<0.01	0.005	<0.05	0.0003	<0.010	<0.001	0.004	<0.0001	<0.001	<0.01	0.02
	23/08/2011	7.59	5600	7.7	2000	0.02	0.005	<0.05	0.0005	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.01
	20/09/2011	7.05	6490	4.4	2050	<0.01	0.006	<0.05	0.0022	<0.001	<0.001	0.001	<0.0001	0.005	<0.01	0.065
BH6	20/11/2010	8.3	642	8.3	67	0.29	0.047	<0.05	<0.0001	<0.010	<0.001	0.016	<0.0001	0.003	<0.01	<0.005
BH7	20/11/2010	8	5290	6.3	1540	0.02	0.008	<0.05	0.0032	<0.010	0.005	0.051	<0.0001	0.026	<0.01	0.241
	23/08/2011	7.12	5120	7.4	1540	0.03	0.004	<0.05	0.0002	<0.001	0.013	0.001	<0.0001	0.012	<0.01	0.031
	20/09/2011	6.81	5000	6.9	1470	0.02	0.013	<0.05	0.0002	<0.001	0.014	0.001	<0.0001	0.013	<0.01	0.052
BH8	20/11/2010	7.5	118	0.5	13	0.04	0.018	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	0.001	<0.01	0.056
	22/08/2011	5.31	110	<0.1	12	0.02	0.003	<0.05	<0.0001	<0.001	0.001	0.005	<0.0001	0.002	<0.01	0.045
	20/09/2011	5.39	118	0.1	12	0.02	0.002	<0.05	<0.0001	<0.001	0.002	0.002	<0.0001	0.002	<0.01	0.02
BH9	20/11/2010	6.56	104	<0.1	<1	0.29	<0.001	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	<0.001	<0.01	0.027
	22/08/2011	5.39	99	<0.1	1	0.03	<0.001	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.013
	20/09/2011	5.45	98	<0.1	1	0.02	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
BH10	20/11/2010	7.92	2670	2.4	1280	<0.01	0.02	<0.05	<0.0001	<0.010	0.02	0.002	<0.0001	0.006	<0.01	0.035
	22/08/2011	7.36	2700	2.9	1260	<0.01	0.012	<0.05	<0.0001	<0.001	0.019	0.001	<0.0001	0.005	<0.01	0.03
	20/09/2011	7.16	2680	2.9	1190	<0.01	0.004	<0.05	0.0001	<0.001	0.007	0.001	<0.0001	0.008	<0.01	0.078
BH11	20/11/2010	8.1	370	2.4	51	<0.01	0.054	<0.05	<0.0001	<0.010	<0.001	0.002	<0.0001	0.002	<0.01	0.043
	22/08/2011	7.47	358	2.9	51	0.01	0.058	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.005
	20/09/2011	7.13	353	2.9	49	<0.01	0.054	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	0.001	<0.01	0.008
EA Trigger Level		6.0 to 7.5	250			0.055	0.013	0.37	0.0002	0.001	0.0014	0.0014	0.0006	0.011	0.011	0.008
EA Contaminant Limit		5 to 9	5970	2	1000	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

Table 11 (Continued): Groundwater monitoring results 2010 – 2011

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH12	20/11/2010	8.44	1400	4.2	186	<0.01	0.024	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	<0.001	<0.01	0.025
	22/08/2011	7.69	1380	4.9	182	<0.01	0.019	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.022
	20/09/2011	7.4	1390	4.6	173	<0.01	0.017	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
SY1	20/11/2010	7.01	51	<0.1	<1	0.04	0.002	<0.05	<0.0001	<0.010	0.001	<0.001	<0.0001	<0.001	<0.01	0.04
	23/08/2011	6.02	60	<0.1	<1	<0.01	0.003	<0.05	<0.0001	<0.001	0.003	<0.001	<0.0001	0.001	<0.01	0.009
GBMB1	20/11/2010	7.91	533	1.7	110	<0.01	0.012	<0.05	<0.0001	<0.010	<0.001	0.002	<0.0001	<0.001	<0.01	0.035
	23/08/2011	7.62	498	1.7	81	0.03	0.037	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
	20/09/2011	6.67	694	2.2	165	0.01	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
GBMB3	23/08/2011	6.25	103	<0.1	<1	0.07	0.016	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	<0.001	<0.01	0.006
	20/09/2011	5.84	61	<0.1	<1	0.21	0.016	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.001	<0.01	0.014
GBMB6	23/08/2011	6.9	247	0.2	1	<0.01	0.096	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.002	<0.01	<0.005
	20/09/2011	6.2	158	0.2	2	<0.01	0.087	<0.05	<0.0001	<0.001	0.001	<0.001	<0.0001	0.002	<0.01	<0.005
EA Trigger Level		6.0 to 7.5	250			0.055	0.013	0.37	0.0002	0.001	0.0014	0.0014	0.0006	0.011	0.011	0.008
EA Contaminant Limit		5 to 9	5970	2	1000	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

Table 12: Groundwater levels in monitoring bores

Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)	Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)
BH1	117	1/03/2008	13.90	103.10	BH6	114	29/03/2010	1.70	112.30
BH1	117	2/04/2009	8.71	108.29	BH6	114	11/07/2010	3.20	110.80
BH1	117	10/08/2009	13.85	103.15	BH6	114	18/10/2010	4.35	109.65
BH1	117	29/03/2010	12.50	104.50	BH6	114	20/11/2010	4.25	109.75
BH1	117	11/07/2010	15.00	102.00	BH6	114	29/03/2011	2.00	112.00
BH1	117	13/08/2010	15.44	101.56	BH6	114	22/08/2011	3.20	110.80
BH1	117	18/10/2010	16.05	100.95					
BH1	117	20/11/2010	16.17	100.83	BH7	116	1/03/2008	4.70	111.30
BH1	117	29/03/2011	11.50	105.50	BH7	116	2/04/2009	3.35	112.65
BH1	117	22/08/2011	13.00	104.00	BH7	116	10/08/2009	3.35	112.65
					BH7	116	29/03/2010	4.60	111.40
BH2	112	1/03/2008	4.70	107.30	BH7	116	11/07/2010	4.60	111.40
BH2	112	2/04/2009	6.17	105.83	BH7	116	18/10/2010	4.65	111.35
BH2	112	10/08/2009	7.14	104.86	BH7	116	20/11/2010	4.60	111.40
BH2	112	29/03/2010	4.90	107.10	BH7	116	29/03/2011	4.10	111.90
BH2	112	11/07/2010	5.30	106.70	BH7	116	22/08/2011	4.30	111.70
BH2	112	13/08/2010	5.41	106.59					
BH2	112	18/10/2010	5.75	106.25	BH8	123.92	1/10/2008	17.12	106.80
BH2	112	20/11/2010	5.84	106.16	BH8	123.92	2/04/2009	12.20	111.72
BH2	112	29/03/2011	3.75	108.25	BH8	123.92	10/08/2009	16.70	107.22
BH2	112	22/08/2011	4.55	107.45	BH8	123.92	29/03/2010	13.55	110.37
					BH8	123.92	10/07/2010	12.50	111.42
BH3	113	1/03/2008	1.10	111.90	BH8	123.92	13/08/2010	12.50	111.42
BH3	113	2/04/2009	0.05	112.95	BH8	123.92	18/10/2010	12.60	111.32
BH3	113	10/08/2009	1.53	111.47	BH8	123.92	20/11/2010	12.57	111.35
BH3	113	29/03/2010	1.45	111.55	BH8	123.92	29/03/2011	8.75	115.17
BH3	113	11/07/2010	3.95	109.05	BH8	123.92	22/08/2011	9.28	114.64
BH3	113	18/10/2010	4.35	108.65					
BH3	113	20/11/2010	4.39	108.61	BH9	122.29	1/10/2008	12.42	109.87
BH3	113	29/03/2011	1.25	111.75	BH9	122.29	2/04/2009	7.40	114.89
BH3	113	22/08/2011	2.82	110.18	BH9	122.29	10/08/2009	9.66	112.63
					BH9	122.29	29/03/2010	8.70	113.59
BH4	113	29/03/2010	4.60	108.40	BH9	122.29	10/07/2010	8.60	113.69
BH4	113	11/07/2010	4.50	108.50	BH9	122.29	13/08/2010	8.85	113.44
BH4	113	18/10/2010	4.80	108.20	BH9	122.29	18/10/2010	9.15	113.14
BH4	113	20/11/2010	4.85	108.15	BH9	122.29	20/11/2010	9.23	113.06
BH4	113	29/03/2011	4.60	108.40	BH9	122.29	29/03/2011	6.50	115.79
BH4	113	22/08/2011	4.70	108.30	BH9	122.29	22/08/2011	7.22	115.07
BH5	114	1/03/2008	5.40	108.60	BH10	103.95	1/10/2008	10.44	93.51
BH5	114	2/04/2009	2.82	111.18	BH10	103.95	2/04/2009	7.98	95.97
BH5	114	10/08/2009	3.89	110.11	BH10	103.95	10/08/2009	7.80	96.15
BH5	114	29/03/2010	4.90	109.10	BH10	103.95	28/03/2010	7.70	96.25
BH5	114	11/07/2010	4.80	109.20	BH10	103.95	11/07/2010	7.50	96.45
BH5	114	18/10/2010	5.10	108.90	BH10	103.95	18/10/2010	7.64	96.31
BH5	114	20/11/2010	5.09	108.91	BH10	103.95	20/11/2010	7.62	96.33
BH5	114	29/03/2011	2.90	111.10	BH10	103.95	29/03/2011	7.30	96.65
BH5	114	22/08/2011	4.48	109.52	BH10	103.95	22/08/2011	7.19	96.76

Table 13 Continued: Groundwater levels in monitoring bores

Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)	Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)
BH11	104. 13	1/10/2008	7.60	96. 53	SY1	107. 48	1/10/2008	10. 62	96. 86
BH11	104. 13	2/04/2009	5.51	98. 62	SY1	107. 48	2/04/2009	8.09	99. 39
BH11	104. 13	10/08/2009	4.73	99. 40	SY1	107. 48	10/08/2009	10. 47	97. 01
BH11	104. 13	28/03/2010	4.26	99. 87	SY1	107. 48	29/03/2010	7.10	100. 38
BH11	104. 13	11/07/2010	3.75	100. 38	SY1	107. 48	11/07/2010	6.75	100. 73
BH11	104. 13	18/10/2010	3.70	100. 43	SY1	107. 48	20/11/2010	8.10	99. 38
BH11	104. 13	20/11/2010	3.75	100. 38	SY1	107. 48	29/03/2011	5.25	102. 23
BH11	104. 13	29/03/2011	2.25	101. 88	SY1	107. 48	22/08/2011	6.00	101. 48
BH11	104. 13	22/08/2011	2.75	101. 38					
BH12	102. 08	1/10/2008	7.46	94. 62					
BH12	102. 08	2/04/2009	7.22	94. 86					
BH12	102. 08	10/08/2009	7.02	95. 06					
BH12	102. 08	28/03/2010	6.90	95. 18					
BH12	102. 08	11/07/2010	6.82	95. 26					
BH12	102. 08	18/10/2010	6.87	95. 21					
BH12	102. 08	20/11/2010	6.83	95. 25					
BH12	102. 08	29/03/2011	6.50	95. 58					
BH12	102. 08	22/08/2011	6.42	95. 66					
GBMB1	109	1/03/2008	3.60	105. 40					
GBMB1	109	2/04/2009	1.09	107. 91					
GBMB1	109	10/08/2009	1.97	107. 03					
GBMB1	109	29/03/2010	3.00	106. 00					
GBMB1	109	11/07/2010	3.15	105. 85					
GBMB1	109	18/10/2010	3.50	105. 50					
GBMB1	109	20/11/2010	3.35	105. 65					
GBMB1	109	29/03/2011	1.90	107. 10					
GBMB1	109	22/08/2011	1.98	107. 02					
GBMB3	113	1/03/2008	7.30	105. 70					
GBMB3	113	2/04/2009	2.48	110. 52					
GBMB3	113	10/08/2009	4.18	108. 82					
GBMB3	113	29/03/2010	2.80	110. 20					
GBMB3	113	11/07/2010	3.55	109. 45					
GBMB3	113	18/10/2010	3.70	109. 30					
GBMB3	113	20/11/2010	3.80	109. 20					
GBMB3	113	29/03/2011	2.75	110. 25					
GBMB3	113	22/08/2011	3.90	109. 10					
GBMB6	113	1/03/2008	11. 70	101. 30					
GBMB6	113	2/04/2009	10. 73	102. 27					
GBMB6	113	10/08/2009	13. 14	99. 86					
GBMB6	113	29/03/2010	10. 05	102. 95					
GBMB6	113	11/07/2010	9.55	103. 45					
GBMB6	113	18/10/2010	9.85	103. 15					
GBMB6	113	20/11/2010	10. 20	102. 80					
GBMB6	113	29/03/2011	7.10	105. 90					
GBMB6	113	22/08/2011	8.00	105. 00					

Figure 6: Golden Butterfly Pit Monitoring Bore Water Levels

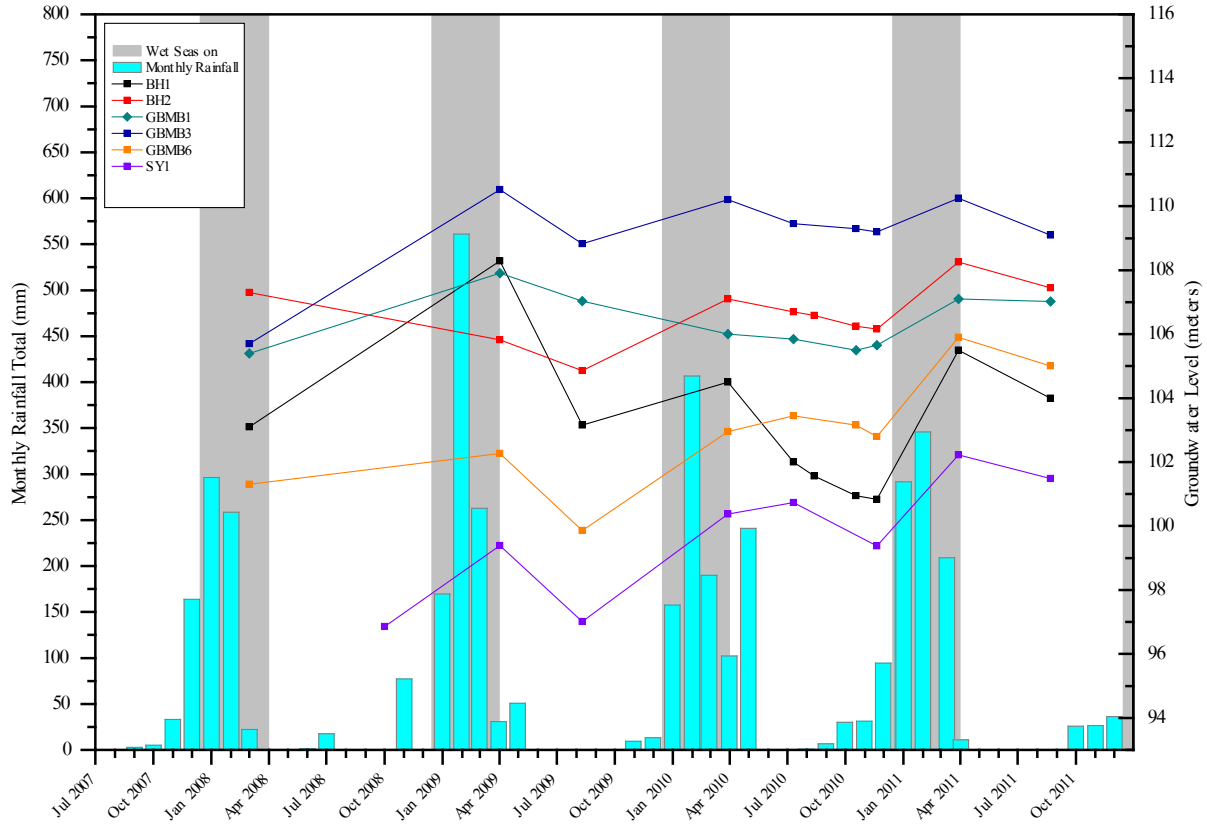


Figure 7: Content Pit local area contour map

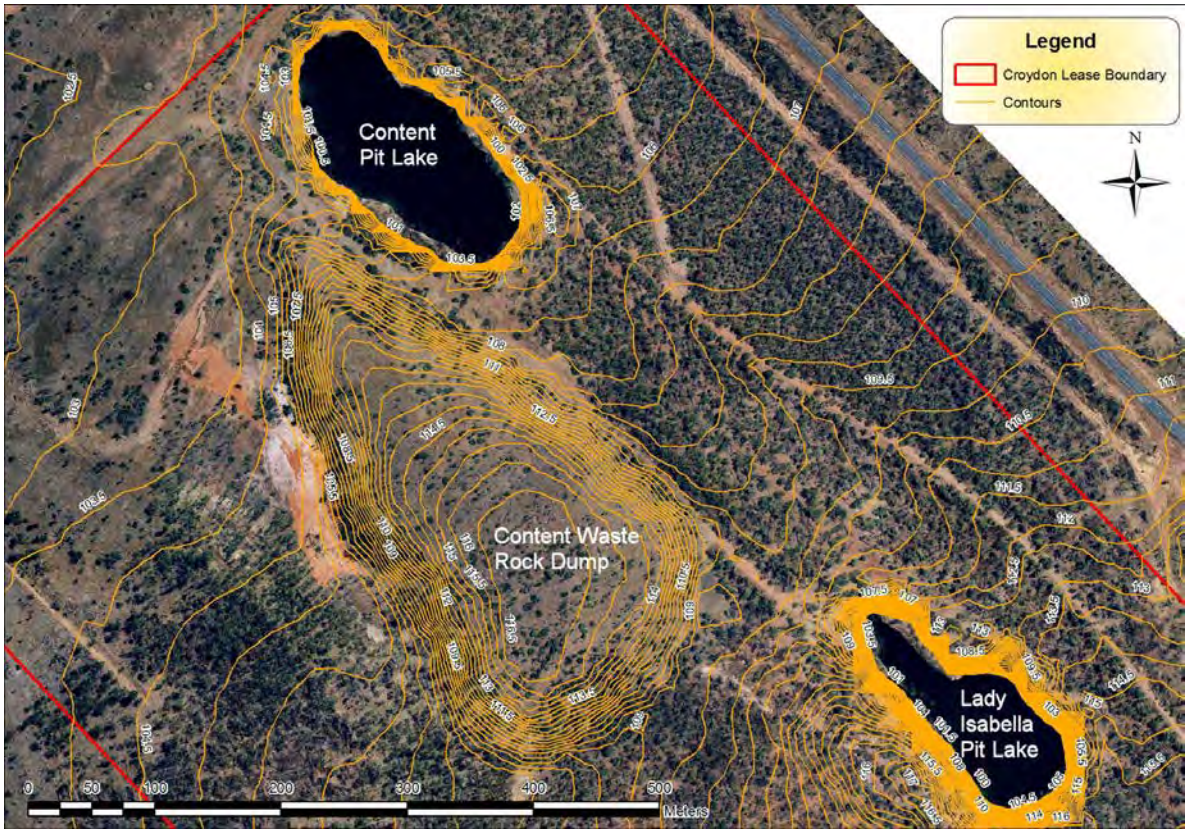


Table 13: Croydon Pit Lake Levels

	Content Pit		Golden Butterfly Pit		Lady Isabella Pit		Golden Butterfly North Pit	
	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate
10th July 2010	102.53	1.54	102.07	12.57	106.93	3.13	112.01	9.71
13th Aug 2010	102.35	1.36	102.0	12.5	106.75	2.95	111.8	9.5
27th Aug 2010	102.30	1.40	101.97	12.47	na	na	na	na
18th Oct 2010	102.10	1.60	na	na	106.53	3.17	111.44	9.86
19th Nov 2010	101.98	1.72	101.86	12.64	106.37	3.33	111.27	10.03
7th Dec 2010	98.98	4.72	103.36	11.14	106.48	3.23	na	na
29th Dec 2010	99.305	4.395	103.56	10.94	na	na	na	na
23rd Feb 2011	103.7	0	na	na	109.7	0.0	na	na
23rd Aug 2011	103.24	0.47	106.31[a]	8.19	108.26[a]	1.44	113.31	9.40
20th Oct 2011	102.89	0.81	104.91[a]	9.59	107.90[a] 108.13[b]	1.57	112.64	10.07
6th Dec 2011	102.65[d]	1.05	104.75[d]	9.75	107.96[c] 107.82[d]	1.74	na	na
22nd Dec 2011	102.57[d]	1.13	104.74	9.76	107.76[d]	1.94	113.78[d]	8.92

a. Using Dumpy Level
b. Compared to last gauge board reading (8th Dec 2010)
c. Using gauge board reading
d. Using survey equipment
e. Reference RL's: Content Pit 103.7m; Golden Butterfly Pit 114.5m; Lady Isabella Pit 109.7m; Golden Butterfly North Pit 122.7m

Lady Isabella Pit

Golden Butterfly North Pit

Golden Butterfly Pit

Content Pit

Figure 8: Croydon Pit Lake water level monitoring stations

6 REHABILITATION MONITORING PROGRAM

A Rehabilitation Monitoring Program has been prepared in accordance with Condition C2 2 (n) of the EA and is included as Attachment A.

The Rehabilitation Monitoring Program includes the description of:

- surface water monitoring;
- groundwater monitoring;
- vegetation monitoring;
- erosion monitoring; and
- final cover system monitoring.

The current Rehabilitation Monitoring Program is focused on rehabilitation performance monitoring and is a refinement of the program that has been in place since 1996. The emphasis is on water and vegetation monitoring and will continue until sufficient data is available to confirm rehabilitation trends satisfy the completion criteria identified in Section 8. In the event rehabilitation monitoring indicates ineffective final cover systems and/or poor vegetation performance, additional reclamation works will be conducted.

Experimental and Statistical Design

A Rehabilitation Monitoring Program has been prepared for the Project and is provided as Attachment A. The Rehabilitation Monitoring Program includes three analogue monitoring sites and 12 rehabilitation monitoring sites (Figure 2). The parameters identified in the Rehabilitation Monitoring Program are collected at both the analogue monitoring sites and the rehabilitation monitoring sites. Comparisons between the data from the analogue monitoring sites and the rehabilitation monitoring sites will be made with the objective of:

- determining if there is significant statistical difference between the analogue monitoring sites and rehabilitation monitoring sites; and/or
- establishing relevant trends from the rehabilitation monitoring site data which establish that these sites demonstrate similar characteristics to the analogue monitoring sites.

In the event that the data indicates no significant difference between the analogue monitoring sites and rehabilitation monitoring sites and/or a trend toward the analogue monitoring site values, it will be considered that the rehabilitation monitoring sites are characteristic of analogue monitoring sites. If the data indicates that there is a significant difference between the analogue monitoring sites and rehabilitation monitoring sites and/or there is no evident trend of rehabilitation monitoring site data toward the analogue monitoring site values, an investigation will be conducted to determine the likely cause of the difference and/or trend (e.g. bushfire has occurred at one monitoring site and not the other). If the investigation indicates the likely cause of the difference and/or trend is likely to be due to rehabilitation site characteristics, additional rehabilitation works will be conducted, amelioration measures will be implemented and/or more time will be allowed for the revegetation performance to improve.

7 GRAZING MANAGEMENT PLAN

A Grazing Management Plan for the Project has been prepared in accordance with Condition C2 2(o) of the EA and is provided as Attachment B.

8 COMPLETION CRITERIA

Measurable completion criteria will provide the ability to monitor the performance of the rehabilitation. The measurable completion criteria for the final landforms, revegetation, surface water and groundwater are outlined below.

8.1 FINAL LANDFORMS

The completion criteria for the final landforms at the Project are outlined in Table 11.

Table 14: Final Landforms Completion Criteria

Rehabilitation Type	Completion Criteria
Final Landforms	• Post mining landforms will be rehabilitated in accordance with rehabilitation objectives defined in Schedule C – Table 1 of the EA which is provided in Table 2. The post mining landforms will: • be stable now and in the foreseeable future; • have a low probability of subsidence, rock falls and/ or slope slippage ; and • have comparable management requirements similar to the non mined land surrounding the Project by demonstrating that the site can sustain a low intensity grazing / disturbed native habitat landuse. The parameters measured will include : • no observable subsidence, rock falls and/ or slope slippage ; • incidence of erosion; and • results from geotechnical investigation (Section 3).

8.2 REVEGETATION

The completion criteria for the revegetated areas at the Project are outlined in Table 12.

Table 15: Revegetation Completion Criteria

Rehabilitation Type	Completion Criteria
Revegetation	• Establish a self sustaining natural vegetation cover on all post mining landforms. • Species diversity is comparable to the surrounding areas of the Project. • Species abundance is comparable to the surrounding areas of the Project. • The abundance of weeds is minimal. • Species composition is comparable to the surrounding areas of the Project. • Projective cover is comparable to the surrounding areas of the Project: Groundcover is adequate to support the intended post mining landuse and is self sustaining. Tree cover is adequate to support the intended post mining landuse and is self sustaining. • Dry matter production is comparable to the surrounding areas of the Project. Nutrient cycling is occurring. Leaf litter is assisting in limiting erosion on the soil/spoil surface. • Stocking rates maintain self sustaining vegetation cover at the Project.

In order to maintain the revegetation performance and satisfy the revegetation completion criteria described above, domesticated stock will be excluded from the western section of ML 5248 (i.e. Content and Lady Isabella mining areas). Controlled low intensity grazing of domesticated stock during the dry season will occur on the eastern section of ML 5248 (i.e. Golden Butterfly mining area) as described in the Grazing Management Plan (Attachment B).

8.3 SURFACE WATER

The completion criteria for surface water, including receiving waters and on site storages, at the Project are outlined in Table 17 to Table 21.

Table 16: Surface Water Completion Criteria

Rehabilitation Type	Completion Criteria
Receiving Waters	• The water quality at the receiving water monitoring locations defined in Schedule F – Table 1 of the EA (Table 14) will be in accordance with contaminant limits specified in Schedule F – Table 3 of the EA (Table 15).
On site Storages	• Any contaminated seepage water will be contained on site within the open pits. • Any on site storages, defined in Schedule F – Table 7 of the EA (Table 16), containing water that exceeds the contaminant limits defined in Schedule F – Table 8 of the EA (Table 17), will be fenced to exclude access by livestock and minimise access by native fauna.

Table 17: Schedule F – Table 1 of EA MIN100401906 Receiving Water Monitoring Sites

Monitoring point	Easting MGA (GDA 94)	Northing MGA (GDA 94)
SW 1 Lower Slaughteryard Creek	630350	7986405
SW 2 Slaughteryard West Tributary at the ML boundary	630197	7987640
SW 3 Slaughteryard Creek upstream of the Golden Butterfly waste rock dump	TBA[2]	TBA[2]
SW 6 Belmore Creek borrow pit / stock dam	627908	7989454
Reference Site[1]		
SW 3b Reference point for Slaughteryard creek	613208	7988220
SW 7 Reference point for Belmore Creek	TBA[2]	TBA[2]

[1] Reference sites must:
(a) be from the same bio geographic and climatic region; and
(b) have similar geology, soil types and topography; and
(c) contain a range of habitats similar to those at the test sites; and
(d) have a similar flow regime; and
(e) not be so close to the test sites that any disturbance at the test site also results in a change at the reference site.

[2] TBA – Location co ordinates to be provided to the Administering Authority by 30 September 2008.

Table 18: Schedule F – Table 2 of EA MIN100401906 Receiving Water Contaminant Limits

Parameter	Unit	Test Value	Contaminant Limit[2]
pH	pH unit	Range	Greater than 5, less than 9
EC	µS/cm	Maximum	5970 [1]
Sulphate	mg/L	Maximum	1000 [1]
Fluoride	mg/L	Maximum	2 [1]
Aluminium [2]	mg/L	Maximum	5 [1]
Arsenic [2]	mg/L	Maximum	0.5 [1]
Boron [2]	mg/L	Maximum	5 [1]
Cadmium [2]	mg/L	Maximum	0.01 [1]
Chromium [2]	mg/L	Maximum	1 [1]
Cobalt [2]	mg/L	Maximum	1 [1]
Copper [2]	mg/L	Maximum	1 [1]
Mercury [2]	mg/L	Maximum	0.002 [1]
Nickel [2]	mg/L	Maximum	1 [1]
Selenium [2]	mg/L	Maximum	0.02 [1]
Zinc [2]	mg/L	Maximum	20 [1]

[1] Contaminant limit based on Australian and New Zealand Environment and Conservation Council (ANZECC) (2000) stock water quality guidelines.

[2] Analysis for soluble metal concentrations only, not totals.

Table 19: Schedule F – Table 7 of EA MIN100401906 On-site Storage Monitoring Sites

Monitoring Point	Easting MGA (GDA 94)	Northing MGA (GDA 94)
Golden Butterfly Pit (base of ramp)	631140	7987525
Golden Butterfly North Pit (base of ramp)	630545	7987921
Lady Isabella Pit (base of ramp)	629473	7990023
Content Pit (base of ramp)	629048	7990435
SW 3a Golden Butterfly waste rock dump toe drain	630913	7988253
SW 4 Stock water dam	631049	7987892
SW 5 Sediment dam at lease boundary	628691	7990012

Table 20: Schedule F – Table 8 of EA MIN100401906 On-site Storage Monitoring Sites

Parameter	Unit	Test Value	Contaminant Limit
pH	pH unit	Range	Greater than 4, less than 9[1]
EC	µS/cm	Maximum	5970 [2]
Turbidity	TDS	Maximum	4000 [2]
Sulphate	mg/L	Maximum	1000 [2]
Fluoride	mg/L	Maximum	2[2]
Aluminium[3]	mg/L	Maximum	5[2]
Arsenic[3]	mg/L	Maximum	0.5[2]
Boron[3]	mg/L	Maximum	5[2]
Cadmium[3]	mg/L	Maximum	0.01[2]
Chromium[3]	mg/L	Maximum	1[2]
Cobalt[3]	mg/L	Maximum	1[2]
Copper[3]	mg/L	Maximum	1[2]
Mercury[3]	mg/L	Maximum	0.002[2]
Nickel[3]	mg/L	Maximum	1[2]
Selenium[3]	mg/L	Maximum	0.02[2]
Zinc[3]	mg/L	Maximum	20[2]

1 Page 4.2 15 of ANZECC (2000) "Soil and animal health will not generally be affected by water with pH in the range of 4–9".

2 Contaminant limit based on ANZECC (2000) stock water quality guidelines.

3 Analysis for soluble metal concentrations only, not totals.
TDS = total dissolved solids

8.4 GROUNDWATER

The completion criteria for groundwater at the Project are outlined in Table 22 to Table 24.

Table 21: Groundwater Completion Criteria

Rehabilitation Type	Completion Criteria
Groundwater	• The water quality at the groundwater monitoring locations identified in Schedule F – Table 9 of the EA (Table 19) will be in accordance with contaminant limits specified in Schedule F – Table 11 of the EA (Table 20). • Confirmation of the conceptual hydrogeological model described in Section 5.2.

Table 22: Schedule F – Table 9 of EA MIN100410906 Groundwater Monitoring Sites

Monitoring Point	Easting MGA (GDA94)	Northing MGA (GDA94)	Surface RL[1] (m)	Monitoring Frequency
BH1 west of Golden Butterfly Pit	631270	7987673	TBA[2]	Annually during the dry season
BH2 east of Golden Butterfly Pit	630985	7987444	TBA[2]	Annually during the dry season
BH3 east of Golden Butterfly Waste Rock Dump	TBA[2]	TBA[2]	TBA[2]	Annually during the dry season
BH5 east of Golden Butterfly Waste Rock Dump	630987	7988051	TBA[2]	Annually during the dry season
BH7 east of Golden Butterfly Waste Rock Dump	631000	7988150	TBA[2]	Annually during the dry season
BH8 (east of Golden Butterfly Waste Rock Dump)	TBA[3]	TBA[3]	TBA[3]	Annually during the dry season
BH9 east of Golden Butterfly Waste Rock Dump	TBA[3]	TBA[3]	TBA[3]	Annually during the dry season
BH10 west of Content Waste Rock Dump	TBA[3]	TBA[3]	TBA[3]	Annually during the dry season
BH11 west of Content Waste Rock Dump	TBA[3]	TBA[3]	TBA[3]	Annually during the dry season
BH12 west of Content Waste Rock Dump at lease boundary	TBA[3]	TBA[3]	TBA[3]	Annually during the dry season
GBMB1 Slaughteryard Creek	630894	7987274	TBA[2]	Annually during the dry season
GBMB3 Slaughteryard Creek	630685	7987087	TBA[2]	Annually during the dry season
GBMB6 Slaughteryard Creek	630257	7986656	TBA[2]	Annually during the dry season
SY1 Slaughteryard Creek	TBA[3]	TBA[3]	TBA[3]	Annually during the dry season

[1] Relative Level (RL) measurement to be taken from top of bore casing.

[2] TBA to be provided by 30 September 2008.

[3] Co ordinates and elevation to be determined once the proposed bores have been constructed.

Table 23: Schedule F – Table 11 of EA MIN100410906 Groundwater Contaminant Limits

Parameter	Unit	Test Value	Contaminant Limit
pH	pH unit	Range	Greater than 5, less than 9
EC	µS/cm	Maximum	5970 [1]
Turbidity	TDS	Maximum	4000 [1]
Sulphate	mg/L	Maximum	1000 [1]
Fluoride	mg/L	Maximum	2 [1]
Aluminium [2]	mg/L	Maximum	5 [1]
Arsenic [2]	mg/L	Maximum	0.5 [1]
Boron [2]	mg/L	Maximum	5 [1]
Cadmium [2]	mg/L	Maximum	0.01 [1]
Chromium [2]	mg/L	Maximum	1 [1]
Cobalt [2]	mg/L	Maximum	1 [1]
Copper [2]	mg/L	Maximum	1 [1]
Mercury [2]	mg/L	Maximum	0.002 [1]
Nickel [2]	mg/L	Maximum	1 [1]
Selenium [2]	mg/L	Maximum	0.02 [1]
Zinc [2]	mg/L	Maximum	20 [1]

[1] Contaminant limit based on ANZECC (2000) stock water quality guidelines.

[2] Analysis for soluble metal concentrations only, not totals.

9 RESEARCH PROGRAM

Research programs and/or trials will be commissioned in instances where baseline environmental surveys and/or on going monitoring indicate the need for additional specific studies. No specific research programs have been proposed. Where additional research activities are considered appropriate, the timing and nature, including associated milestones, of the research programs will be provided to the EPA.

10 REVIEW

EA Condition A2 4 is of additional relevance to this PMLP and is provided below:

> *(A2-4) Any management or monitoring plans, systems or programs required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm as often as necessary but at least every two years and amended promptly if required.*

In accordance with Condition A2 4 of the EA this PMLP will be reviewed for effectiveness at least every two years and amended promptly when required.

11 REFERENCES

Australian and New Zealand Environment and Conservation Council (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*

Barrick Gold of Australia (2008a) *Croydon Gold Mine – Plan of Operations.*

Barrick Gold of Australia (2008b) *Croydon Gold Mine Project – Environmental Management Plan.*

Barrick Gold of Australia (2010) *Croydon Gold Mine Project – Hydrological Investigation*, June 2010.

Barrick Gold of Australia (2011) *Croydon Mine – 2010 Revegetation Efforts Monitoring, Evaluation and Recommendations*, November 2011.

Barrick Gold of Australia (2011) *Croydon Gold Mine – Plan of Operations.*

Commonwealth Bureau of Meteorology (2008) *Climate Averages for Australian Sites – Averages for Croydon Township.*
Internet site: http://www.bom.gov.au/climate/averages/tables/cw_029012.shtml
Date retrieved: 22 September 2008.

Department of Minerals and Energy (1998) *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland.*

Fawcett, M. (2001) *Rehabilitation works undertaken at Croydon in 1996 and 1997*. Letter report prepared by Fawcett Mine Rehabilitation Services Pty Ltd for Goldfields Limited, May 2001.

HLA Enviroscience (2001a) *Draft Final Rehabilitation Report – Croydon Gold Mine*. Report prepared for Goldfields Ltd, November 2001.

HLA Enviroscience (2001b) *Water Level Analysis of Golden Butterfly Pit – Croydon Gold Mine*. Report prepared for Goldfields Ltd, May 2001.

Landline Consulting (2007) *Croydon ML 5248 Monitoring Report 2006*. Report prepared for Barrick Gold of Australia, April 2007.

Woodward Clyde (1996) *Croydon Gold Mine – (Amended) Decommissioning Plan for ML 5248.* Report prepared for Pancontinental Mining Limited.

APPENDIX F REHABILITATION MONITORING PROGRAM

ATTACHMENT A
REHABILITATION MONITORING PROGRAM

CROYDON GOLD MINE

REHABILITATION MONITORING PROGRAM

DECEMBER 2011

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1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Barrick holds Environmental Authority No. MIN100401906 (EA) for the Project.

This Rehabilitation Monitoring Program (RMP) has been prepared in accordance with EA Condition C2 2:

> *C2-2 The Post Mine Land Use Plan must be included in the Plan of Operations and updated with each subsequent Plan of Operations, describing how the rehabilitation objectives in Schedule C – Table 1 will be achieved. The Post Mine Land Use Plan must include:*
> *…*
> *(n)* ***rehabilitation monitoring program****, including the monitoring of:*
> *(i) surface water quality;*
> *(ii) groundwater quality;*
> *(iii) erosion rates;*
> *(iv) integrity and effectiveness of final cover systems; and*
> *(v) health and resilience of vegetative cover.*

Other EA conditions of relevance to this RMP are provided below:

> *C3-1 The holder of the environmental authority must conduct a Rehabilitation Monitoring Program on at least a yearly basis, which must include sufficient spatial and temporal replication to enable scientifically justifiable conclusions as established under the rehabilitation program or other methodology to the satisfaction of the Administering Authority.*
>
> *C3-2 The rehabilitation monitoring program must be developed by 1 October 2008 and be implemented by a person nominated by the environmental authority holder possessing appropriate qualifications and experience in the field of rehabilitation management.*
>
> *C3-3 Verification of rehabilitation success is to be determined by comparison with the criteria documented in the Post Mine Land Use Plan required under Condition C2-1.*

The above conditions are also addressed where relevant in this RMP.

In accordance with EA Condition C2 2 this RMP will be included in the Croydon Gold Mine Plan of Operations.

The remainder of this RMP is structured as follows:

Section 2: Provides a description of the Project.

Section 3: Presents an overview of rehabilitation monitoring at the Project.

Section 4: Details the surface water monitoring program.

Section 5: Illustrates the stream sediment monitoring program.

Section 6: Presents the groundwater monitoring program.

Section 7: Describes the rehabilitation monitoring program.

Section 8: Details monitoring of erosion and the final cover systems at the Project.

Section 9: Describes the review process for this RMP.

Section 10: Lists the references cited in this RMP.

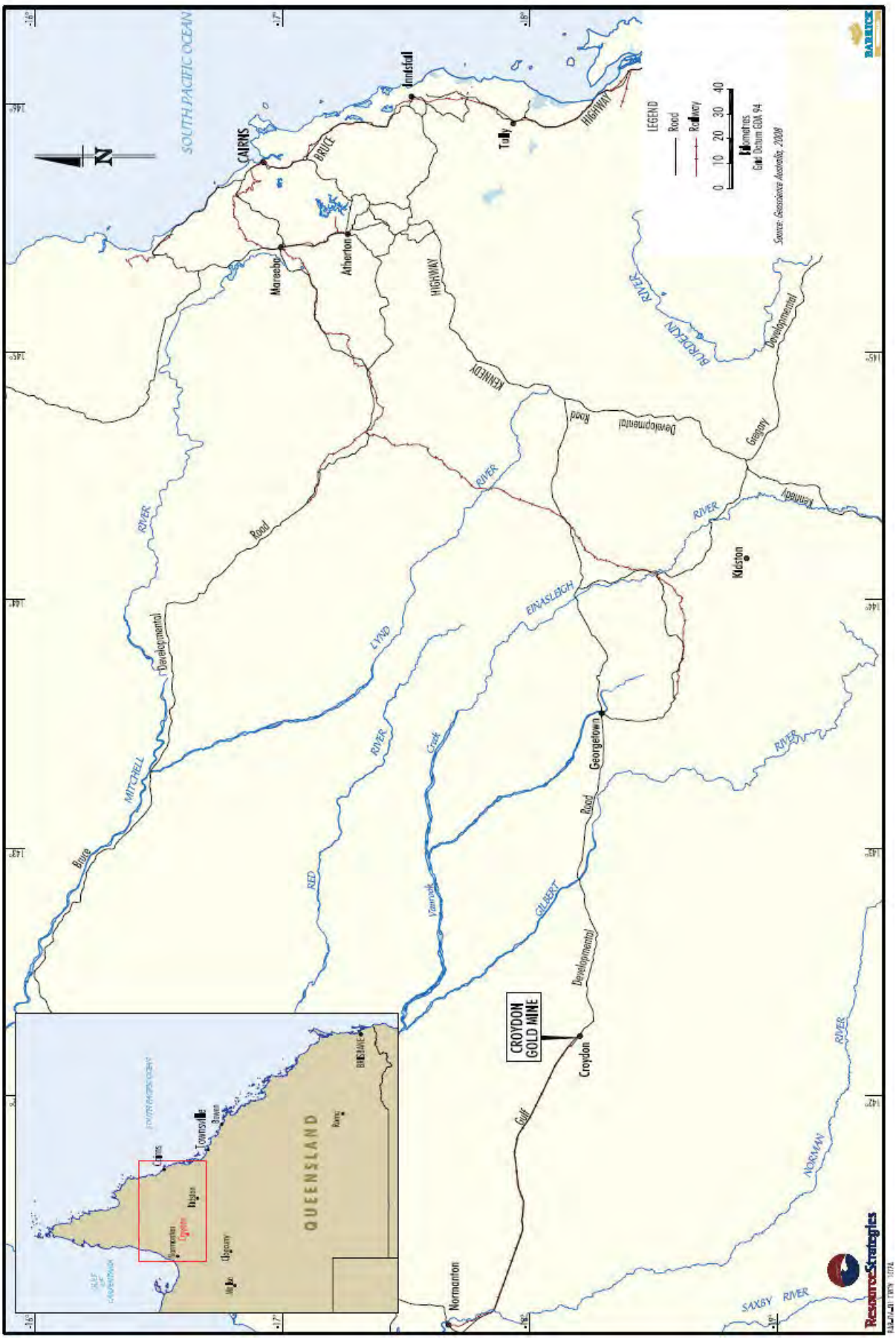


Figure 1: Regional Location

2 BACKGROUND

Extensive gold mining at the Project commenced in the late 1880s for approximately 30 years, before recommencing in 1987. Operational mining ceased in 1990 and the Project was decommissioned by late 1993 (Barrick, 2008). Reclamation performance was audited in 1996/97 and significant additional reclamation works were undertaken in 1996 and 1997 (Barrick, 2008).

The mining related landforms on ML 5248 comprise of waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps.

Specifically they include (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Golden Butterfly waste rock dump;
- Content Pit;
- Content waste rock dump;
- Lady Isabella Pit;
- abandonment bunds across the access ramps of the four open pits;
- hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps;
- water diversion bunds and sediment dams adjacent to the Content and Golden Butterfly waste
- rock dumps; and
- roads and tracks.

Schematic diagrams of the final landforms, inclusive of drainage features, are provided in Figure 3 of the Post Mine Landuse Plan (Appendix A of the Plan of Operations [Barrick, 2008a]).

The final landform concept is to achieve a stable post mining landform that is able to meet the identified post mining landuse and rehabilitation objectives. The post mining land descriptions and rehabilitation objectives are specified in Schedule C – Table 1 of the EA, which is reproduced in Table 2.

3 OVERVIEW OF PROJECT REHABILITATION MONITORING

Monitoring of surface water, groundwater, vegetation and soil fertility at the Project has been conducted since 1997. Annual rehabilitation monitoring results are available from 1997 to 2001 and from 2004 to present. Vegetation, soil fertility and erosion monitoring has occurred at vegetation monitoring transects on the Golden Butterfly and Content waste rock dumps and at analogue transects between these two waste rock dumps (Figure 2).

Surface water monitoring has occurred at monitoring sites in the receiving waters of Slaughteryard Creek and Belmore Creek, as well as at the base of the access ramp to the four open pit on site storages of Golden Butterfly Pit, Golden Butterfly North Pit, Lady Isabella Pit and Content Pit (Figure 2).

Groundwater monitoring has occurred at BH1 and BH2 adjacent to the Golden Butterfly Pit, BH3, BH5 and BH7 on the eastern side of the Golden Butterfly waste rock dump and at bores GBMB1, GBMG3 and GBMB6 parallel to Slaughteryard Creek (Figure 2).

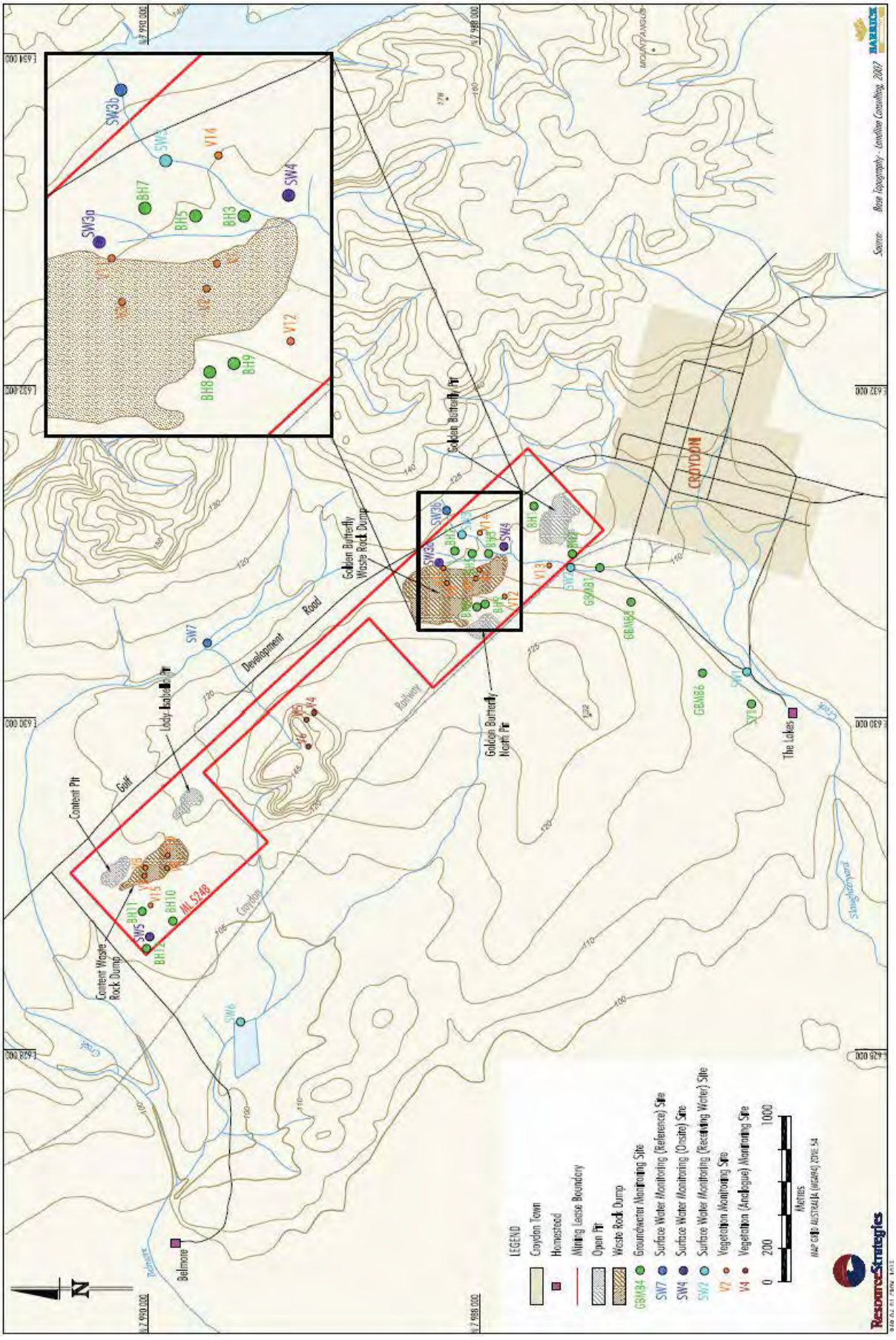


Figure 2: Site Location and Location of Environmental Monitoring Stations

4 SURFACE WATER MONITORING

Surface water monitoring will be conducted at the Project in accordance with EA No. MIN100401906. A description of the surface water monitoring program is provided in Sections 4.1 and 4.2.

The surface water monitoring program described below is based on the existing monitoring program currently implemented at the Project.

4.1 RECIEVING WATERS

In accordance with EA Condition F1 3 receiving waters monitoring will be conducted at the locations defined in Schedule F – Table 1 of the EA for the parameters identified in Schedule F – Tables 2 and 3 of the EA. The frequency of monitoring will be conducted in accordance with EA Condition F1 3. A summary of the receiving waters monitoring for the Project is provided in Table 1.

Table 1: Receiving Water Monitoring Programme

Monitoring Location (refer Figure 2)	Frequency	Parameters
SW1 Lower Slaughteryard Creek	For routine monitoring: • Twice yearly once during wet season (January – March) & once during dry season (July – September). Event based sampling of discharge event[1] or flow events[2]: • One representative sample must be taken of a discharge event or flow event. • Where a discharge event or a flow event has a duration of 24 hours or greater, samples must be taken	pH EC Turbidity Sulphate Fluoride Aluminium Arsenic Boron Cadmium Chromium (CrVI) Cobalt Copper Mercury (inorganic) Nickel Selenium (total) Zinc
SW 2 Slaughteryard Creek West Tributary at the ML boundary		
SW 3 Slaughteryard Creek upstream of the Golden Butterfly WRD		
SW 6 Belmore Creek borrow pit / stock dam		
Reference Sites		
SW3b Reference point for Slaughteryard Creek		
SW 7 Reference point for Belmore Creek		

1 Discharge event is an unauthorised surface water discharge from water storages or contaminated areas on the licensed place.
2 Flow event is a surface water flow in Slaughteryard Creek and/ or Belmore Creek that occurs as a result of rainfall.
Note: Where discharge events or flow event occur simultaneously only one set of samples are required to be taken.
No sample is required where there is insufficient flow during the dry season (July – September).

The sampling method for the receiving waters will comply with the latest edition of the Environment al Protection Agency's Water Quality Sampling Manual in accordance with EA Condition F1 2. As required by EA Condition F1 6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

4.2 ON-SITE STORAGES

In accordance with EA Condition F3 1 monitoring of the on site storages will be conducted at the locations defined in Schedule F – Table 7 for the parameters identified in Schedule F – Table 8. The frequency of monitoring will be conducted in accordance with EA Condition F3 1. A summary of the monitoring for the on site storages for the Project is provided in Table 2.

Table 2: On-site Storages Monitoring Programme

Monitoring Location (refer Figure 2)	Frequency	Parameters
Golden Butterfly Pit (base of ramp) Golden Butterfly North Pit (base of ramp) Lady Isabella Pit (base of ramp) Content Pit (base of ramp) SW3a Golden Butterfly WRD toe drain SW 4 Stock water dam SW 5 Sediment Dam at lease boundary	For routine monitoring: • Twice yearly once during wet season (January – March) & once during dry season (July – September). Event based sampling of discharge event[1] or flow events[2]: • One representative sample must be taken of a discharge event or flow event. • Where a discharge event or a flow event has a duration of 24 hours or greater, samples must be taken	pH EC Turbidity Sulphate Fluoride Aluminium Arsenic Boron Cadmium Chromium (CrVI) Cobalt Copper Mercury (inorganic) Nickel Selenium (total) Zinc

1 Discharge event is an unauthorised surface water discharge from an on site water storage.

Note:

Samples must be analysed for all parameters listed in Schedule F – Table 8.

Monitoring of the storage is to be conducted at the spillway.

No sample is required where there is insufficient water present in on site locations during the dry season (July – September).

The sampling method for the on site storages will comply with the latest edition of the Environmental Protection Agency's Water Quality Sampling Manual in accordance with EA Condition F1 2. As required by EA Condition F1 6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

5 STREAM SEDIMENT MONITORING

In accordance with EA Condition F2 1 stream sediment monitoring will be conducted at the locations and frequencies defined in Schedule F – Table 4 of the EA for the parameters identified in Schedule F – Table 5 and Table 6 of the EA. A summary of the stream sediment monitoring for the Project is provided in Table 3.

Table 3: Stream Sediment Monitoring Program

Monitoring Location (refer Figure 2)	Frequency	Parameters
SW1 Lower Slaughteryard Creek	Twice yearly in wet season (January – March) & dry season (July – September).	Aluminium Arsenic Boron Cadmium Chromium Cobalt Copper Mercury Nickel Selenium Zinc
SW2 Slaughteryard Creek West Tributary at the ML boundary		
SW3 Slaughteryard Creek upstream of the Golden Butterfly WRD		
SW6 Belmore Creek borrow pit / stock dam		
Reference Sites		
SW3b Reference point for Slaughteryard Creek		
SW7 Reference point for Belmore Creek		

The sampling method for stream sediment will comply with the Australian Standard 5667. 12 Guidance on Sampling of Bottom Sediments 1998 in accordance with EA Condition F2 4. As required by EA Condition F1 6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

6 GROUNDWATER MONITORING

Groundwater monitoring will be conducted at the Project in accordance with EA No. MIN100401906. A description of the groundwater monitoring program is provided below. The groundwater monitoring program described below is based on the existing monitoring program currently being used at the Project.

In accordance with EA Condition F4 1 groundwater monitoring will be conducted at the locations and frequencies defined in Schedule F – Table 9 of the EA for the parameters identified in Schedule F – Tables 10 and 11 of the EA. A summary of the groundwater monitoring for the Project is provided in Table 4.

Table 4: Groundwater Monitoring Program

Monitoring Location (refer Figure 2)	Frequency	Parameters
BH1 North of Golden Butterfly Pit	Annually during the dry season	pH EC Turbidity Sulphate Fluoride Aluminium Arsenic Boron Cadmium Chromium (CrVI) Cobalt Copper Mercury (inorganic) Nickel Selenium (total) Zinc
BH2 South west of Golden Butterfly Pit		
BH3 South east of Golden Butterfly Waste Rock Dump		
BH5 East of Golden Butterfly Pit Waste Rock Dump		
BH7 East of Golden Butterfly Waste Rock Dump		
BH8 West of Golden Butterfly Waste Rock Dump		
BH9 West of Golden Butterfly Waste Rock Dump		
BH10 West of Content Waste Rock Dump		
BH11 West of Content Waste Rock Dump		
BH12 West of Content Waste Rock Dump at lease boundary		
GBMB1 Slaughteryard Creek		
GBMB3 Slaughteryard Creek		
GBMB6 Slaughteryard Creek		
SY1 Slaughteryard Creek		

The sampling method for groundwaters will comply with the latest edition of the Environmental Protection Agency's Water Quality Sampling Manual in accordance with EA Condition F1 2. As required by EA Condition F1 6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

In accordance with EA Condition F4 4 annual groundwater reports analysing the groundwater chemistry and hydrogeological status of all groundwater bores and groundwater conditions will be prepared by November each year.

7 REHABILITATION MONITORING

A monitoring program will be implemented to assess the performance of rehabilitation at the Project. In accordance with EA Conditions C3 1 and C3 2, rehabilitation monitoring will be conducted on at least a yearly basis by a person nominated by Barrick possessing appropriate qualifications and experience in the field of rehabilitation management.

The monitoring program described below is based on the existing monitoring program currently being used at the Project. Section 7.1 describes the monitoring program, Section 7.2 discusses data analysis and assessment, and Section 7.3 outlines rehabilitation objectives and criteria.

7.1 MONITORING PROGRAM

7.1.1 Location of Monitoring Transects

Rehabilitation monitoring will be conducted at 12 vegetation transect sites (Figure 2). Each of the transect sites is 50 metres long. Four transect sites have been established on the Golden Butterfly waste rock dump, four transect sites have been established on the Content waste rock dump, and four transect sites will be established on areas of general disturbance (Figure 2).

In addition, three transect sites have been established as analogue sites. These analogue transect sites are located to the south of ML 5248 between the Golden Butterfly and Content waste rock dumps (Figure 2).

7.1.2 Monitoring Parameters

Vegetation

The following vegetation parameters will be monitored at each of the transect sites:

- tree density;
- tree height;
- tree species composition;
- pasture biomass;
- pasture cover;
- pasture species composition;
- weed abundance; and
- dry matter production.

In addition to the above, a photographic record will be taken of each transect. The health and resilience of the vegetation cover at the Project will be determined by the performance of the vegetation parameters identified above.

Soils

Soil samples will be taken to a depth of ten centimetres at five metre intervals along the transect sites. Large debris and stone will be extracted from the soil samples before they are sent to a commercial laboratory for analysis for the following parameters:

- pH (1:5 soil:H2O);
- EC (1:5 soil:H2O);
- nitrate;
- extractable phosphorus;
- organic carbon;
- total nitrogen and total carbon;
- cation exchange capacity (CEC);
- exchangeable cations (calcium, magnesium, potassium, sodium and aluminium); and
- DTPA extractable copper, zinc, iron and manganese.

7.2 DATA ANALYSIS AND ASSESSMENT

The rehabilitation monitoring results obtained from annual monitoring will be reviewed by a person possessing appropriate qualifications and experience in the field of rehabilitation management to track rehabilitation progress against the analogue sites and the rehabilitation objectives and criteria discussed in Section 7.3.

The monitoring programs outlined in this RMP will allow sufficient spatial and temporal replication to enable scientifically justifiable conclusions to be established.

7.3 REHABILITATION OBJECTIVES AND CRITERIA

7.3.1 Rehabilitation Objectives

The rehabilitation objectives for the Project are prescribed in Condition C1 1 of the EA in Schedule C – Table 1 which is reproduced in Table 5. This condition requires ML 5248 (except for the open pits) to be rehabilitated to a post mine landuse of low intensity grazing/disturbed native habitat. Condition C1 1 of the EA also requires ML 5248 (except for the open pits) to be rehabilitated to a land classification of Class VI or better (DME, 1995).

The open pits are required to be rehabilitated to a post mine landuse of "non beneficial land use" and to a land classification of Class VIII (DME, 1995) by Condition C1 1 of the EA.

Table 5: Schedule C – Table 1 of the EA MIN10401906

		Rehabilitation Objectives		
Landform (refer Schedule H – Map 1)	**Surface Area (ha)**	**Post-mine Land Description**	**Land Classification[1]**	**Analogue Site Identification**
Golden Butterfly North Pit	1.6	Non beneficial land use	Class VIII	Sites to be rehabilitated to a standard nominated in the rehabilitation program developed in accordance with Condition C2 1 based on analogue sites.
Golden Butterfly Pit	5.1	Non beneficial land use	Class VIII	
Lady Isabella Pit	1.7	Non beneficial land use	Class VIII	
Content Pit	2.1	Non beneficial land use	Class VIII	
Content Dump	6.3	L.I.G[2]/ disturbed native habitat	Class VI or better	
Golden Butterfly Dump	15.2	L.I.G[2]/ disturbed native habitat	Class VI or better	
Content Hardstand	2.0	L.I.G[2]/ disturbed native habitat	Class VI or better	
Golden Butterfly Hardstand	0.5	L.I.G[2]/ disturbed native habitat	Class VI or better	
Sediment Dams	1.5	L.I.G[2]/ disturbed native habitat	Class VI or better	
Roads / Tracks	3.5	L.I.G[2]/ disturbed native habitat	Class VI or better	

1 Technical guidelines for the Environmental Management of Exploration and Mining in Queensland (DME), 1995.
2 L.I.G. (Low Intensity Grazing) defined by criteria listed in Land Use Acceptance Criteria

7.3.2 Rehabilitation Criteria

The Post Mine Landus e Plan (PMLP) (Appendi x A of the Plan of Oper ations [Barrick, 2008a]) has been prepar ed in ac cordanc e with Con dition C2 1 of the EA. As requi red by EA Condi tion C2 2, the PMLP inc ludes the following:

(g) proposed revegetation criteria including:

(i) species diversity, abundance and composition;

(ii) projective cover;

(iii) dry matter production; and

(iv) stocking rates to ensure self sustaining vegetation is maintained.

…

(h) measurable completion criteria for each rehabilitation indicator that enables determination of rehabilitation success for each disturbance type.

In ac cordanc e with Condi tion C3 3 of the EA (Sec tion 1) the verificat ion of rehabi litat ion succes s will be det ermined by the comp ar ison with the meas urabl e comp letion criteria doc um ent ed in Sec tion 8 of the PMLP (Appendi x A of the Plan of Oper ations [Barrick, 2008a]).

8 EROSION AND FINAL COVER SYSTEM MONITORING

8.1 EROSION MONITORING

Eros ion monitoring at the Projec t will cons ist of conduc ting an annual qual itat ive as ses sment at eac h of the veget at ion monitoring trans ec ts listed in Sec tion 7.1.1. In gener al ac cordanc e with the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME, 1995) this will inc lude:

- field trav erses to obs erve inc idenc e of eros ion;
- rec ording det ails of any inc idenc e of eros ion (e.g. rills and sheet ing); and
- maintaining a phot ographi c rec ord for com par ison.

In addi tion to the abov e, the following par am et ers will be monitored as par t of the rehabi litat ion monitoring program at the veget at ion monitoring trans ec ts to provide an indic at ion of the pot ent ial for eros ion at the Projec t:

- tree dens ity;
- pas ture biom as s;
- pas ture cover; and
- pas ture spec ies com pos ition.

8.2 FINAL COVER SYSTEM MONITORING

The final cover system of the Cont ent was te rock dum p and the Golden Butterfly was te rock dum p cons ists of a clay cappi ng layer, a rock fill surfac e protec tion layer and tops oil layer, ex cept for the wes tern bat ter of the Cont ent was te rock dum p.

The per formanc e of the final cover system at the Projec t is monitored indirec tly via eros ion, veget at ion and wat er monitoring. Thes e monitoring par am et ers provide an indirec t indic at ion of the integr ity of the final cover system . Eros ion and veget at ion cover monitoring on the was te rock dum ps will be monitored at the sites listed in Sec tion 7.1.1 utilising the par am et ers ident ified in Sec tion 8.1 for eros ion monitoring and in Sec tion 7.1.2 for veget at ion cover monitoring.

Pot ent ial fai lure of the final cover system would pos sibly res ult in impac ts on surfac e wat er and groundw at er qual ity and veget at ion cover per formanc e. Accordingly, the integr ity and effec tivenes s of the final cover system s at the Projec t are monitored indirec tly via surfac e wat er, groundw at er, veget at ion and eros ion monitoring (Sec tions 4, 6, 7 and 8).

9 REVIEW

EA Condition A2 4 is of additional relevance to this RMP and is provided below:

(A2-4) Any management or monitoring plans, systems or programs required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm as often as necessary but at least every two years and amended promptly if required.

In accordance with Condition A2 4 of the EA this RMP will be reviewed for effectiveness at least every two years and amended promptly when required.

10 REFERENCES

Barrick Gold of Australia (2008) *Croydon Gold Mine Project – Environmental Management Plan.*

Barrick Gold of Australia (2008a) *Croydon Gold Mine – Plan of Operations*.

Department of Minerals and Energy (1995) *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland,* Queensland Government.

APPENDIX G RGS SUMMARY REPORT ON GOLDSIM MODELLING

Date: 16 November 2020
Project Name: Wilson Minerals Croydon Project
Revision Number: 001
Project Number: 2020049

From: RGS Environmental Pty Ltd
3/30 Lensworth Street,
Coopers Plains QLD 4108

To: Epic Environmental

Attention: Maria Mahon

Content: Summary Report on the GoldSim ERC Modelling

1 Background

Epic Environmental (Epic) is going through an Estimated Rehabilitation Cost (ERC) decision process with Wilson Minerals (Wilson) for their Croydon Gold Mine in northern Queensland. Croydon Gold Mine consists of four open cut pits, currently filled with water. The Department of Environment and Science (DES) who assess the ERC application have asked Wilson to provide additional information to support the statement in the ERC Application that there is no risk of spill from the pits, including an assessment of the risk of uncontrolled releases based on current volumes of water stored in the pit.

DES's concerns arise from an overtopping event in 2010/2011 due to a significant localised rainfall event, although evaluation of monthly rainfall data from Croydon from 2000 to 2020 verifies that the spill event during the 2010/2011 wet season was in response to a consecutive series of above average rainfall events over the 2005/2006 and 2008/2019 through to 2010/2011 wet seasons.

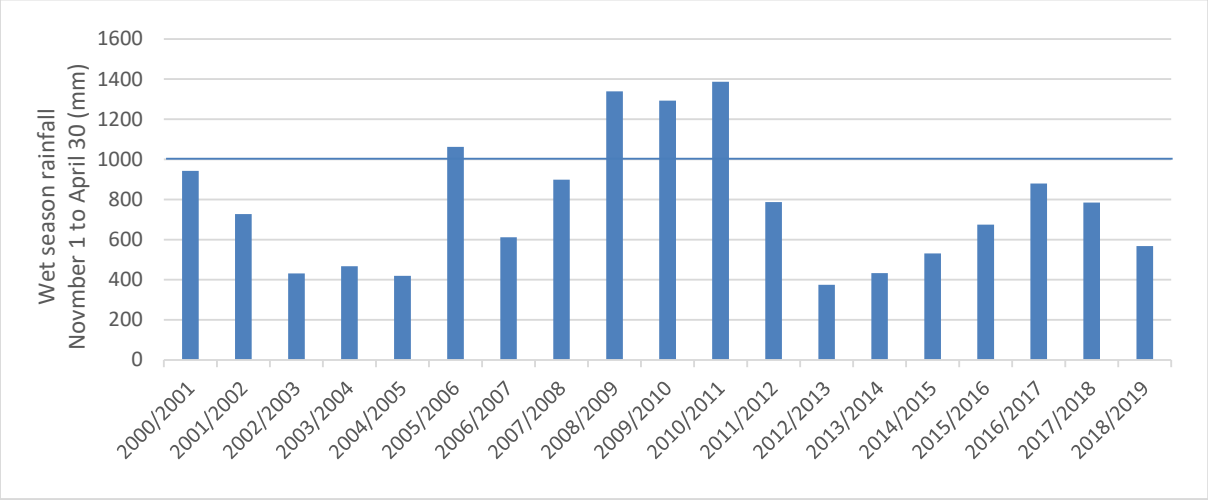


Figure 1-1: Wet season rainfall 2000 to 2019 at Croydon (BOM)

The annual rainfall > 800 mm / year in verifies that the rainfall events that contributed to the overtopping of the Content Pit are not isolated events and extended and consecutive periods of above average rainfall occurred in the rainfall record back to 1889 (**Figure 1-2)**.

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP) for Croydon, derived from BOM rainfall data, are in **Table 1-1**.

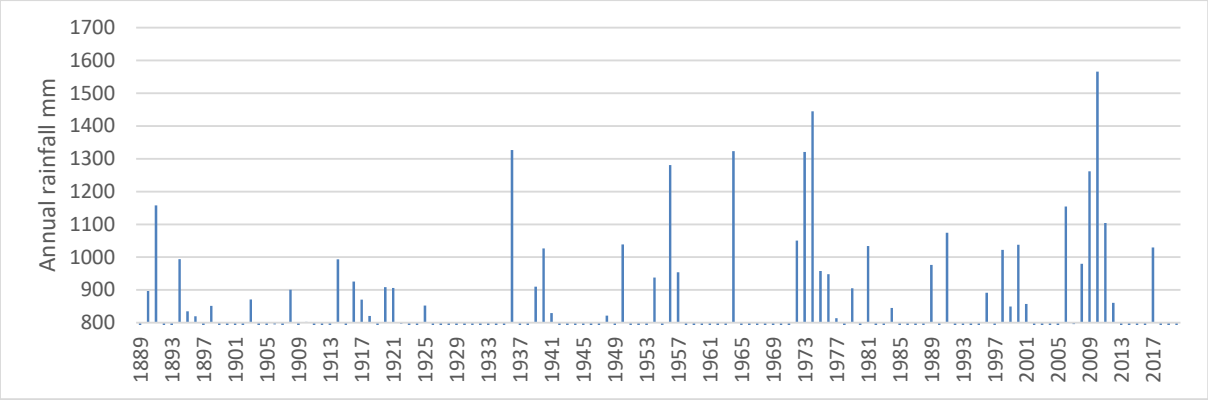


Figure 1-2: Annual rainfall > 800 mm / year at Croydon (BOM)

Table 1-1: Croydon AEP data (BOM)

Equivalent ARI event	1 in 1 Year	1 in 1.4	1 in 4.5	1 in 10	1 in 20	1 in 50	1 in 100
	AEP %	AEP %	AEP %	AEP %	AEP %	AEP %	AEP %
Duration	63.2%	50%#	20%*	10%	5%	2%	1%
1 min	2.43	2.72	3.60	4.17	4.70	5.38	5.87
2 min	4.24	4.79	6.39	7.39	8.29	9.27	9.93
3 min	5.97	6.73	8.96	10.4	11.6	13.1	14.1
4 min	7.58	8.52	11.3	13.1	14.7	16.7	18.0
5 min	9.07	10.2	13.5	15.6	17.6	20.0	21.7
10 min	15.2	17.0	22.4	26.0	29.3	33.7	36.9
15 min	19.7	22.1	29.2	33.8	38.1	43.8	48.0
20 min	23.4	26.1	34.5	40.0	45.1	51.8	56.7
25 min	26.3	29.4	38.9	45.1	50.9	58.4	63.8
30 min	28.8	32.3	42.7	49.5	55.9	63.9	69.8
45 min	34.4	38.7	51.4	59.6	67.2	76.7	83.5
1 hour	38.4	43.2	57.6	66.8	75.5	86.0	93.5
1.5 hour	43.9	49.6	66.4	77.1	87.1	99.3	108
2 hour	47.7	53.9	72.5	84.4	95.4	109	119
3 hour	52.8	59.8	80.9	94.5	107	123	135
4.5 hour	57.8	65.6	89.2	105	119	139	153
6 hour	61.4	69.7	95.2	112	128	150	167
9 hour	66.7	75.8	104	124	143	169	190
12 hour	70.8	80.5	111	133	154	184	208
18 hour	77.4	88.1	123	147	172	208	237
24 hour	82.9	94.3	132	159	188	228	260
30 hour	87.7	99.8	140	170	201	244	279
36 hour	92.0	105	148	180	213	259	296
48 hour	99.7	114	161	196	233	284	325
72 hour	112	129	183	223	266	322	367
96 hour	123	141	200	244	290	351	399
120 hour	132	151	215	261	308	373	424
144 hour	140	160	227	274	321	390	445
168 hour	147	168	237	284	331	403	462

Note:
The 50% AEP IFD **does not** correspond to the 2 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 1.44 ARI.
* The 20% AEP IFD **does not** correspond to the 5 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 4.48 ARI.

2 Scope

To address DES concerns, a Stage 1 water balance model was compiled using a probabilistic approach to model parameters which were unknown at that stage (catchment areas, pit stage curves, runoff coefficients etc). The model results determined that within a 12-month period it was unlikely that any of the pits would overflow to the environment. DES had comments on the Stage 1 model and required additional work that has been addressed in a Stage 2 model. The Stage 1 and Stage 2 model were compiled in GoldSim. GoldSim is the premier Monte Carlo simulation software solution for dynamically modelling complex systems in engineering, science, and business. GoldSim supports decision-making and risk analysis by simulating future performance while quantitatively representing the uncertainty and risks inherent in all complex systems.

3 Stage 2 Water balance model

The Stage 2 model has additional information.

- Revised modelling of scenarios that could be expected to occur post-closure over a suitable timescale.
- Further details of the water balance modelling undertaken, sufficient that a suitably qualified third-party expert could replicate the modelling and assess the reasonableness of all inputs and assumptions relied upon.
- Sensitivity analyses for the water balance model outputs (i.e. runoff coefficients, catchment areas, seepage inflows and outflows from each pit, evaporation coefficients and pit storage curves)
- In the absence of information and where assumptions are relied upon, the revised modelling should reflect a conservative approach and/or further justification be given for chosen inputs (i.e. where calibrated runoff coefficients are unavailable and the runoff coefficients applied is less than 1, further justification is sought).

This Stage 2 Model adds to the reliability and certainty of model results and reduced uncertainty by:

- Providing reliable estimates of catchment areas for each of the pits based on LiDAR data.
- Improved stage curves for all four pits, especially Golden Butterfly and Golden Butterfly North, based on surveyed bathymetry data.
- Calibrating model parameters (evaporation factors, runoff coefficients and groundwater seepage) to the measured pit lake level fluctuation data between approximately 2012 and 2016, for all of the pits.

4 Model structure

Conceptually, the Croydon Gold Mine Water Balance model represents a typical hydrological cycle, including water inflows and outflows of the pit lakes. The model comprises of the respective mine pits (pit modules) and a climate module providing climate inputs (rainfall and evaporation rates) on daily timesteps. Each of the mine pit modules comprise the following.

- Pit geometry, defining pit lake storage curves (relationships between pit lake volume – pit lake area and pit lake water level) and maximum pit volume. If the water volume in the pit exceeds maximum pit lake volume, then overflow event occurs.
- Pit inflows, including:
    - Rainfall on the pit lake
    - Runoff from the exposed pit walls
    - Runoff from the surrounding catchment
    - Groundwater inflow
- Pit outflows, including:
    - Evaporation from pit lake surface
    - Groundwater outflow

The hydrological process captured in the model is depicted conceptually in **Figure 4-1**.

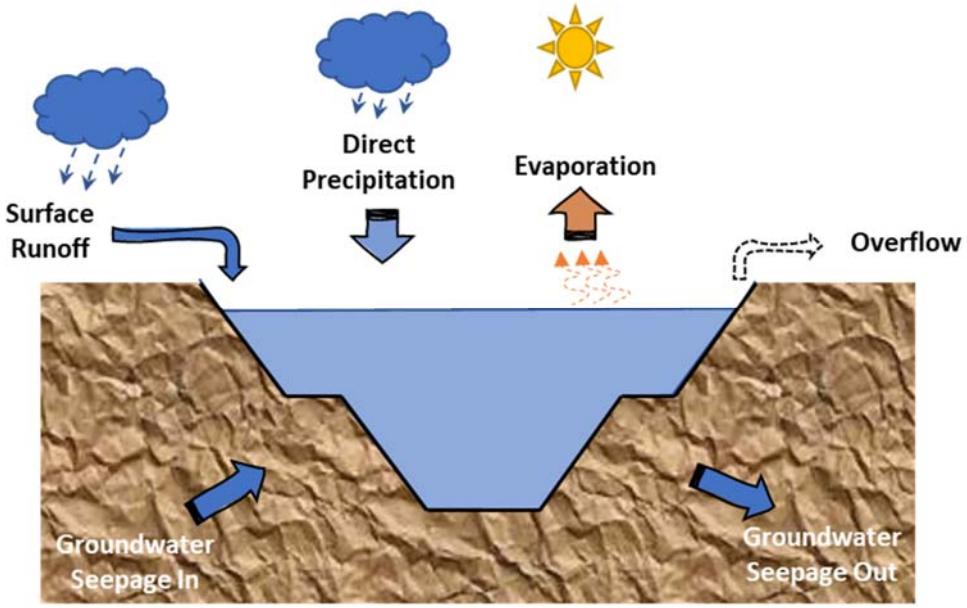


Figure 4-1

The GoldSim model operates on daily time steps. In each time step the calculation of the pit lake volume is presented schematically in **Figure 4-2**. In every time step, pit lake area and pit water level elevations are calculated internally by applying the Stage Curve relationship discussed in **Section 5.1**.

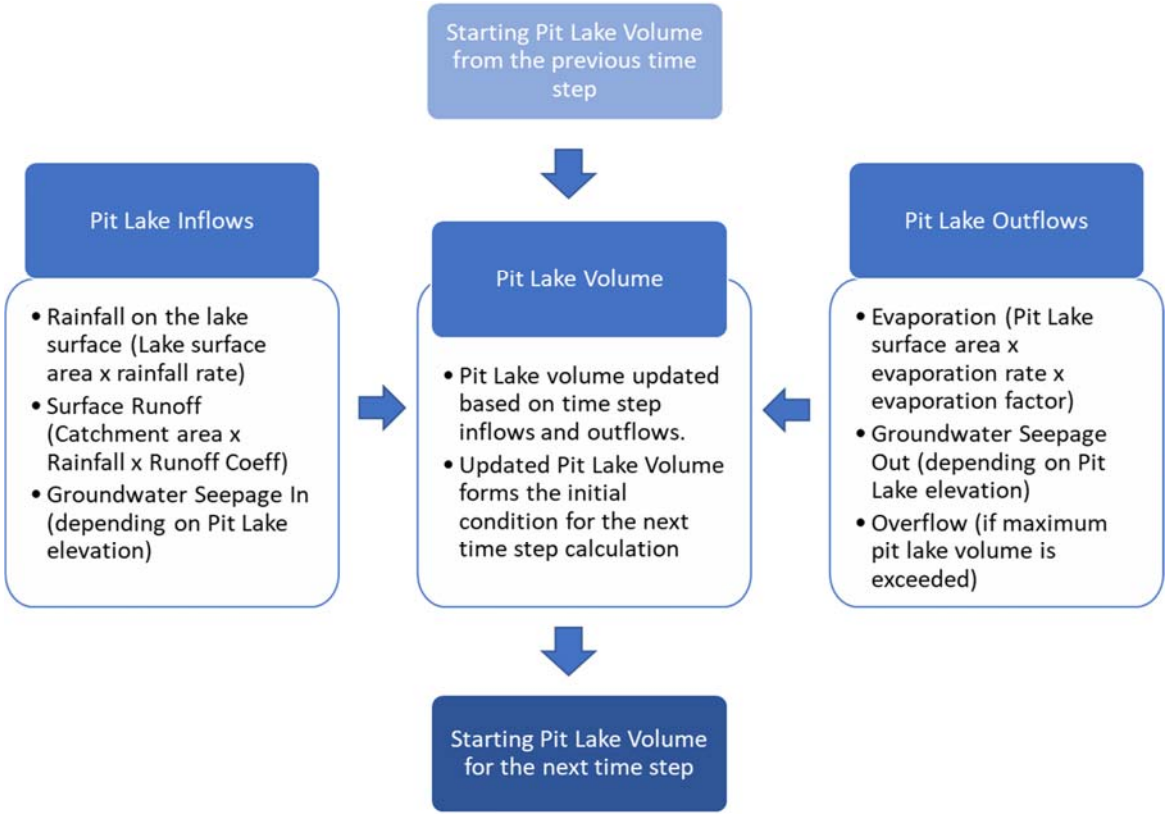


Figure 4-2: GoldSim model schematic and process flow

5 Model inputs and assumptions

The climate simulated in the model includes rainfall (**Figure 5-1**) and evaporation (**Figure 5-2**). Daily rainfall and pan evaporation data was downloaded from SILO database (www.longpaddock.qld.gov.au/silo) from the weather station number 29012 (CROYDON TOWNSHIP), for the period of 1 January 1900 to 1 January 2020 (available data).

The evaporation data shows it was not measured prior to 1970 (**Figure 5-2**), and available SILO data represents long term daily averages only.

Depending on the phase of the simulation process, a full set of data or selected periods of data were used, as described in detail in the following sections of the report.

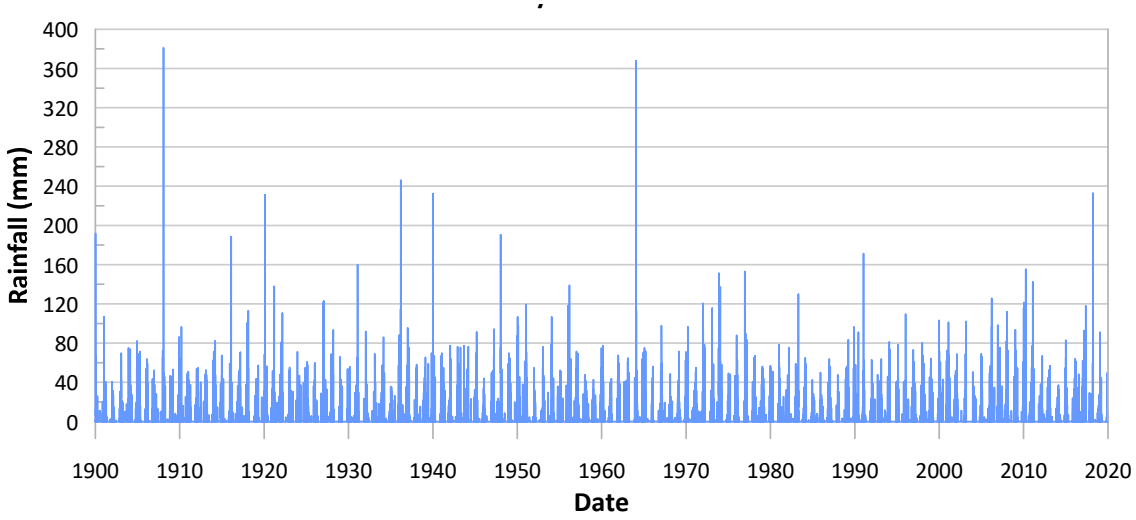


Figure 5-1: BOM daily rainfall

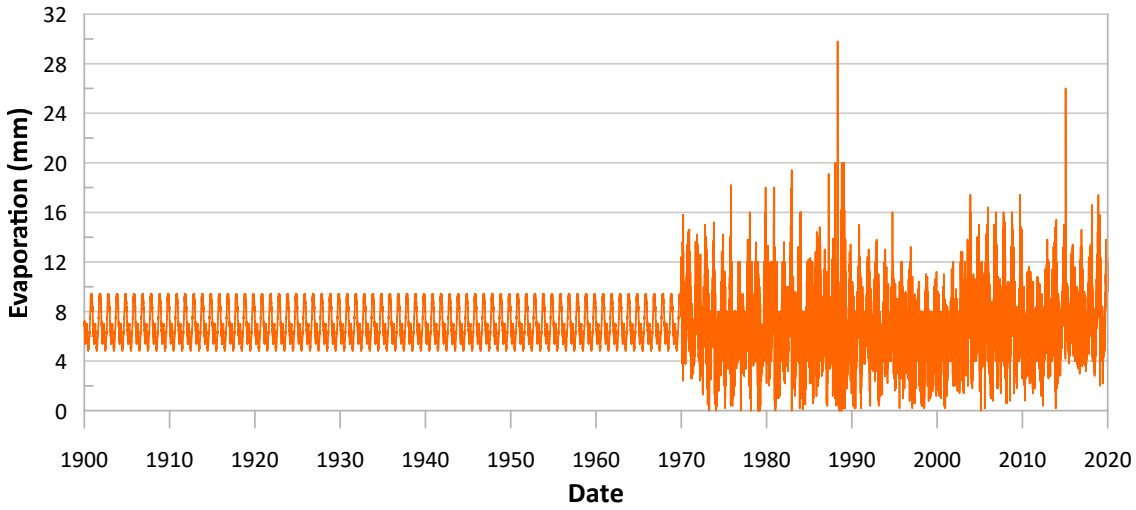


Figure 5-2: BOM daily evaporation

5.1 Pit lake geometry

Pit lake geometry (Stage Curve – SC) describes the relationship between pit lake volume – pit lake surface area – surface lake elevation. Stage curves applied in the model for the respective pit shells are in **Figure 5-3**.

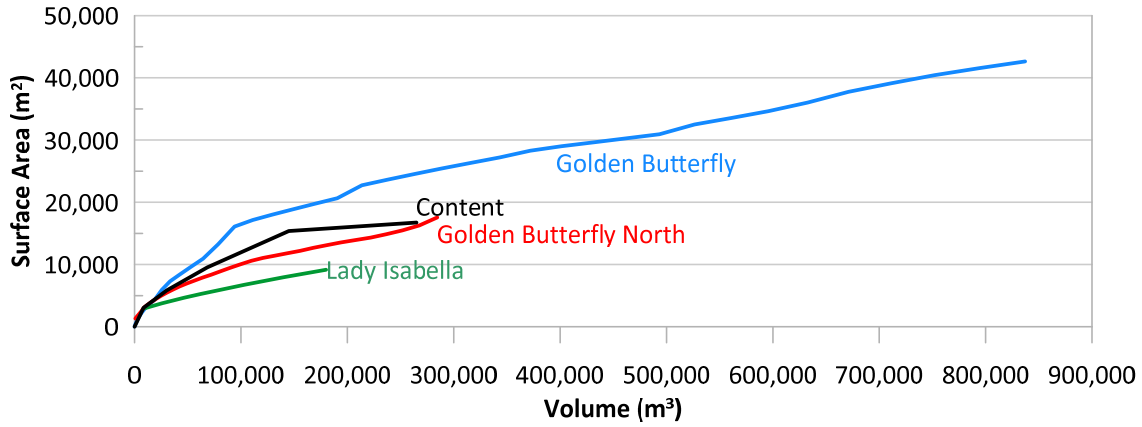


Figure 5-3: Stage curve – pit lake volume versus surface area

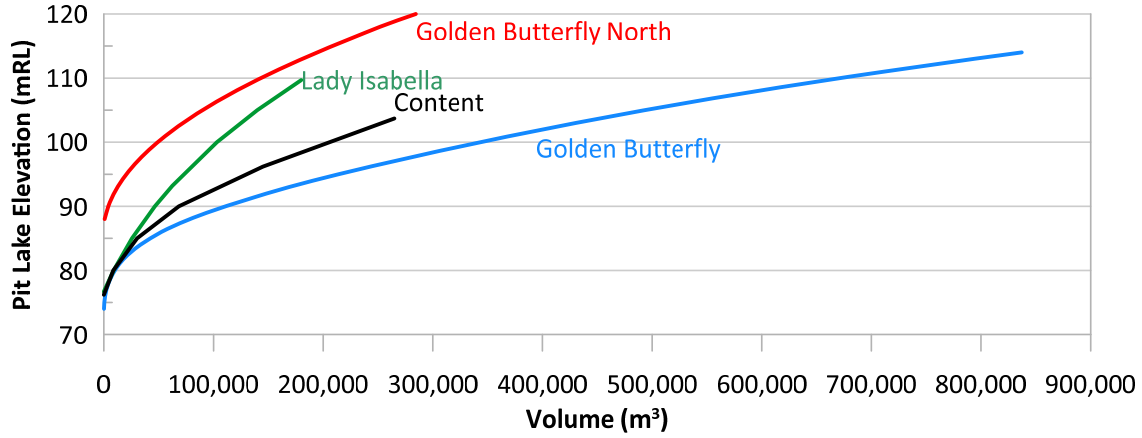


Figure 5-4: Stage curve – pit lake volume versus elevation

Stage curves for Golden Butterfly North Pit Lake and Golden Butterfly Pit Lake were based on 3-dimensional DTM files for the pit bathymetry provided by Wilson. It is understood that the data is approximate.

Lady Isabella and Content Pit Lake stage curves were approximated using “inverted” cone equations, based on data from “Wilson Pit Water Volumes Summary – August 2019” provided by Wilson. For the calculation, the area of the full pit lake was approximated by an equivalent circle based on LiDAR analysis.

The volume – area – depth relationship was approximated using a cone equation with varying pit wall slope to match Volume – Water Level measurements provided in the abovementioned document.

5.2 Pit wall area

The exposed pit wall area is calculated in the model as a planar area difference between the current pit lake area (on any given day) and the maximum pit lake area for the given total pit shell.

5.3 Catchment area

External catchment areas for each of the pits were calculated based on LiDAR data provided by Wilson.

An example of the catchment extent calculation based on slope analysis for the Golden Butterfly North Pit is shown in **Figure 5-5**. Catchment areas derived using this process are in **Table 5-1.**

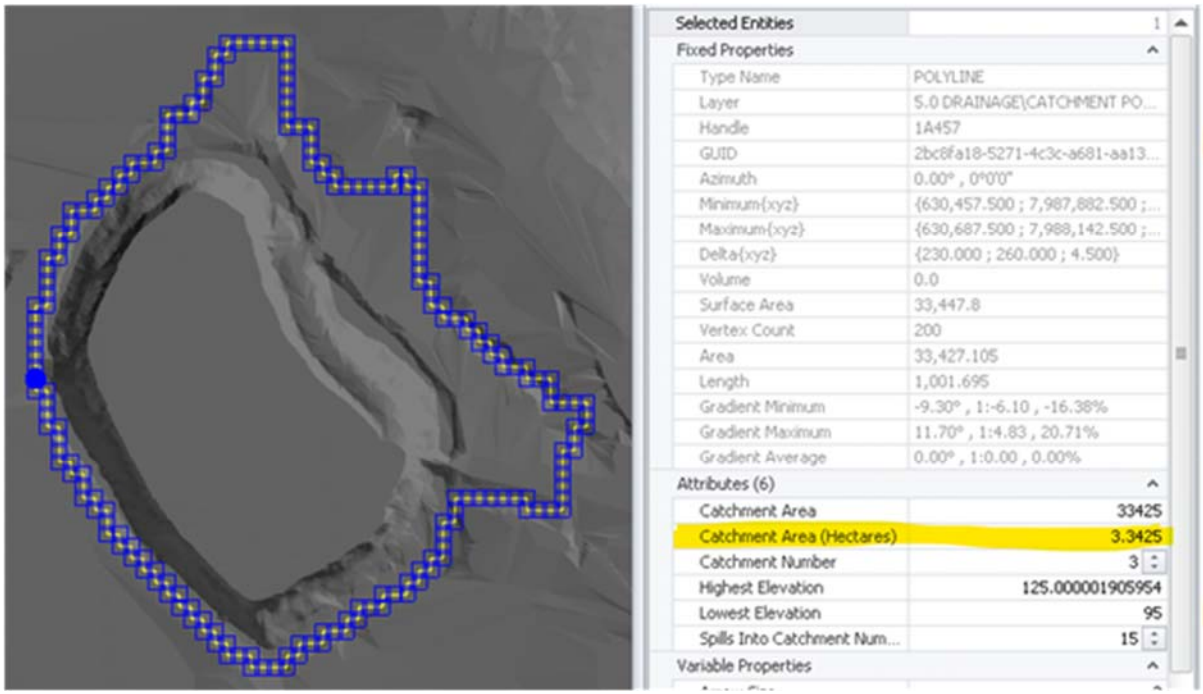


Figure 5-5: Catchment areas derived from LiDAR data and analysis using Deswik.CAD

Table 5-1: LiDAR derived catchment areas

Pit	Catchment Area (ha)
Golden Butterfly	6.29
Golden Butterfly North	3.34
Lady Isabella	2.37
Content	2.49

5.4 Runoff coefficients

Runoff coefficients were adjusted during the calibration process described below. During the process, they were allowed to vary between 0.5 and 1, based on typical values for these in north Queensland water balance models (1 being the physically maximum value – all rainfall reports as runoff, and 0.5 being the lower reasonable value for small catchments where catchment retention is limited and does not “trap” significant volumes of rain preventing generation of runoff).

Additionally, catchment runoff was split between pit wall runoff and external catchment runoff to allow for potential variability in runoff magnitude based on the topography.

6 Model calibration

Model calibration was run using GoldSim automatic optimization scheme. The calibration was carried out based on pit lake level measurements reported in "Annual Groundwater Monitoring Report, 2016". The calibration models were run for 50 years using the rainfall and evaporation data from between 1970 and 2019.

In essence, historical pit lake elevations provided in the above mentioned report were digitized and compared to model simulated water levels during the optimization runs. The model parameters were then adjusted until the best possible match was achieved.

An "objective function" comparing accuracy of matches was prepared, and the GoldSim optimisation task was to minimize the difference between historical measured water levels and model simulated water levels, by adjusting:

- Evaporation factor
- External Catchment Runoff Coefficient (RC)
- Pit Wall Runoff Coefficient (RC)
- Groundwater Seepage In rate Modifier
- Groundwater Seepage Out rate Modifier
- Catchment Area Modifier
- Pit Stage Curve Modifier

Evaporation Factor – it is used to modify the pan evaporation rate to account for lower evaporation rates from the actual water bodies compared to weather station measured data. Typical values oscillate within a range of 0.7 – 0.9. In the calibration process the evaporation factor boundaries were constrained to between 0.5 to 1.0 of the SILO sourced evaporation rates.

External Catchment Runoff Coefficient – The runoff from the catchment is calculated as catchment area x rainfall x runoff coefficient. For small catchment areas the typical number would oscillate within a range of 0.5 – 0.8. During the calibration process the External Catchment Runoff Coefficient was constrained to within a 0.5 to 1.0 range of the rainfall rate. It should be noted that the external catchment area used by the model to generate runoff is calculated as Catchment Area minus Pit lake Area and Exposed Pit Walls surface area, therefore it varies during the model run as pit lake surface area and exposed pit wall surface areas vary.

Pit Wall Runoff Coefficient (RC) – to account for the steeper exposed pit walls compared to overall catchment around the pit lakes, a distinction was introduced to allow the model to increase the runoff coefficient for the model calculated exposed pit walls. Pit Wall Runoff Coefficient was constrained to a 0.5 to 1.0 range within the calibration, with an assumption that its value has to be equal or greater than External Catchment Runoff Coefficient.

Groundwater seepage in and out of the pit is one of the less understood parameters at this stage. To account for the seepage, a seepage function was introduced to the model. The function assumed that:

- At "average" pit lake elevation, the lake acts as a groundwater sink (groundwater seeps in, there is no seepage out).
- At maximum pit elevation groundwater seeps out at maximum rate, there is no seepage in.
- Half-way between the average pit lake elevation and the maximum pit lake elevation, the seepage rates are zero.
- When the water level is lower than the average pit lake elevation the seepage rate into the pit lake attains its maximum flow rate and remains constant below that point.

During the calibration process, the maximum seepage rates were set to 300 m^3/d and seepage rate modifiers were allowed to vary between 0 and 2.

Catchment Area Modifier – although the catchment areas were estimated fairly precisely from the LiDAR data, there were allowed to be slightly modified during the calibration process. The range of modification were set to 0.8 to 1.2 initially.

Pit Stage Curve Modifier – it was introduced to account for errors in estimated Stage Curves. The modifier greater than 1 indicates that for a given pit volume, the pit lake surface area should be greater and pit elevation should be higher than suggested from the Stage Curve applied. A modifier smaller than 1 indicates the opposite. The initial range of modification allowed was set to 0.8 to 1.2.

During the calibration, the parameters were allowed to be adjusted freely by GoldSim within the set range and the model averaged approximately 500 runs to achieve a reasonable match.

In case of Content Pit Lake, some of the parameters "hit" the boundaries of the parameters ranges. In this case the Catchment Area Modifier and Stage Curve Modifiers were further relaxed to allow the software to find the optimal solution. The results of the calibration and resulting parameters values are in **Figure 6-1** to **Figure 6-4.**

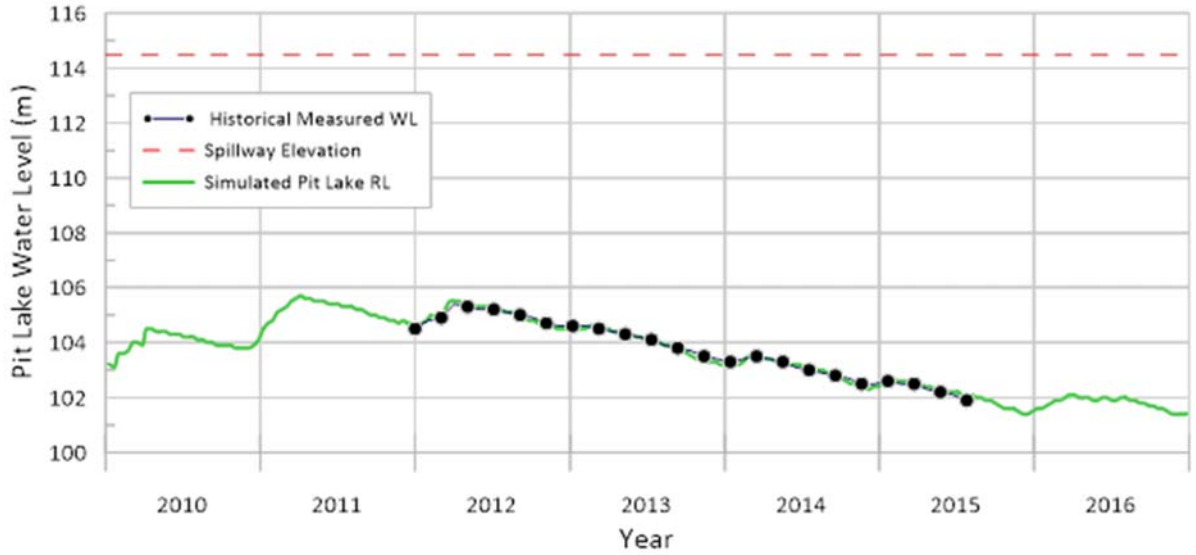


Figure 6-1: Golden Butterfly Pit Lake calibration results

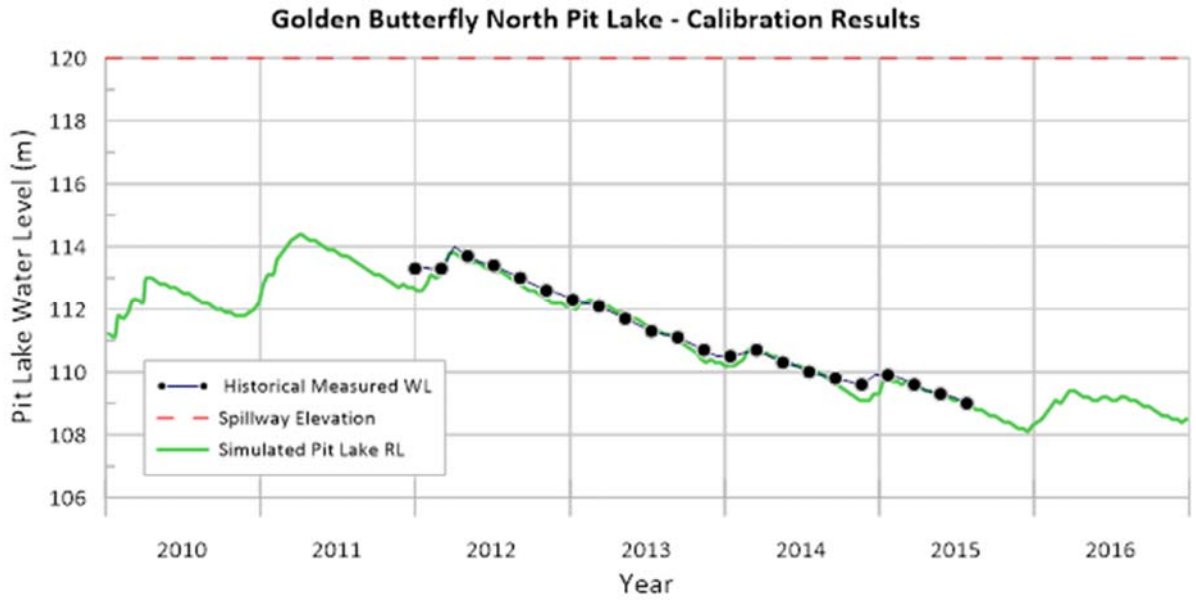


Figure 6-2: Golder Butterfly / North Pit Lake calibration results

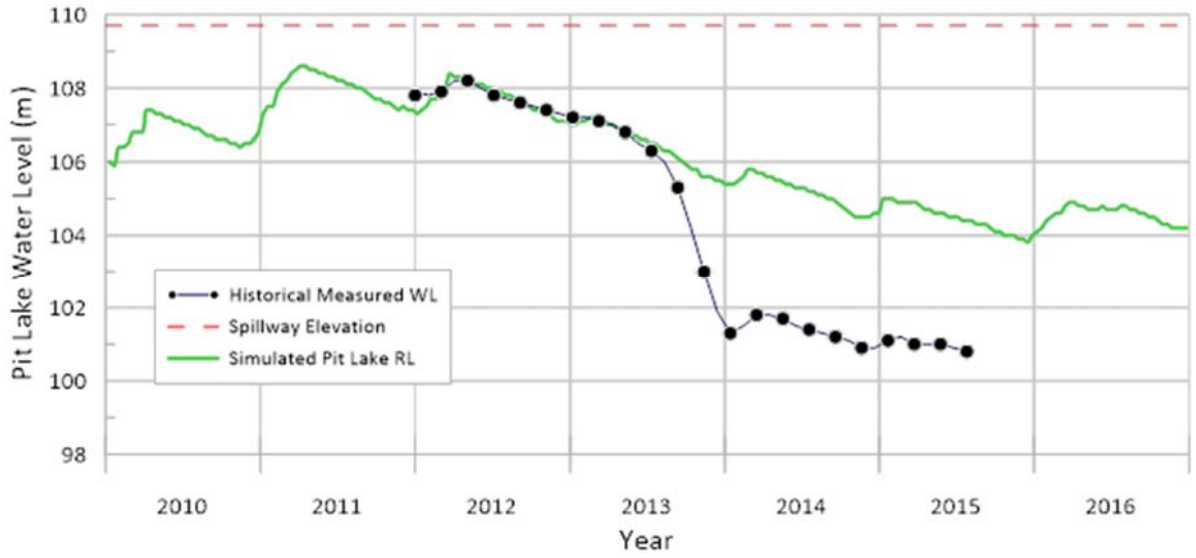


Figure 6-3: Lady Isabella Pit Lake calibration results

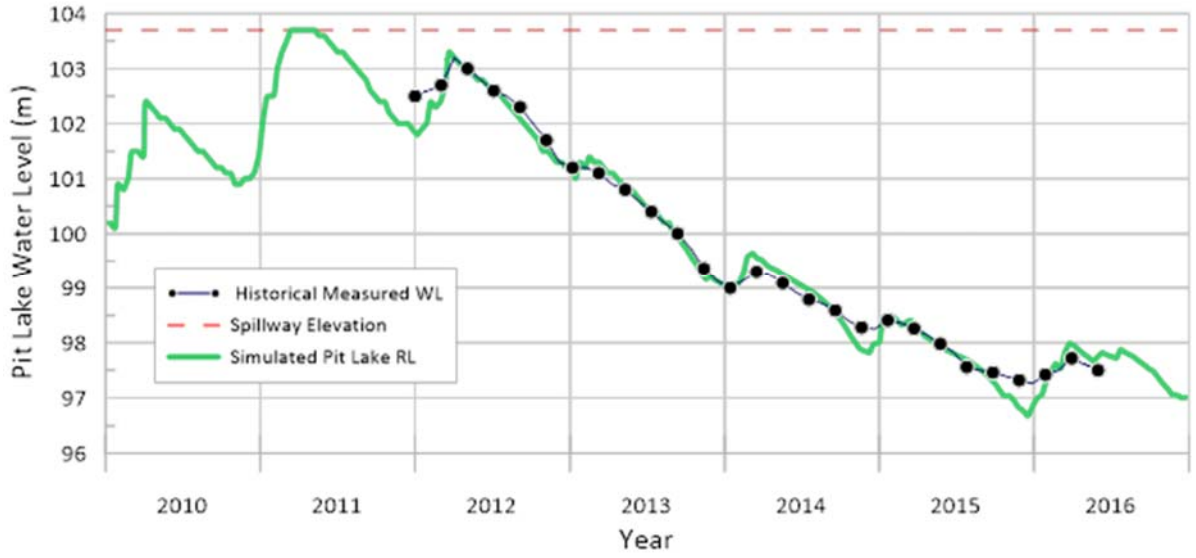


Figure 6-4: Content pit lake calibration results

Table 6-1: Model parameters

	Evaporation Factor	Catchment RC	Pit Wall (RC)	Seepage IN Modifier	Seepage OUT Modifier	Catchment Area Modifier	SC Modifier
GB	0.92	0.74	0.86	0.87	1.02	1	1
GBN	0.86	0.8	0.81	0.5	0.14	1	1.16
LI	0.84	0.6	0.72	0.7	0	1	1.03
C	0.97	0.99	0.99	0.3	0	1.23	1.60

6.1 Calibration results

The calibration results have a high level of reliability for Golden Butterfly and Golden Butterfly North pits.

Deviation in the calibration of Lady Isabella Pit Lake and Content Pit Lake are attributed to uncertainty in how water in these pits was managed, rather than uncertainty in model parameters.

According to the Barrick Annual Groundwater Monitoring Report (2016) limestone dosing of both the Content Pit and Lady Isabella Pit lakes was undertaken to achieve neutral pH. The increase in pH from acid to neutral pH enabled the Content and Lady Isabella Pit Lakes to achieve stock watering guideline quality. Subsequently the local pastoralist and Croydon Shire Council received approval to extract water from the Content and Lady Isabella Pit Lakes for stock watering and road construction purposes, respectively.

The effect of the water extraction is particularly obvious in historical water level data from 2013 in the Lady Isabella Pit Lake. Because water extraction flow rates and the timing and duration of the extraction are not known it was decided to calibrate this pit to pre-extraction water level data. The calibrated parameters used for the Lady Isabella Pit Lake provide a more conservative outcome for the forecasted future water levels in this pit lake.

The water extraction from Content Pit Lake is less obvious but it seems likely it occurred towards the end of dry seasons in 2014 and 2015. Content Pit Lake required the greatest modifications to the model parameters to achieve reasonable calibration. However, following the calibration the model appears to calibrate well to the Content Pit Lake historical data, including the overflow event in 2011 and pit water level recorded in late 2019.

7 Sensitivity analyses

Following the calibration, sensitivity analyses were carried out. To assess the relative impact of the model parameters on the maximum simulated pit lake levels, the parameters were varied +/- 10% of their calibrated values and the impact on pit water levels were assessed.

Not surprisingly, in most cases, the models are most sensitive to evaporation rates as they exceed the rainfall for most of the year and the catchment area which generates majority of the pit inflow rates.

The lowest (the least important) parameters for the model calibration are typically pit wall runoff (relatively small area compared to the external catchment and pit lake surface area) and groundwater seepage out (indicating that for majority of time pit lakes form a groundwater sink).

Sensitivity results are presented in the form of tornado charts (**Figure 7-1** to **Figure 7-4**).

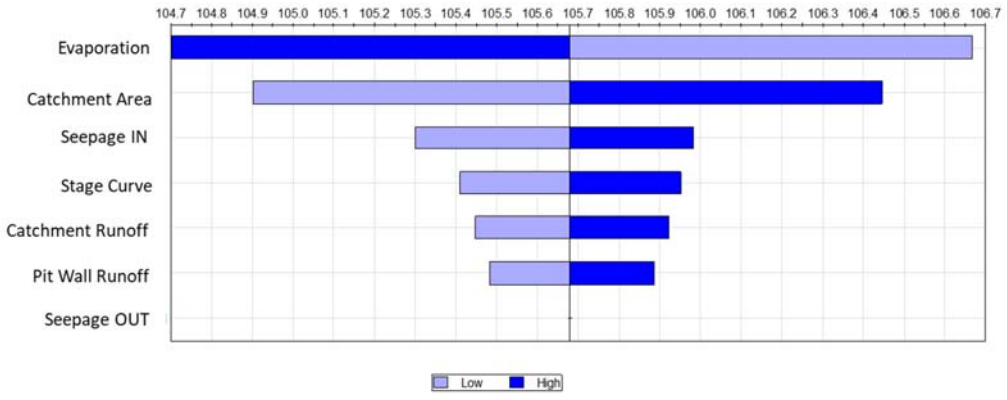


Figure 7-1: Tornado sensitivity chart for Golden Butterfly Pit Lake – maximum water level

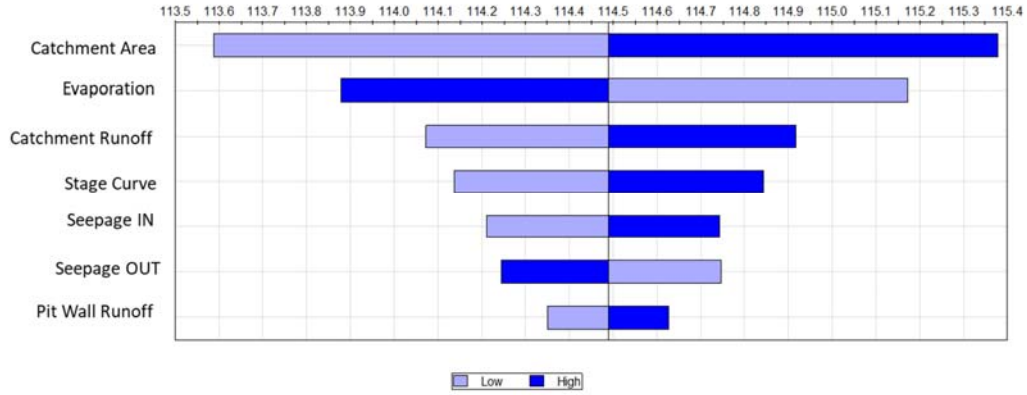


Figure 7-2: Tornado sensitivity chart for Golden Butterfly Pit Lake – maximum water level

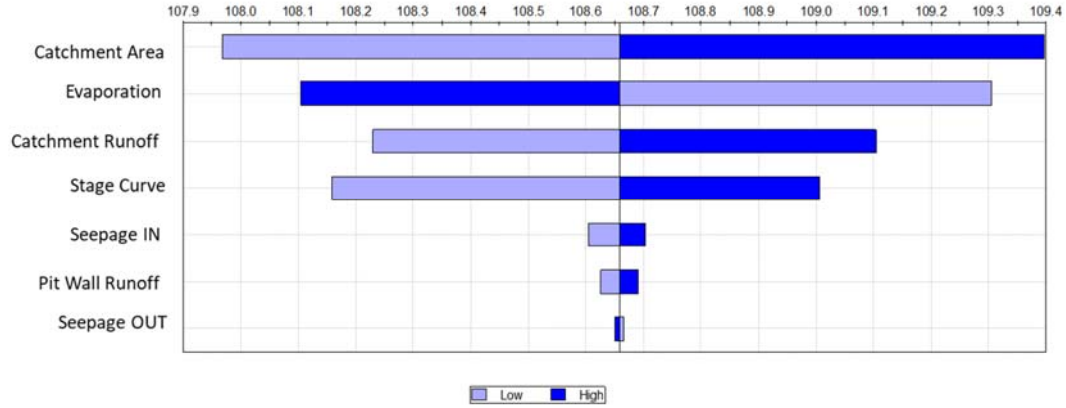


Figure 7-3: Tornado sensitivity chart for Lady Isabella Pit Lake – maximum water level

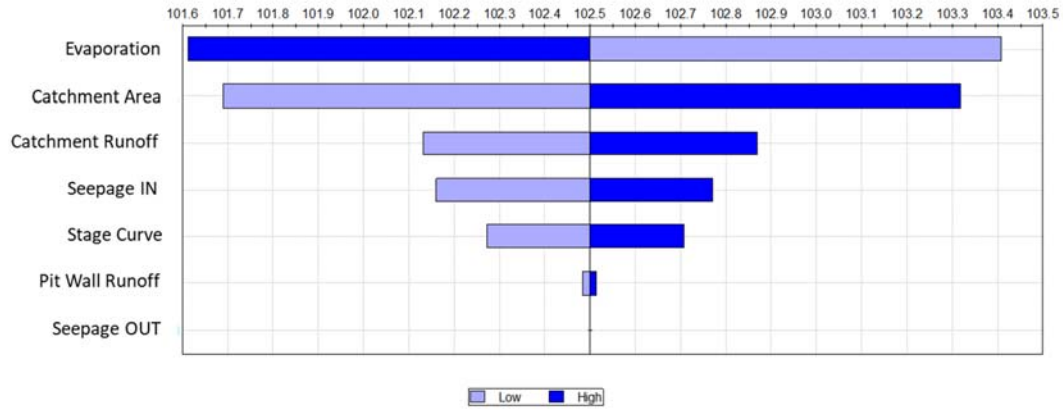


Figure 7-4: **Tornado sensitivity chart for Content Pit Lake – maximum water level**

8 Forecast scenarios

The forecast scenarios are run for a period of 5 years, from 1 January 2021 to 31 December 2025. To quantify potential risk of over-topping the pits, the forecast scenarios included three distinctive steps:

Step 1 - Repeat of 2008 – 2012 wet period (the wettest 5 year period on recent record (Figure 1-2)).

Step 2 - Simulation of 5 years of repeated annual rainfall based on actual annual rainfall data for all the years on record (i.e. 5 consecutive years of 1900 rainfall record – run 1. Then 5 years of 1901 rainfall record – run 2, etc., until 5 years of 2019 rainfall record – run 120).

Step 3 - 1,000 Monte Carlo (MC) runs in which 5-year rainfall sequence is randomly selected from the available data (for example – one set of MC runs may include rainfall years 1954, 2009, 1900, 2019, 1932. The following set may include 1943, 2010, 2011, 1967, 1974. And so on. The whole process is repeated 1000 times resulting in 1000 unique combination of rainfall sequences based on historical rainfall data).

Step 1 utilises the actual evaporation data for the 2008 – 2012 years, the Steps 2 and 3 use average monthly (applied daily) evaporation rates.

8.1 Initial conditions

Model initial conditions (current water levels) are based on data provided by Epic. The spillway elevations are based on the Barrick Annual Groundwater Monitoring Report (2016).

Table 8-1: Initial model conditions

	Golden Butterfly North Pit	Golden Butterfly Pit	Lady Isabella Pit	Content Pit
Spillway Elevation (m RL)	122.7	114.5	109.7	103.7
Current Water Level (m RL)	103.5	100	93.2	96.2
Current Freeboard (m)	19.2	14.5	16.5	7.5

9 Model results

The results for the four pit lakes are provided in **Figure 9-1** to **Figure 9-4** and present the outcomes of Steps 1 – 3 in **Section 8.**

The results represent a range of outcomes and include:

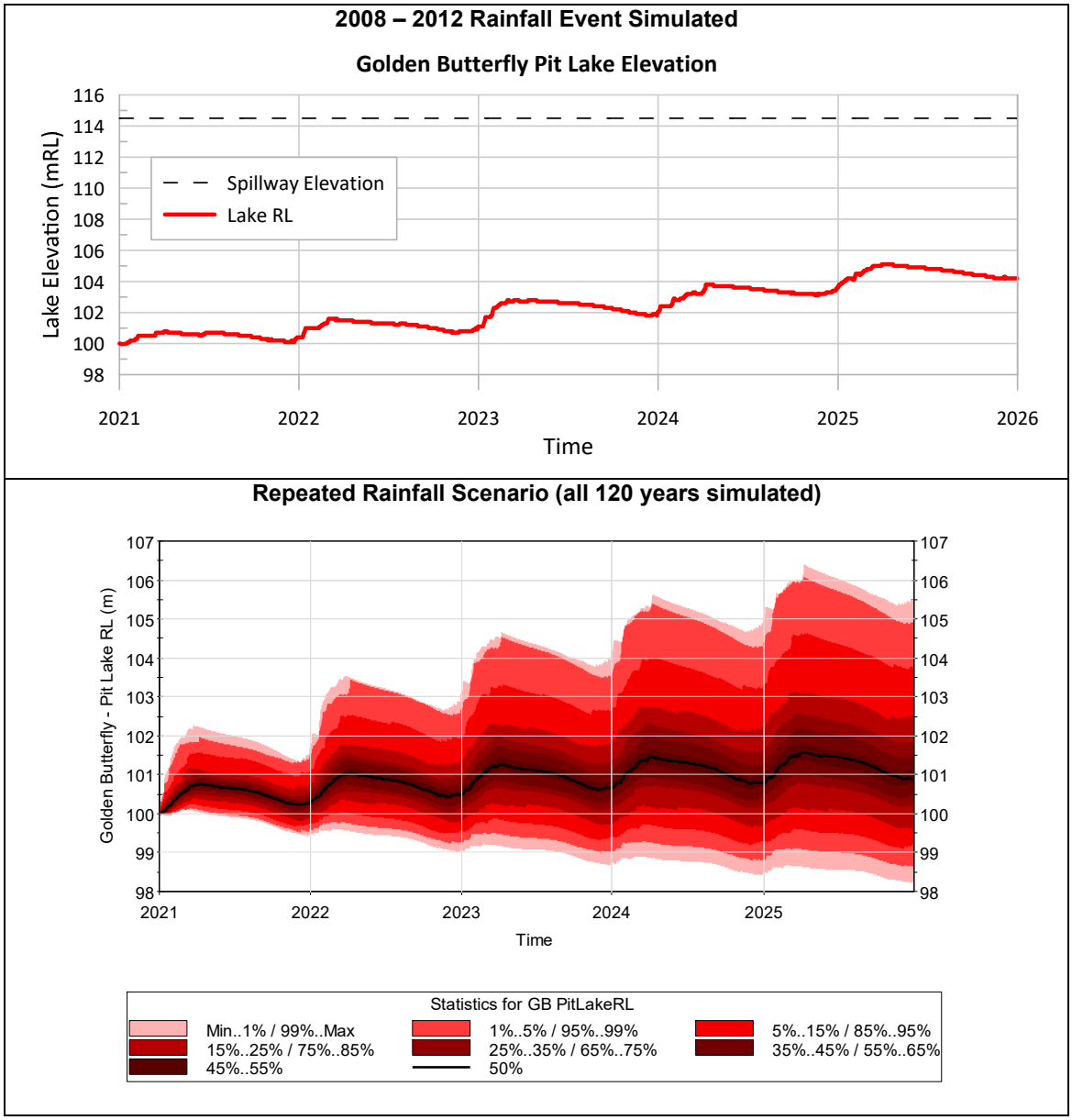
- Pit lake water level variation over the course of a simulated period of 5 years.
- Probabilistic distributions of predicted pit lake elevations from each of the runs (for Steps 2 and 3).

Modelling results indicate that potential spills from Golden Butterfly, Golden Butterfly North and Lady Isabella Pit Lakes are unlikely within the 5-year modelling timeframe.

There is a chance the Content Pit could overflow, if there is an unusually wet year or sequence of wet years and under the assumption that no anthropogenic water extraction occurs from the pit lake during that time.

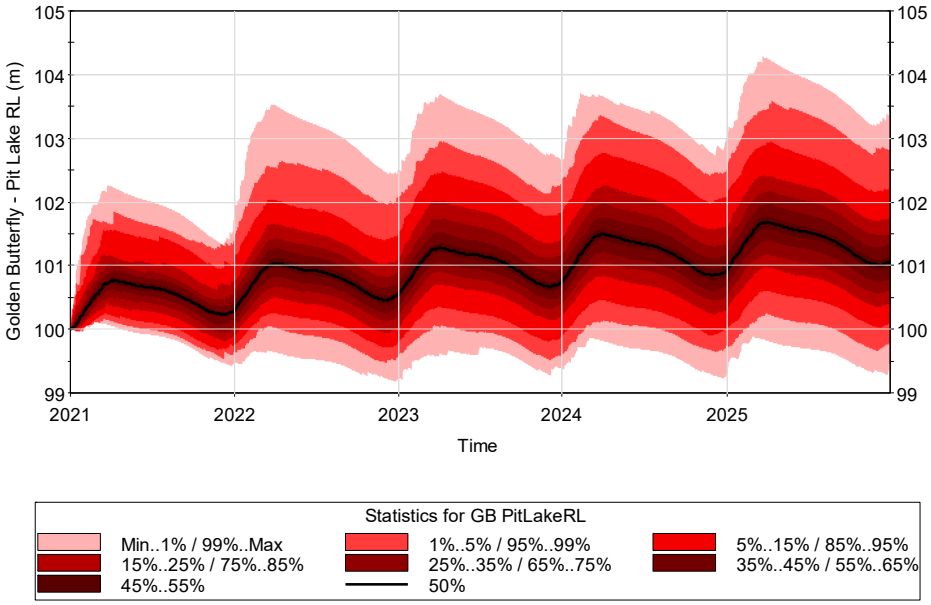
However, it should be noted that water is currently extracted from the Content Pit for stock watering purposes.

Figure 9-1: Golden Butterfly Pit Lake – Forecast Results



1000 runs x 5 Random Years in sequence

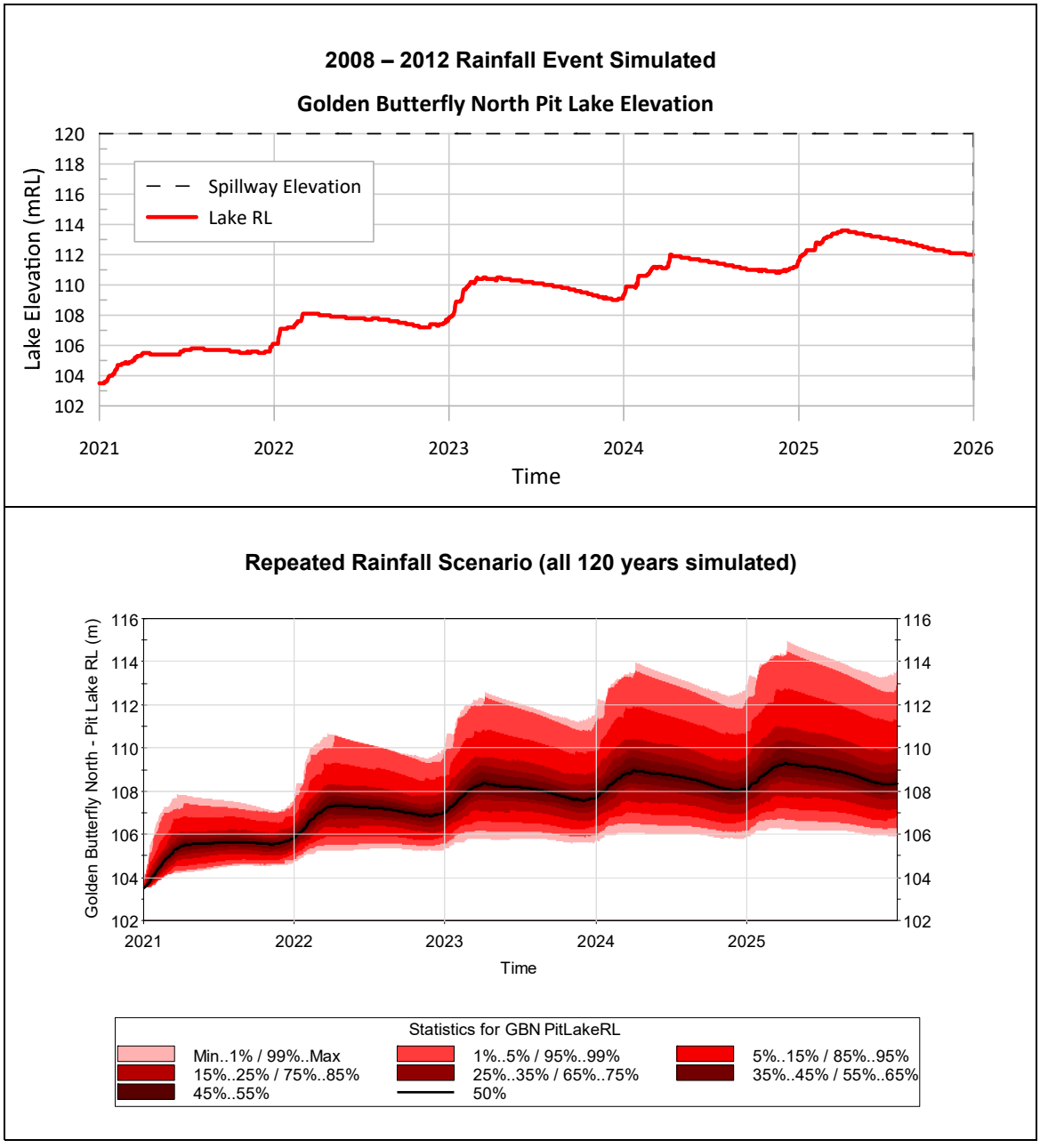
(Monte Carlo Run)

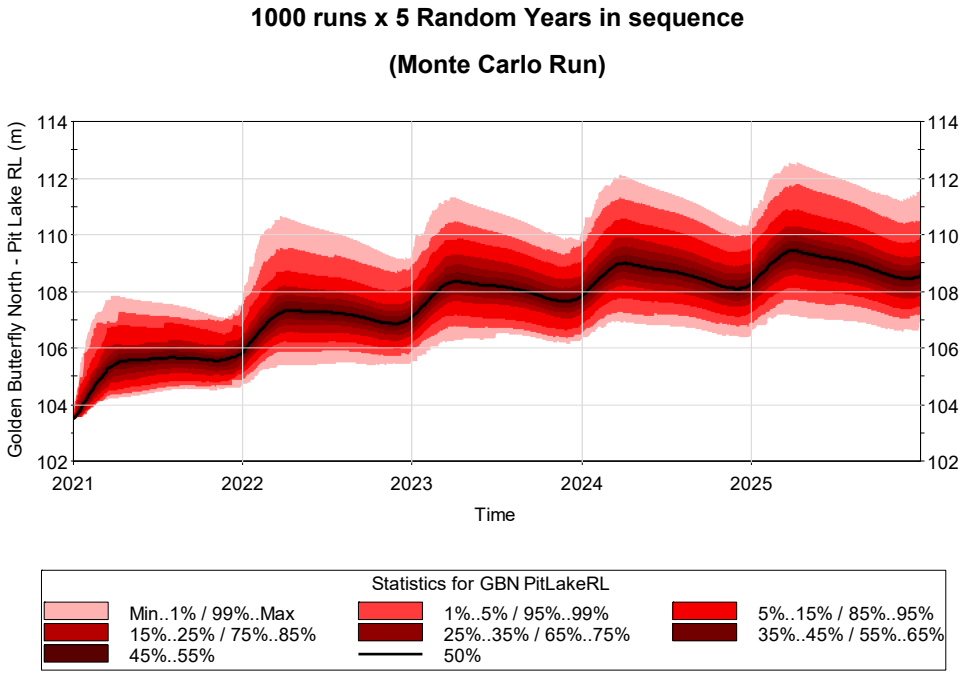


Comments

Modelling results (subject to all the model inputs and assumptions) indicate that a spill event for Golden Butterfly Pit Lake is **unlikely** within the next 5 years for 2008 – 2012 rainfall period, the 120 year rainfall period or the 1,000 Monte Carlo iterations of the random rainfall generation.

Figure 9-2: Golden Butterfly North Pit Lake – Forecast Results

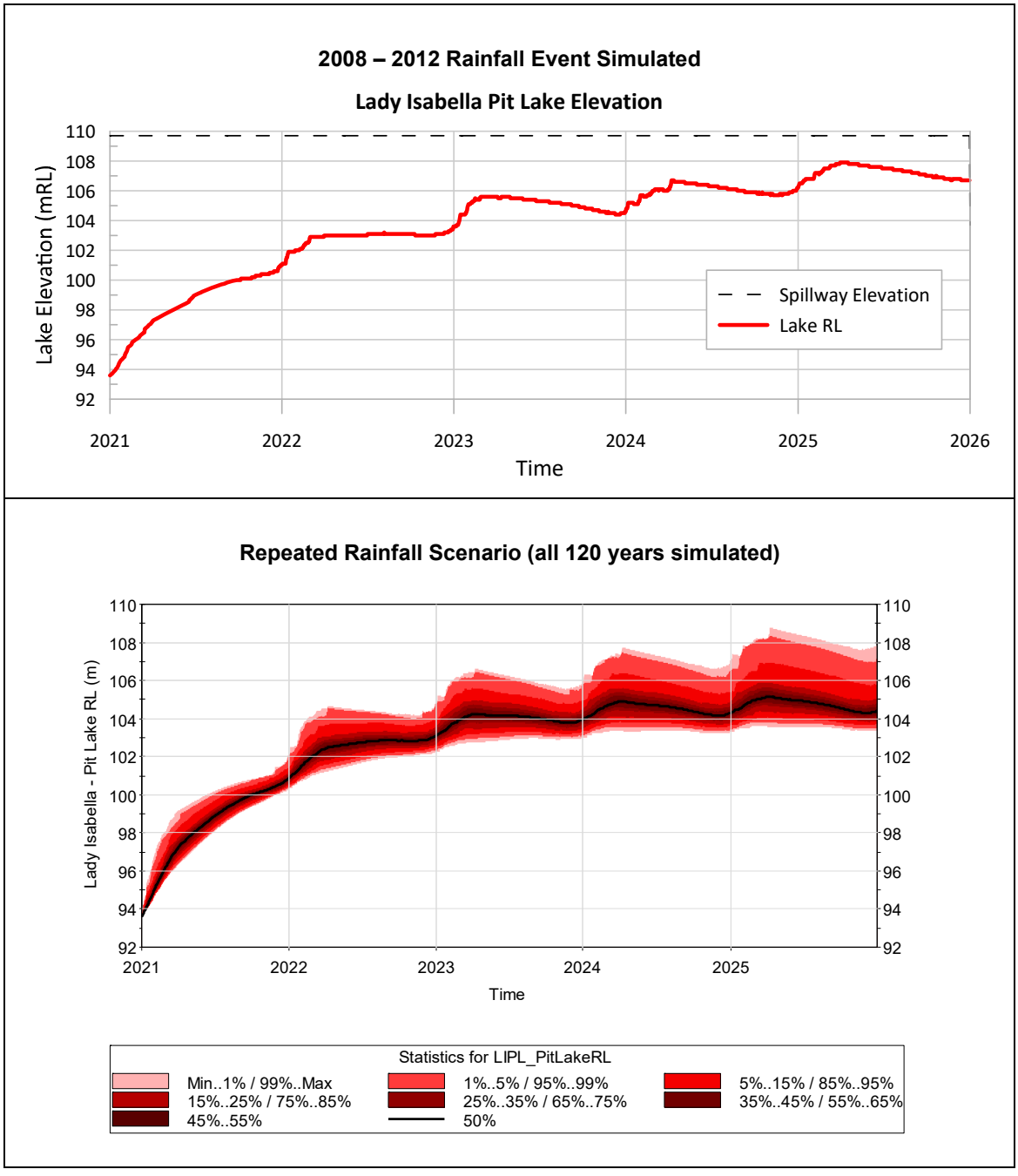




Comments

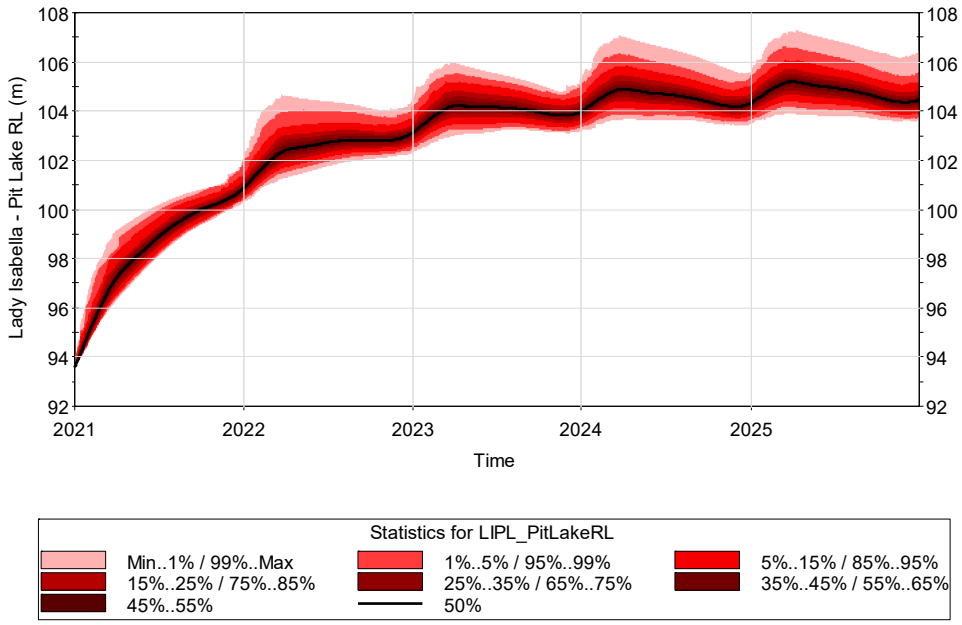
Modelling results (subject to all the model inputs and assumptions) indicate that a spill event for Golden Butterfly North Pit Lake is **unlikely** within the next 5 years for 2008 – 2012 rainfall period, the 120 year rainfall period or the 1,000 Monte Carlo iterations of the random rainfall generation.

Figure 9-3: Lady Isabella Pit Lake – Forecast Results



1000 runs x 5 Random Years in sequence

(Monte Carlo Run)



Comments

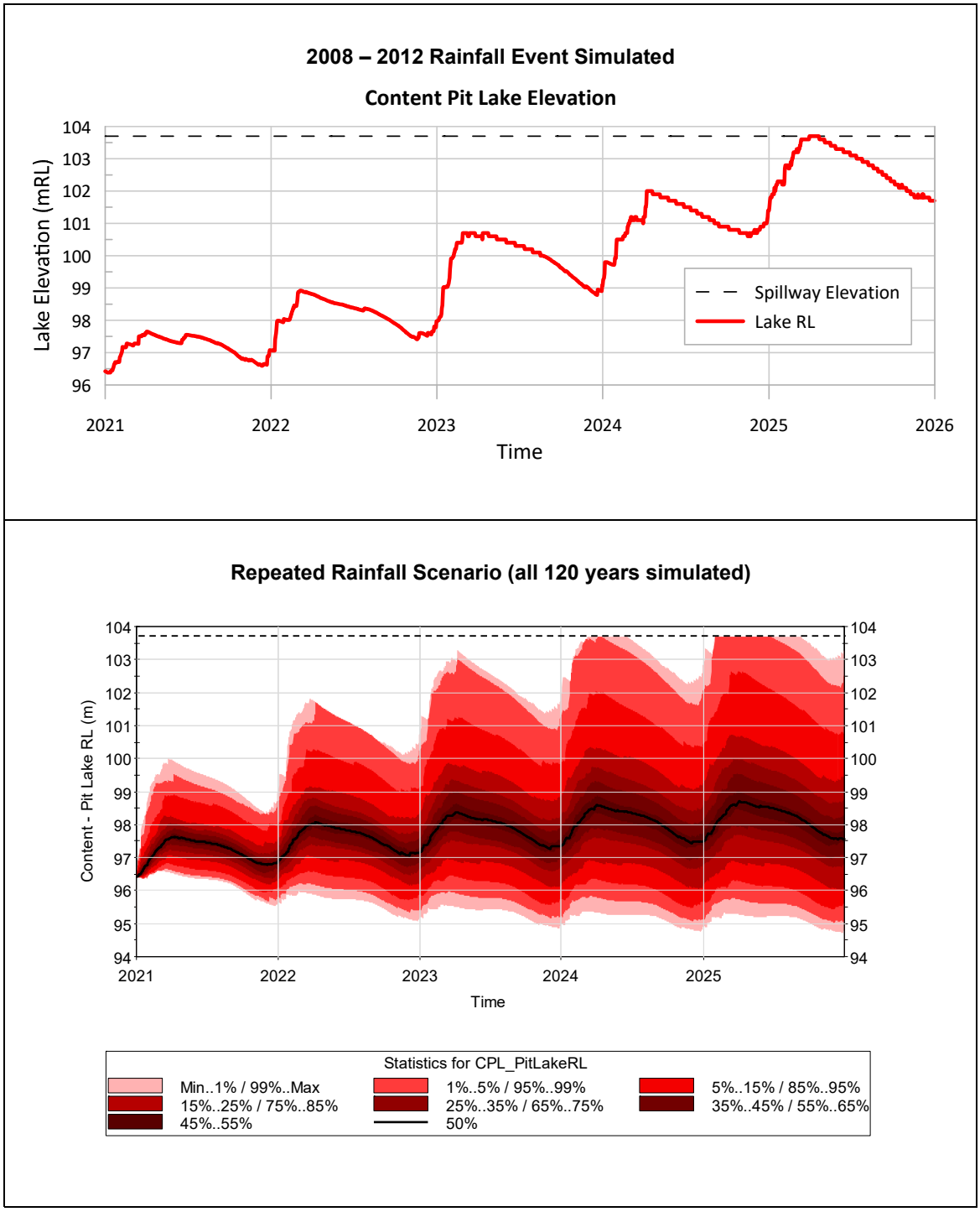
Modelling results (subject to all the model inputs and assumptions) indicate that a spill event is **unlikely** within the next 5 years for 2008 – 2012 rainfall period, the 120 year rainfall period or the 1,000 Monte Carlo iterations of the random rainfall generation.

As discussed earlier, the calibration process did not include water extraction from this pit lake, and therefore the model parameters are considered conservative as they result in higher pit lake elevation than measured post 2012.

Water extraction for water use from the pit lake was not considered in this model as a conservative approach.

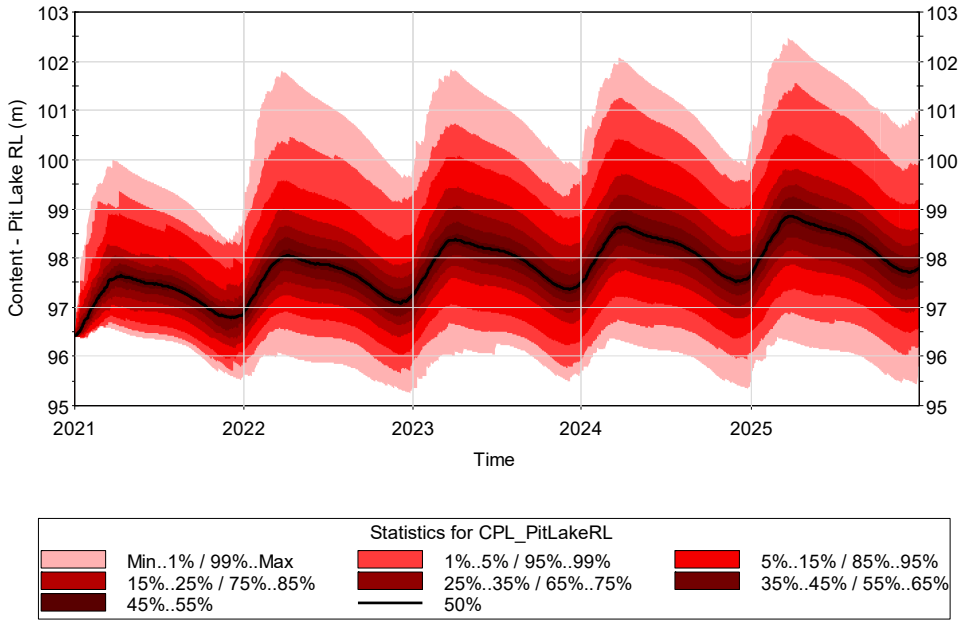
Because, water extraction currently occurs from Lady Isabella Pit Lake, and if this were to continue over the modelled period, this is likely to result in lower pit lake elevations than those presented in these figures.

Figure 9-4: Content Pit Lake – Forecast Results – spillway in pit lake is at 103.7 m RL



1000 runs x 5 Random Years in sequence

(Monte Carlo Run)



Comments

Modelling results (subject to all the model inputs and assumptions) indicate that a spill event is **unlikely** within the next 5 years for the 1,000 Monte Carlo iterations of the random rainfall generation.

However, there is the potential for a spill event when the 2008 – 2012 rainfall period and the 120 year rainfall period are modelled. It is worth noting that during the Repeated Rainfall Scenario, the overflow occurred only during simulating 1974 and 2010 year rainfall events, which are the two highest on record (approximately 2x average annual rainfall).

Water extraction for water use from the pit lake was not considered in this model as a conservative approach.

Because, water extraction currently occurs from the Content Pit Lake, and if this were to continue over the modelled period, this is likely to result in lower pit lake elevations than those presented in these figures.

10 Risk mitigation

10.1 2010/2011 mitigation by Barrick

In recognition of the possibility of a discharge from the Content Pit over the 2010/2011 wet season, Barrick transferred water from the Content Pit to the Golden Butterfly Pit to minimise the risk of Content Pit overtopping during the 2010/2011 wet season (Barrick, 2016). The water level of the Content Pit was decreased by approximately 4 meters during November and December 2010 with a subsequent increase of 1 meter in the Golden Butterfly Pit (Barrick, 2016). Nevertheless, on the 29th March 2011 the Content Pit began discharging water which continued until the 13th April 2011 when no flow was observed to be entering receiving streams (Barrick, 2016).

The mitigation undertaken by Barrick was a viable strategy, the limitation was that the water level was not decreased enough to accommodate the rainfall events that occurred.

10.2 Proposed mitigation

The 2010/2011 spill event from Content Pit led to concern from DES that a similar event could occur. This is a reasonable assumption and cannot be discounted.

To address this concern and limit the potential for a repeat spill event RGS is currently amending the Stage 2 model discussed in this report to a Stage 3 level of development.

The scope of work for Stage 3 includes utilising measured data from site e.g. utilising existing water levels during each model run, using measured bathymetry to derive updated stage area storage curves, detailed survey data to optimise key model parameters, and measured permeability to improve runoff co-efficient. The inclusion of this data in the model will lead to reduced uncertainty.

The Stage 3 optimised model will include a Dashboard (operational window to simulate water management options) and can then be used as an operational tool by Wilson Minerals to verify how the implementation of management options that could reduce the potential for a spill event.

Options that could be tested in the GoldSim model to limit the potential for a spill event may include:

- Verifying how much water needs to be removed from the Content Pit
- Determine which pit(s) could be used to contain the water from Content Pit without causing a spill event in these pits
- How changes to catchment areas could be used to reduce surface runoff to open pits.

11 Closing

Please contact Greg Maddocks on 07 3344 1222 (office) or on 0423 872 154 (mobile) if you require further information.

Yours sincerely,

RGS Environmental Pty Ltd

Dr Greg Maddocks

Principal Hydrogeochemical Engineer

MINE WASTE AND
WATER MANAGEMENT

APPENDIX H CROYDON GOLD MINE WATER MANAGEMENT STRATEGY

CROYDON GOLD MINE WATER

MANAGEMENT STRATEGY

JULY 2018

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1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low- grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Wilson Pty Ltd (Wilson) holds Environmental Authority No. EPML00950913 (EA) for the Project.

This Water Management Strategy (WMS) has been prepared in accordance with EA Condition F10-1:

> *F7-1 A water management strategy must be prepared for inclusion in the Plan of Operations. The strategy willinclude:*
>
> *(a) Data collection and identify existing data requirements.*
>
> *(b) Design and detail additional works as required.*
>
> *(c) Implement / construct additional works.*

In accordance with EA Condition F10-1 this WMS will be included in the Croydon Gold Mine Plan of Operations. This WMS has been prepared with the assistance of Metago Environmental Engineers.

The remainder of this WMS is structured as follows:

Section 2: Provides a review of the drainage for the Project.

Section 3: Describes the proposed drainage management plans for the post-mining final landforms.

Section 4: Identifies the monitoring program for this WMS.

Section 5: Outlines the water requirements for the Project.

Section 6: Describes the review process for this WMS.

Section 7: Lists the references cited in this WMS.

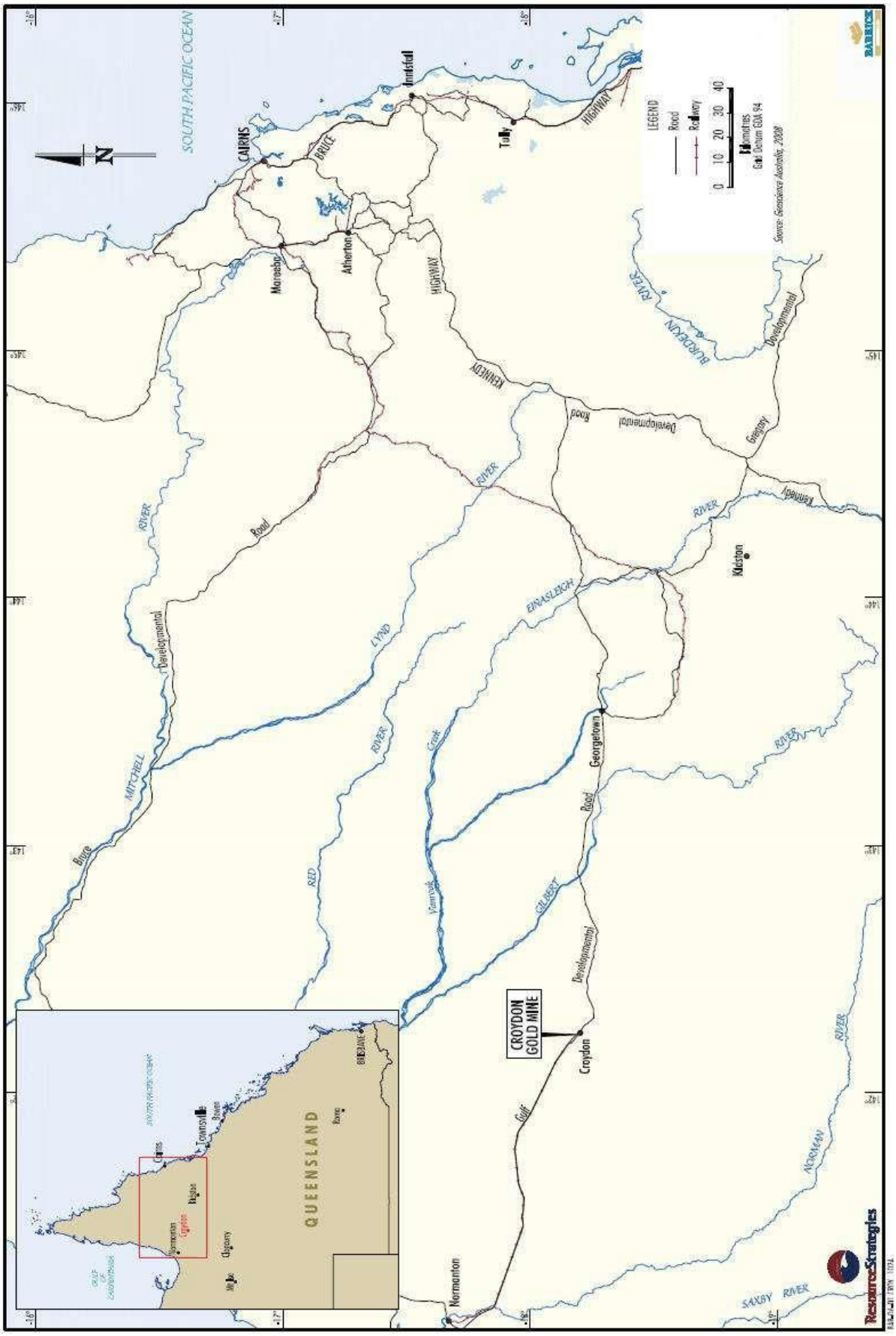

Figure 1: Regional Location

2 DRAINAGE REVIEW

2.1 POST-MINING FINAL LANDFORMS

The mining-related landforms on ML 5248 comprise of waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps.

Specifically they include (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Golden Butterfly waste rock dump;
- Content Pit;
- Content waste rock dump;
- Lady Isabella Pit;
- abandonment bunds across the access ramps of the four open pits;
- hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps;
- water diversion bunds and sediment dams adjacent to the Content and Golden Butterfly waste rock dumps; and
- roads and tracks.

Schematic diagrams of the final landforms, inclusive of drainage features, are provided in Figure 3. The final landform concept is to achieve a stable post-mining landform that is able to meet the identified post-mining landuse and rehabilitation objectives.

2.2 GENERAL RELIEF

The Project is located on the edge of the Gulf Country in Northern Queensland. There is little to no elevation difference across ML 5248 with the only significant natural landform a low (approximately 25 metre) hill located between the two mined areas (Figure 2). The south-eastern section of ML 5248 (i.e. the Golden Butterfly mining area) is within the upper catchment of Slaughteryard Creek and has a single shallow drainage line that flows from north to south across ML 5248.

The north-western section of ML 5248 (i.e. Content and Lady Isabella mining areas) lies within the Belmore Creek catchment with a very gentle slope (1:140) to the north-west with no defined drainage network. Sheetflow is the dominant hydrological runoff mechanism.

2.3 SURFACE HYDROLOGY

The Project receives highly seasonal rainfall and therefore all local creeks are ephemeral. The only permanent source of surface water (other than water within the open pits) is within the borrow pit located off ML 5248 on Belmore Creek to the west of the Content mining area (Figure 2). No hydrological flow gauging records exist for the ML 5248 area. However given the highly seasonal nature of rainfall in the area, it is expected that runoff in local creeks and drainage lines cease relatively soon after storm events.

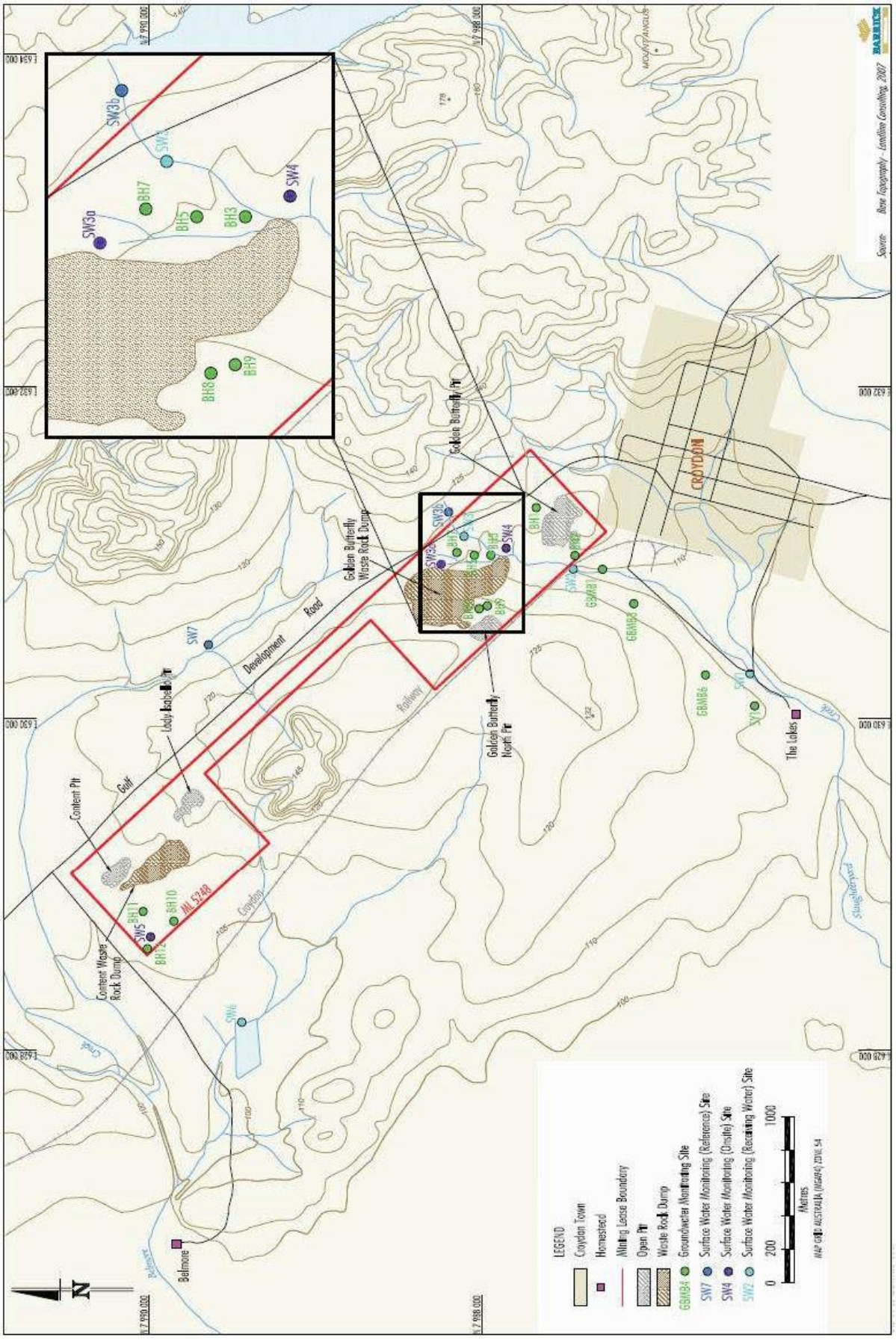

Figure 2: Surface Water and Groundwater Monitoring Sites

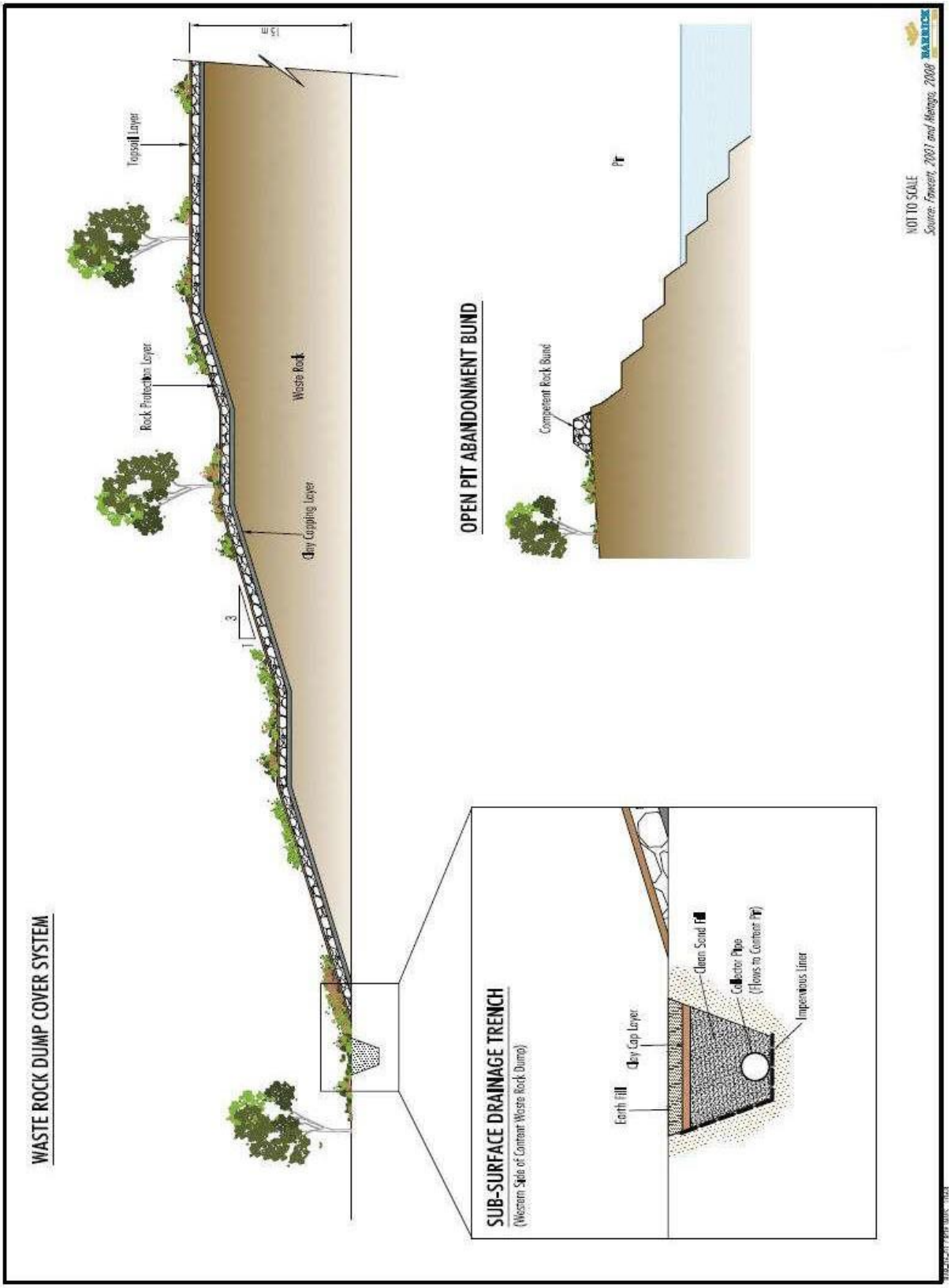

Figure 3: Waste Rock Dump Cover System and Open Pit Abandonment Bund Schematic Cross Sections

In the northern section of ML 5248 seasonal surface water runoff does contribute to the surface water storage in Belmore Creek borrow pit (SW6). In the southern section ML 5248 seasonal surface runoff probably provides some recharge to the shallow alluvial aquifer located along the lower section of Slaughteryard Creek (the original town borefield). However the western tributary that originates on the ML 5248 area constitutes a very small component of the overall Slaughteryard Creek catchment. Figure 4 identifies the surface water drainage flow on ML 5248. A summary of the most recent surface water quality data from 2000 to 2011 is provided in Attachment A.

All four mine pits now contain pit lakes. Pit lake water quality data for each pit lake is provided in Attachment A, with pit lake water quality time series graphs presented in Attachment B. The Golden Butterfly Pit Lake has low pH and raised levels of sulphate, aluminium, arsenic, cadmium, copper, nickel and zinc. Both the Content and Lady Isabella Pits have water quality that meets ANZECC (2000) stock water quality guidelines except for pH, which is below the lower limit, and in the case of Lady Isabella Pit cadmium concentration is also above ANZEEC (2000) stock water quality guidelines. Consequently, the Content and Lady Isabella pit lakes are considered potential stock water supplies. Reference to the time series graphs in Attachment B clearly show an improving trend in water quality versus time within these pits.

Water quality in Golden Butterfly North Pit Lake is considered of good quality and meets ANZECC (2000) livestock drinking water quality guidelines. The Golden Butterfly North Pit does receive a limited amount of surface runoff from the area to the immediate north-east. Water from this pit lake has in the recent past been used by the Croydon Shire Council for irrigation of town recreational areas.

An investigation conducted by HLA-Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping. The pits therefore represent groundwater sinks with limited capacity to influence groundwater quality much beyond the immediate footprint of the pit.

The consecutive unprecedented rainfall totals experienced since 2008/2009 support this conclusion in regards to the Golden Butterfly and Golden Butterfly North Pits. However, the overtopping and discharge from the Content Pit during early 2011 obviously shows that the conceptual hydrogeological model in terms of the Content Pit and Lady Isabella Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation. Section 6 details the hydrological data collection and modelling to be undertaken to provide a validated predictive representation of the Content Pit and Lady Isabella Pits to inform management options.

2.4 HYDROGEOLOGY

ML 5248 contains no springs or groundwater supported surface drainage features. Groundwater occurs in deep fractured rock aquifers, but is not utilised as a water resource on or adjacent to ML 5248. Any aquifers linked to the main mineralised zones might be expected to have raised levels of metals and sulphate. This assumption is supported by water quality analysis from the monitoring bores located in this area. It is likely that water quality will vary significantly between individual fractured rock aquifers, with limited hydrogeological linkage between aquifers. These aquifers would therefore not be considered as potential potable water supplies, irrespective of potential yields.

The original Croydon town borefield, decommissioned more than 12 years ago, is located within Slaughteryard Creek approximately one kilometre south-west of Golden Butterfly Pit. No bore logs or water quality data is available for these bores which are known to have been relatively shallow, exploiting both an unconfined alluvial aquifer and deeper fractured rock aquifers in the underlying sandstone units. Bore yields were never more than 1.25 litres per second (L/sec) and over time dropped to less than 0.25 L/sec resulting in their abandonment (Croydon Shire Council, pers. com., April, 2008).

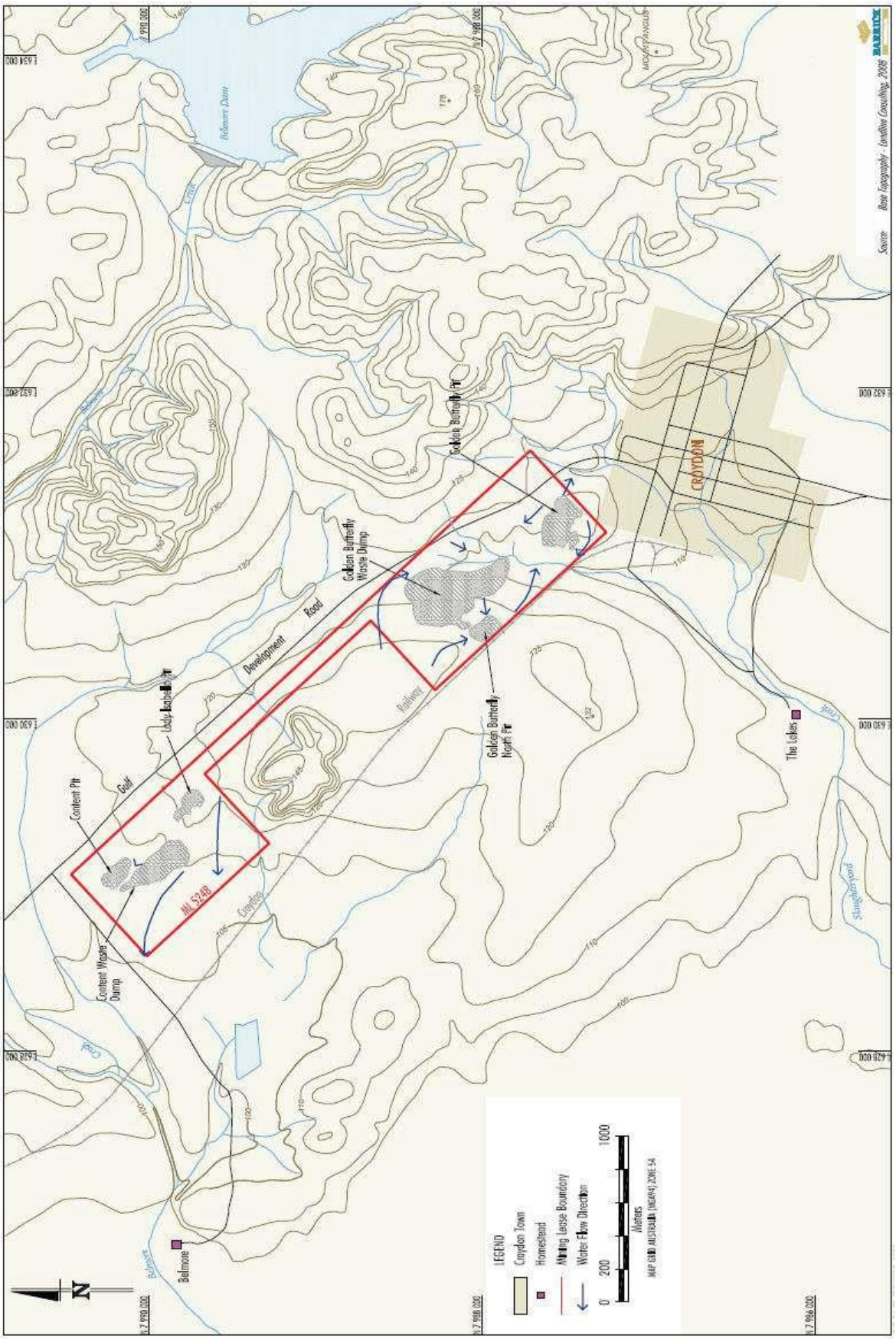

Figure 4: Site Drainage

An attempt was made at an artificial recharge scheme, but this was soon abandoned due to contamination as a result of acid mine drainage (AMD) from the Golden Butterfly waste rock dump and hardstand area. The source of AMD was removed during the 1996/1997 reclamation works and any contaminated soil within the creek removed (HLA-Envirosciences, 2001b).

Two shallow wells (1.2 metres diameter and 15 metres deep) located on the eastern side of the borefield are still used for irrigation of the town oval. The water quality is considered acceptable but has high iron content and requires lime dosing. A series of monitoring bores located between the old town borefield and ML 5248 have been monitored over 14 years and continue to show no influence (i.e. hydrogeological linkage) between Golden Butterfly Pit and the borefield. A summary of the most recent groundwater quality data from 2000 to 2011 is provided in Attachment A.

3 DRAINAGE MANAGEMENT PLAN

Drainage management strategies are proposed for all post-mining related landforms. It is considered these management strategies could impact drainage patterns within ML 5248.

3.1 GOLDEN BUTTERFLY WASTE ROCK DUMP

The Golden Butterfly waste rock dump was capped with an engineered cover system consisting of a clay capping layer, a rock fill surface protection layer and topsoil layer during the reclamation works conducted in 1996/1997. During periods of extreme rainfall any excess water from the waste rock dump surface is engineered to spill down rock lined drains that follow the original haul ramp to discharge to the western tributary of Slaughteryard Creek.

In addition an open seepage collection trench was excavated along the eastern toe of the waste rock dump. Water monitoring has been conducted at this trench for more than 14 years and no seepage or contaminant discharge has been observed. The trench also collects surface runoff from the natural catchment to the east of the waste rock dump and channels this water into the western tributary of Slaughteryard Creek. Additional details of the reclamation works conducted in 1996/1997 are provided in the Post Mine Landuse Plan (Appendix A of the Plan of Operations [Barrick, 2008a]).

Proposed Drainage Management Strategy

No further drainage management measures are considered necessary for the Golden Butterfly waste rock dump area. However, surface water and groundwater monitoring will be continued in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Barrick, 2008a]).

3.2 CONTENT WASTE ROCK DUMP

The Content waste rock dump was capped with an engineered cover system consisting of a clay capping layer and a rock fill surface protection layer during the reclamation works conducted in 1996/1997. At the time the rehabilitation and revegetation status of the waste rock dump western batter was considered adequate and no capping was constructed on this section of the waste rock dump (HLA-Envirosciences, 2001a).

The northern most section of the waste rock dump upper surface was not levelled to the same degree as the remainder of the dump. Subsequently some surface ponding has been noted to occur during extreme rainfall events. General erosion control works were conducted to the north-western part of the waste rock dump in 2009/2010. Several small gullies were beginning to form on the upper crest where water was concentrated in deep vehicle rut marks and localised depressions. Back fill material, sourced from the Golden Butterfly waste rock dump east haul ramp, was utilised to fill these localised depressions to reduce infiltration through the waste rock dump. No excavation was conducted on the top surface of the waste rock dump to avoid potential impacts to the integrity of the clay capping layer. Subsequent rainfall and surface runoff has not caused a recurrence and no further general erosion control works on the Content Waste Rock Dump are currently planned. Continual regular review will be undertaken to ascertain if potential problems are developing in order to schedule any necessary remedial action.

Proposed Drainage Management Strategy

No further drainage management measures are considered necessary for the Content waste rock dump area. However, surface water and groundwater monitoring will be continued in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Wilson, 2008a]).

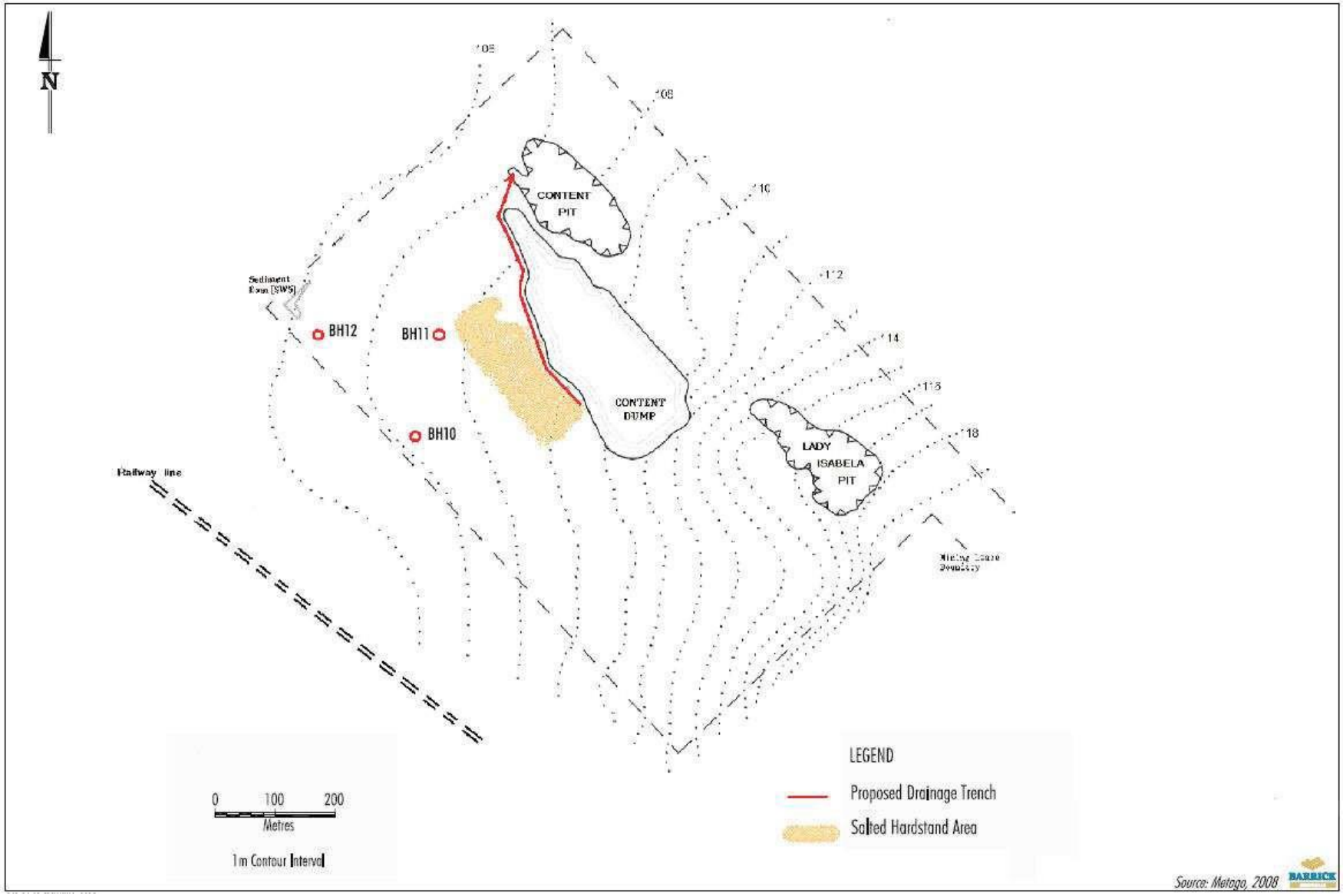

Figure 5: Proposed Reclamation Work on Content Waste Rock Dump

Three additional groundwater monitoring bores (BH10, BH11 and BH12) (Figure 5) were constructed to the west of Content waste rock dump to monitor the performance of the proposed works. Continual review of the groundwater hydrology to enable refining of the hydrogeological model may result in additional bores in the area of the Content waste rock dump to provide better resolution groundwater level data.

3.3 GOLDEN BUTTERFLY PIT

Water levels in the Golden Butterfly Pit Lake are slowly rising and are expected after several decades to reach equilibrium well below the upper pit crest (Wilson, 2008). A water balance conducted by HLAEnvirosciences (2001b) indicates that based on historic rainfall and evaporation data there is no risk of the Golden Butterfly Pit overtopping even during the wettest rainfall cycles. The consecutive unprecedented rainfall totals experienced since 2008/2009 support this conclusion in regards to the Golden Butterfly and Golden Butterfly North Pits.

The abandonment bund restricts any surface water discharge into the pit from surrounding areas. The pit represents a groundwater sink with limited capacity to influence groundwater quality much beyond the immediate footprint of the pit. The upper section of the access ramp to the pit has been engineered to restrict any vehicle access and the abandonment bund has been extended across the access ramp (Figure 3). The extension of the abandonment bund further reduces the amount of surface water reporting to the Golden Butterfly Pit. A water level gauging station has been installed so that pit water levels may be regularly monitored.

Proposed Drainage Management Strategy

Groundwater monitoring will be conducted in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Wilson, 2008a]).

3.4 GOLDEN BUTTERFLY NORTH PIT

The water quality in the Golden Butterfly North Pit is expected to remain fresh for some time however it is considered that the water will become brackish and even saline with time (i.e. 100s of years). The pit represents a groundwater sink with limited capacity to influence groundwater quality much beyond the immediate footprint of the void. Two bores (a deep and shallow bore) (BH8 and BH9) (Figure 2) have been drilled between the pit and Golden Butterfly waste rock dump and the Golden Butterfly North Pit to identify seepage which may be migrating towards the pit lake from the waste rock dump. Although the pit lake water quality is considered as a potential water resource, vehicle access to the pit has been restricted for safety reasons.

The upper section of the access ramp to the pit has been engineered to restrict vehicle access and the abandonment bund has been extended across the access ramp with a gate installed (Figure 3). The extension of the abandonment bund further reduces the amount of surface water reporting to the Golden Butterfly North Pit. A water level gauging station has been installed so that pit water levels may be monitored.

Proposed Drainage Management Strategy

Groundwater monitoring will be conducted in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Wilson, 2008a]).

3.5 CONTENT PIT

An investigation conducted by HLA-Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping.

The 2008/2009 and 2009/2010 wet seasons resulted in extraordinary rainfall totals. In recognition of the possibility of a discharge from the Content Pit, Wilson had undertaken short-term remediation works involving the transfer from water from the Content Pit to the Golden Butterfly Pit to minimise the risk of the Content Pit overtopping during the 2010/2011 wet season. The water level of the Content Pit was decreased by approximately four (4) meters during November and December 2010 (with a subsequent increase of one (1) meter in the Golden Butterfly Pit). Nevertheless, on the 29th March 2011 the Content Pit began discharging water which continued until the 13th April 2011 when no flow was observed to be entering receiving streams. This event obviously shows that the conceptual hydrogeological model in terms of the Content Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation.

A possible addition to the hydrogeological model for the Content Pit is the inclusion of a hydraulic connection with the Lady Isabella Pit. The Lady Isabella Pit when full is approximately five meters higher in elevation that the Content Pit discharge level. This elevation difference provides a hydraulic driving force which with the relative close proximity of the Lady Isabella Pit to the Content Pit and possible connecting facture zones and or fault lines enabling water flow. Section 6 details the hydrological data collection and modelling to be undertaken to provide a validated predictive representation of the Content Pit and Lady Isabella Pits to better inform management options.

The upper section of the access ramp to the pit has been engineered to restrict vehicle access and the abandonment bund has been extended across the access ramp with a gate installed (Figure 3). The extension of the abandonment bund further reduces the amount of surface water reporting to the Content Pit. Additional diversion drains were installed during 2009/2010 to ensure surface water flow in the vicinity of the Content Pit is maintained as much as possible to avoid ponding which may increase groundwater infiltration and possible input to the Content Pit lake.

Proposed Drainage Management Strategy

A water level gauging station was installed so that pit water levels may be monitored. Groundwater monitoring will be conducted in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Wilson, 2008a]).

3.6 LADY ISABELLA PIT

An investigation conducted by HLA-Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping.

The 2008/2009 and 2009/2010 wet seasons had extraordinary rainfall totals which resulted in the Lady Isabella Pit being full to capacity during early 2011, but with no overtopping and discharge observed. This event obviously shows that the conceptual hydrogeological model in terms of the Lady Isabella Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation.

A possible addition to the hydrogeological model for the Lady Isabella Pit is the inclusion of a hydraulic connection with the Content Pit. The Lady Isabella Pit when full is approximately five meters higher in elevation that the Content Pit discharge level. This elevation difference provides a hydraulic driving force which with the relative close proximity of the Lady Isabella Pit to the Content Pit and possible connecting facture zones and or fault lines enabling water flow. Section 6 details the hydrological data collection and modelling to be undertaken to provide a validated predictive representation of the Content Pit and Lady Isabella Pits to better inform management options.

Proposed Drainage Management Strategy

The upper section of the access ramp to the pit has been engineered to restrict vehicle access and the abandonment bund has been extended across the access ramp (Figure 3). The extension of the abandonment bund further reduces the amount of surface water reporting to the Lady Isabella Pit. A water level gauging station has been installed so that pit water levels may be monitored. Groundwater monitoring will be conducted in accordance with the groundwater monitoring program. Details are provided in the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Wilson, 2008a]).

3.7 STOCK WATERING DAM

The stock watering dam (i.e. SW4 surface water monitoring site) (Figure 2) is located to the north of Golden Butterfly Pit and captures runoff from the natural catchment to the immediate east of the mining area. Any spillage from this facility is directed into the western tributary of Slaughteryard Creek.

Proposed Drainage Management Strategy

No further drainage management measures are considered necessary for site SW4. However, surface water and groundwater monitoring will be continued in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Wilson, 2008a]).

4 MONITORING PROGRAM

All surface water and groundwater monitoring will be conducted in accordance with the Rehabilitation Monitoring Program which is provided in Attachment A of Appendix A of the Plan of Operations (Wilson, 2008a).

5 PROJECT WATER REQUIREMENTS

As the Project is decommissioned/closed no water is currently required on-site. In the event a water supply is required during the proposed reclamation works, water would be sourced from the Golden Butterfly North Pit.

6 HYDROLOGICAL MODELLING

Details of the existing conceptual and mathematical modelling of the hydrological environment of the Croydon site are provided in the Post Mine Landuse Plan (Wilson, 2011). An investigation conducted by HLA-Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping. The consecutive unprecedented rainfall totals experienced since 2008/2009 support this conclusion in regards to the Golden Butterfly and Golden Butterfly North Pits (see Figure 6). However, the overtopping of the Content Pit and the filling to capacity of the Lady Isabella Pit in 2011 obviously shows that the conceptual hydrogeological model in terms of these two pits, in view of the additional rainfall data currently available, inadequately describes the physical situation.

As previously discussed (Section 2.3) the Content Pit and Lady Isabella Pit show improving trends in pit lake water quality and are potential stock water supplies (see Attachment A and B for pit lake water quality summaries) whereas the Golden Butterfly Pit contains water of poor quality. Therefore, the existing hydrological model, confirmed by physical observation of pit lake levels, deals adequately with the pit lake that has a significant water quality issue. Nevertheless, the Content Pit and Lady Isabella Pit Lakes do not currently meet ANZECC (2000) stock water quality guidelines for pH (and in the case of Lady Isabella Pit for cadmium, which is marginally above the limit with a decreasing

trend). Therefore, a program of hydrological data collection and modelling will be undertaken to provide a validated predictive representation of the Content Pit and Lady Isabella Pits to better inform management options.

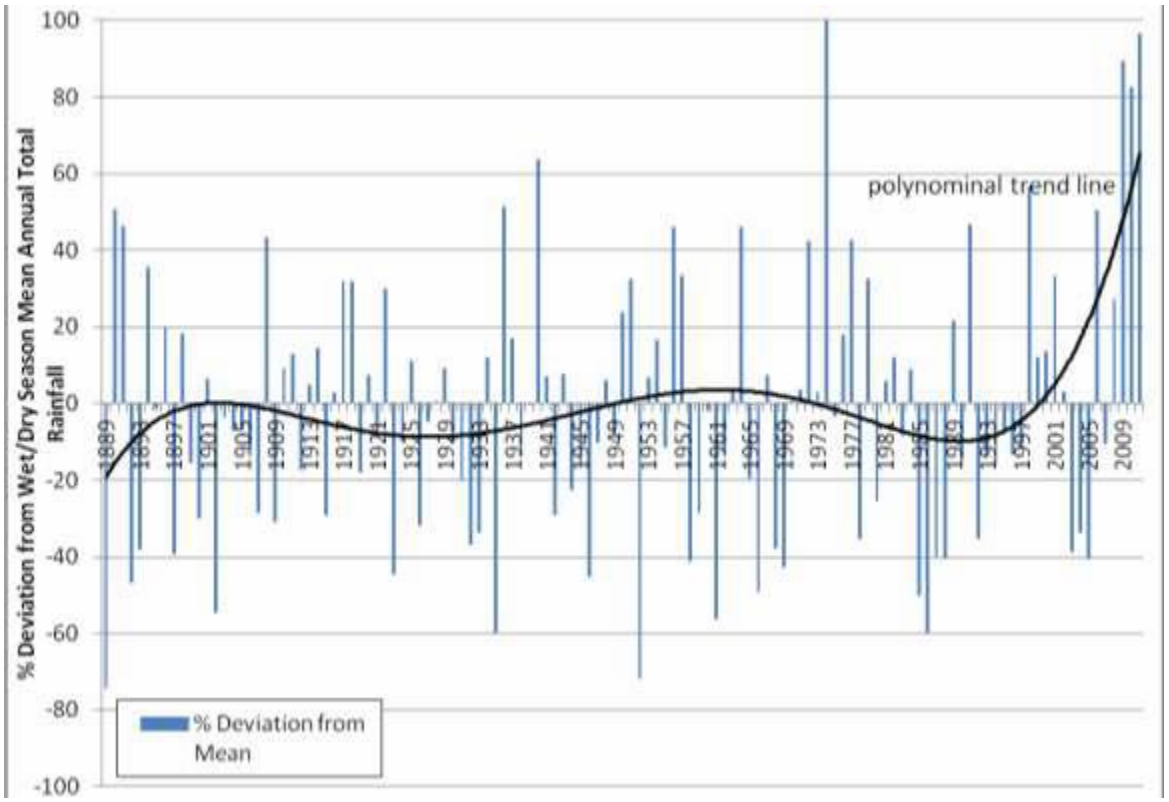

Figure 6: Croydon wet/dry season rainfall, %deviation from annual mean

The use of computer modelling has obvious benefits in providing information to form the basis of management decisions regarding water quantity and quality considering the complexities of the systems being considered. However, the level of abstraction required in order to provide this summary management information can also mask underlying knowledge gaps and or inaccurate assumptions. "The output from a model is only as good as the input data ... If the data are of low quality, the output will be poor no matter how sophisticated the model ... If the model's structure poorly approximates the operation of the real system, the output will always be poor no matter how good the input data." (Thompson, 1999).

In view of this, a data review of available information from the Croydon site was undertaken by Australasian Groundwater & Environmental Consultants Pty Ltd (AGE, 2011). The review concluded that direct rainfall alone does not explain the significant water level rises in the Content Pit and Lady Isabella Pit, and noted the following:

- A groundwater contribution must be occurring.
- Ponding of water, groundwater flow along the ore zone, or groundwater flow from the waste rock dumps, are considered unlikely causes of pit overflow.
- There is little subsurface and groundwater information available for the Content and Lady Isabella Pits areas
- The influence and presence of possible historic mine workings is currently unknown, but potentially significant; and
- The nature of the ferricrete layer needs better understanding due to influences on infiltration.

Therefore, in order to refine the existing conceptual hydrogeological model additional information beyond what has been identified during the initial data review is required, including:

- Characterisation of local geological structures (particularly the ferricrete layer);
- Characterisation of aquifer physical properties (e.g. permeability);
- Characterisation of local water levels and other groundwater investigations; and
- Location of historical mine shafts.

Such information collection, collation and interpretation is necessarily the preliminary step prior to selecting an appropriate computer modelling approach. The actual modelling (i.e. the computer code and output) will aim to identify any long term risk of pit overtopping and estimate likely frequencies and volumes of any such events. The final void water balance models for the various pits will utilise available contour data (for catchment area estimation) and open pit depth-volume data. Rainfall data would be developed from the available Bureau of Meteorology database. Key to the water balance model will be estimates of groundwater inflow/outflow provided by the initial groundwater investigation based upon the refined conceptual hydrogeological discussed previously. Model calibration will be based upon monitored pit void water levels.

In order to provide additional information to assist in refining the conceptual hydrological model, a series of water level monitoring stations have been installed during November 2011 in each of the pit lakes at Croydon. Each of these stations is fitted with a pressure sensor transducer connected to a data logger with solar powered battery supply. Additionally, in the event of a further discharge from the Content Pit, a measuring flume has been installed in the v-drain which will direct any outflow from the Content Pit. Further, a tipping bucket rain gauge with datalogger has been installed at the Content Pit. This will provide detailed rainfall intensity data to augment the Bureau of Meteorology data.

7 REVIEW

EA Condition F7-2 is of additional relevance to this WMS and is provided below:

> *F7-2 An annual review of the water management strategy must be submitted by November each year.*

In accordance with EA Condition F7-2 this WMS will be reviewed, and if necessary updated, annually. This review will be submitted to the EPA by November of each year.

8 REFERENCES

AGE (2011), *Croydon Gold Mine – Groundwater Studies for Pit Water Balance Stage 1 Data Review*, prepared for Wilson Gold of Australia.

Wilson Gold of Australia (2008) *Croydon Gold Mine Project – Environmental Management Plan. p*

Wilson Gold of Australia (2008a) *Croydon Gold Mine – Plan of Operations.*

Wilson Gold of Australia (2011) *Croydon Gold Mine – Post Mine Landuse Plan.*

Environmental Protection Agency (1998) *Draft Guidelines for the Assessment and Management of Contaminated Land*.

HLA-Envirosciences (2001a) *Draft Final Rehabilitation Report – Croydon Gold Mine*. Report prepared for Goldfields Limited, November, 2001.

HLA-Envirosciences (2001b) *Water Level Analysis of Golden Butterfly Pit – Croydon Gold Mine*. Report prepared for Goldfields Limited, May, 2001.

Thompson, S.A., (1999), p 318, *Hydrology for Water Management*, Balkema Publishers, Rotterdam.

ATTACHMENT A

WATER QUALITY SUMMARY TABLES

Table 1: Water Quality Summary of Surface Water Monitoring Sites 2000- 2014

Parameter	Sample Site													
	SW1		SW2		SW3		SW3b		SW4		SW5		SW6	
	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	6.2-9.2	7.20	5.7-9.1	6.78	6.2-8.00	6.96	5.3-6.76	6.16	6.4-9.3	7.45	3.5-6.75	4.3	5.3-9.0	7.4
EC (µS/cm)	77-610	245	64-301	144	38-450	116	17-97	54	38-770	159	32-1400	473	24-480	105
S04 (mg/L)	12-100	44	18-96	42	9-140	25.3	5-23	12.4	8-150	32	6-810	210	<1-43	12.6
Cu (mg/L)	0.004-0.063	0.019	<0.001 – 0.022	0.01	0.001-0.05	0.02	0.001-0.03	0.01	0.002-0.020	0.008	<0.001-2.5	0.38	0.001-0.158	0.018
Pb (mg/L)	<0.001-0.004	0.002*	0.001-0.01	<0.002*	<0.002-0.004	<0.002*	<0 .002-0.004	<0.002*	0.001-0.012	0.004	<0.002-0.006	<0.002*	<0.002-0.047	0.006*
Ni (mg/L)	<0.002-0.003	0.002	<0.001 – 0.011	0.004	<0.001-0.03	0.02	<0.001-0.03	0.01	<0.001-0.025	0.010	<0.001-1.0	0.20	<0.001-0.025	0.017
Al (mg/L)	0.06-2.7	0.55	0.01-18	1.08	<0.05-3.5	0.41	<0.01-0.62	0.12	0.03-11.0	0.93	0.11-77	9.8	0.025-350	9.1
Zn (mg/L)	0.008-0.03	0.018	<0.005 – 0.07	0.04	0.003-0.17	0.02	0.01-0.03	0.01	<0.005-0.110	0.020	<0.005-6.0	0.95	<0.005-0.073	0.019
Co (mg/L)	<0.005-<0.05	<0.05*	<0.001-0.003	0.002	<0.001-0.03	0.3	<0.001-0.03	0.01	<0.001-<0.05	<0.05*	<0.001-1.0	0.21	<0.001-0.025	0.020
Cd (mg/L)	<0.0002-0.00025	<0.0002*	<0.0001-0.0002	0.0001	<0.0001-0.0003	0.0001	<0.0001-0.0003	0.0001	<0.0001-0.0002	0.0001	<0.0001-0.24	0.036	<0.0001-0.0004	0.0001
Fe (mg/L)	0.33-2.7	1.19	0.27-1.2	0.69	0.73-5.2	2.05	0.33-1.2	0.77	0.42-5.1	1.30	0.08-0.39	0.24	0.57-13	2.6
Mn (mg/L)	<0.05-0.24	<0.05*	<0.05-0.014	0.08*	<0.05-1.9	<0.05*	<0.05-0 .07	<0.05*	<0.05-0 .14	<0.05*	0.31-10	3.69	<0.05-0.14	<0.05*
As (mg/L)	<0.005-0.033	0.010	<0.001 – 0.055	0.02	0.002-0.07	0.01	<0.001-0.018	0.004	0.003-0.04	0.01	0.002-0.02	0.004	<0.001-0.011	0.003

Notes: * indicates median, below detection results have been replaced with half the relevant detection limit to calculate averages.

Table 2: Pit Lake Water Quality 2000-2014

Parameter	Sample Site							
	Golden Butterfly		Golden Butterfly North		Content		Lady Isabella	
	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	2.3-2.8	2.5	5.8-7.7	6.8	3.3-4.3	3.8	3.4-4.6	3.7
EC (µS/cm)	2910-12000	5971	60-370	270	737-1800	1135	491-1300	891
SO_4 (mg/L)	1910-8000	5130	11-92	69	300-780	483	180-610	372
Cu (mg/L)	3.3-24	14.1	<0.005-<0.05	<0.05*	0.048-0.28	0.12	0.13-1.4	0.69
Pb (mg/L)	<0.002-<0.005	<0.005*	<0.001-<0.002	<0.002*	<0.001-<0.002	<0.002*	0.002-0.007	0.003
Ni (mg/L)	1.56-8.5	5.10	<0.004-<0.05	<0.05*	0.087-0.32	0.18	0.14-0.77	0.39
Al (mg/L)	122-700	436	0.025-0.73	0.20	1.31-7.0	3.1	2.98-20	9.8
Zn (mg/L)	2.4-36	19.2	<0.005-0.05	0.011	0.23-1.1	0.58	0.82-5.8	2.98
Co (mg/L)	1.24-7.3	3.5	<0.005-<0.05	<0.05*	0.09-0.29	0.14	0.109-0.53	0.25
Cd (mg/L)	0.055-0.34	0.19	<0.0001-0.0002	<0.0002*	0.0021-0.023	0.006	0.013-0.19	0.08
Fe (mg/L)	240-450	356	<0.05-0.18	0.06*	0.69-1.5	0.95	<0.05-0.66	0.23*
Mn (mg/L)	56-110	79	<0.05-0.17	<0.05*	3.7-5.2	4.4	3.3-6.3	4.7
As (mg/L)	0.34-1.3	0.71	<0.005-0.01	<0.005*	<0.005-0.058	0.015	<0.003-0.013	0.004

Notes: * indicates median, below detection results have been replaced with half the relevant detection limit to calculate averages.

Table 3: Groundwater Quality – Confined Fractured Rock Aquifer 1995 - 2009

Parameter	Sample Site																	
	BH1		BH2		BH3		BH4		BH5		BH6		BH7		GBMB1		GBMB2	
	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median
pH (pH units)	6.1-7.9 (42)	7.2 7.2	3.3-6.5 (41)	3.7 3.6	5.5-7.7 (35)	6.41 6.4	6.9-8.6	7.4	7.3-7.8 (13)	7.5 7.5	6.9-7.5	7.15	6.4-7.1	6.8	6.4-7	6.7	6.9-7.7	7.3
EC (µS/cm)	985-2260 (42)	1298 1300	740-1300 (41)	1016 980	110-3000 (35)	604 340	4800-7200	5611	4900-6800 (13)	5550 5600	480-2200	933	6400-8700	7472	160-760	591	2200-2700	2491
SO_4 (mg/L)	310-1160 (42)	471 460	260-850 (40)	442 435	20-990 (35)	172 100	1200-1800	1522	1400-2000 (13)	1733 1800	59-530	172	1400-2600	1950	36-190	120	630-790	703
Cu (mg/L)	<0.001-0.05 (16)	0.008 0.005	0.002-0.05 (15)	0.011 0.005	0.001-0.025 (13)	0.009 0.005	<0.001-<0.05	<0.01	<0.001-0.03 (13)	0.007 0.005	0.009-0.02	0.01	<0.003-0.03	<0.01	0.001-0.01	<0.01	<0.001-<0.05	<0.01
Pb (mg/L)	<0.001-0.35 (13)	0.031 0.001	<0.001-0.15 (13)	0.051 0.046	<0.001-0.072 (11)	0.013 0.001	<0.001-0.006	<0.002	<0.001-0.24 (11)	0.023 0.001	<0.002-0.056	0.009	<0.001-0.35	<0.002	<0.002-0.003	<0.002	<0.002-0.02	0.002
Ni (mg/L)	0.002-0.025 (16)	0.016 0.025	0.025-0.09 (15)	0.056 0.05	<0.001-0.025 (10)	0.014 0.0145	<0.002-<0.05	<0.05	<0.001-0.025 (13)	0.016 0.025	0.002-<0.05	<0.05	0.004-<0.05	<0.05	0.02-<0.05	<0.05	<0.002-<0.05	<0.05
Al (mg/L)	0.02-0.25 (15)	0.045 0.025	0.16-2.7 (14)	1.54 1.65	0.07-2.1 (10)	0.49 0.33	<0.05-0.37	<0.05	<0.01-0.29 (13)	0.049 0.025	0.14-6.8	2.35	<0.05-0.16	<0.05	<0.05-0.092	<0.05	<0.05-0.21	<0.05
Zn (mg/L)	0.01-0.18 (16)	0.053 0.038	0.043-1.06 (15)	0.40 0.36	<0.005 2.9 (13)	0.24 0.015	0.008-0.04	0.017	0.0025-0.032 (13)	0.0127 0.012	0.005-0.055	0.021	0.029-0.15	0.072	0.012-0.047	0.024	0.011-0.056	0.028
Co (mg/L)	<0.001-0.025 (11)	0.016 0.025	0.018-0.045 (11)	0.018 0.025	<0.001-0.025 (9)	0.015 0.025	<0.005-<0.05	<0.05	<0.001-<0.05	<0.05	<0.005-<0.05	<0.05	<0.005-0.07	<0.05	<0.05-<0.05	<0.05	<0.005-<0.05	<0.05
Cd (mg/L)	<0.0001-0.0025 (16)	0.0003 0.0001	<0.0001-0.0025 (15)	0.0007 0.0007	<0.0001-0.0009 (13)	0.0002 0.0001	<0.0001-0.0003	<0.0002	<0.0005-0.0004 (13)	<0.0005 0.0001	<0.0001-<0.0002	<0.0002	0.0002-0.002	0.00085	<0.0001-0.0067	0.0005	<0.0001-0.0003	<0.0002*
Fe (mg/L)	<0.05-3.2 (32)	0.436 0.1	0.025-27 (32)	4.54 1.3	0.025-1.75 (29)	0.33 0.25	<0.05-<0.05	<0.05	<0.05-0.09 (5)	<0.05	0.06-3.1	1.4	<0.05-0.27	<0.05	<0.05-0.08	<0.05	<0.05-<0.05	<0.05
Mn (mg/L)	<0.05-1.19 (8)	0.247 0.075	0.95-1.97 (8)	1.23 1.1	0.0025-0.025 (4)	0.019 0.025	<0.05-<0.05	<0.05	<0.05-0.06 (7)	0.034 0.025	<0.05-0.68	0.06	<0.05-1.9	<0.05	0.26-1.4	0.83	0.67-1.2	0.90
As (mg/L)	0.01-0.022 (16)	0.014 0.014	<0.001-0.09 (15)	0.008 0.025	<0.003-0.03 (13)	0.010 0.009	<0.005-0.003	<0.005	<0.05-0.009 (13)	0.012 0.007	0.013-0.048	0.026	<0.005-0.007	<0.005	0.007-0.034	0.02	<0.003-0.023	<0.005

* Below detection limit results have been substituted with a value of half of the detection limit

Table 4: Groundwater Quality – Unconfined Alluvial Aquifer 2001 - 2014

Parameter	Sample Site							
	GBMB3		GBMB4		GBMB5		GBMB6	
	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	5.7-6.8	6.2	5.9-6.5	6.1	5.6-7.1	6.0	5.7-7.1	6.2
EC (µS/cm)	52-110	79.4	260-350	308	68-490	114	66-580	152
SO_4 (mg/L)	3-13	6.3	17-38	28.8	2-13	4.4	3-19	7.1
Cu (mg/L)	0.001-0.01	<0.01*	<0.001-<0.05	<0.01*	<0.001-0.01	<0.01*	<0.001-<0.05	<0.01*
Pb (mg/L)	0.002-0.018	0.008	<0.001-0.008	<0.002*	<0.001-0.004	<0.002*	<0.001-0.31	<0.002*
Ni (mg/L)	<0.002-<0.05	<0.05*	<0.002-<0.05	<0.05*	<0.002-<0.05	<0.05*	<0.002-<0.05	<0.05*
Al (mg/L)	0.07-4.8	0.99	<0.05-0.29	<0.05*	<0.05-0.05	<0.05*	<0.05-0.69	<0.05*
Zn (mg/L)	0.017-0.11	0.052	0.006-0.18	0.043	0.01-.015	0.08	<0.005-0.092	0.025*
Co (mg/L)	<0.005-<0.05	<0.05*	<0.005-<0.05	<0.05*	<0.005-<0.05	<0.05*	<0.005-<0.05	<0.05*
Cd (mg/L)	<0.0002-<0.0002	<0.0002*	<0.0001-0.0018	<0.0002*	<0.0001-<0.0002	<0.0002*	<0.0001-<0.0002	<0.0002*
Fe (mg/L)	0.53-3	1.8	<0.05-6.6	0.18*	<0.05-<0.05	<0.05	<0.05-0.39	<0.05*
Mn (mg/L)	<0.05-0.15	0.05*	<0.05-.07	<0.05*	<0.05-0.26	<0.05*	<0.05-.037	<0.05*
As (mg/L)	0.003-0.012	<0.005*	<0.003-0.007	<0.005*	<0.003-0.091	<0.005*	<0.005-0.15	0.005

* indicates Median.

Table 5: Groundwater monitoring results 2010 – 2014

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH01	29/03/2010	7.94	1420	3.7	473	0.01	0.013	<0.05	<0.0001	<0.01	<0.001	0.004	<0.0001	<0.001	<0.01	0.049
BH01	22/08/2011	8	1390	4	497	0.04	0.014	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.023
BH01	20/09/2011	7.62	1410	3.7	476	<0.01	0.01	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.013
BH01	07/09/2012	7.55	1390	3.6	384	<0.01	0.013	<0.05	<0.0001	0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.011
BH01	24/06/2013	7.82	1420	3.9	485	<0.01	0.015	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.011
BH01	31/7/2014	7.58	1360	4.7	563	<0.01	0.015	<0.05	<0.0001	<0.001	<0.001	0.003	<0.0001	<0.001	<0.01	0.026
BH02	20/11/2010	3.69	940	0.8	374	0.99	0.001	<0.05	0.0001	<0.010	0.017	0.003	<0.0001	0.027	<0.01	0.204
BH02	22/08/2011	3.7	934	1.4	383	0.96	<0.001	<0.05	0.0001	<0.001	0.016	0.01	<0.0001	0.026	<0.01	0.171
BH02	20/09/2011	3.69	989	1.2	380	1.05	0.001	<0.05	0.0004	<0.001	0.019	0.015	<0.0001	0.034	<0.01	0.183
BH02	08/07/2012	3.67	982	1.3	362	1.06	0.001	<0.05	0.0002	0.002	0.016	0.014	<0.0001	0.027	<0.01	0.153
BH02	24/06/2013	3.73	995	1.2	353	1.46	<0.001	<0.05	0.0002	<0.001	0.017	0.021	<0.0001	0.029	<0.01	0.236
BH02	31/7/2014	4.04	931	1.5	415	1.45	0.004	<0.05	0.0001	<0.001	0.016	0.026	<0.0001	0.028	<0.01	0.198
BH03	20/11/2010	8	746	3.6	148	0.43	0.01	<0.05	<0.0001	<0.010	<0.001	0.003	<0.0001	<0.001	<0.01	0.031
BH03	23/08/2011	7.08	454	2.9	92	0.17	0.008	<0.05	<0.0001	<0.001	0.003	0.003	<0.0001	0.002	<0.01	0.007
BH03	20/09/2011	7.09	499	3	95	0.23	0.031	<0.05	<0.0001	<0.001	0.006	0.002	<0.0001	0.002	<0.01	0.007
BH03	08/07/2012	7.12	474	2.6	100	0.03	0.008	<0.05	<0.0001	0.002	<0.001	0.003	<0.0001	0.002	<0.01	<0.005
BH03	24/06/2013	6.97	317	2	70	3.04	0.009	<0.05	<0.0001	<0.001	<0.001	0.004	<0.0001	0.001	<0.01	0.005
BH03	31/7/2014	6.83	800	5.3	188	0.36	0.086	<0.05	<0.0001	<0.001	0.006	0.002	<0.0001	<0.001	<0.01	0.006
BH05	20/11/2010	8.37	5500	6.6	1930	<0.01	0.005	<0.05	0.0003	<0.010	<0.001	0.004	<0.0001	<0.001	<0.01	0.02
BH05	23/08/2011	7.59	5600	7.7	2000	0.02	0.005	<0.05	0.0005	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.01
BH05	20/09/2011	7.05	6490	4.4	2050	<0.01	0.006	<0.05	0.0022	<0.001	<0.001	0.001	<0.0001	0.005	<0.01	0.065
BH05	08/07/2012	7.42	5420	6.7	1980	<0.01	0.004	<0.05	0.0005	0.003	<0.001	<0.001	<0.0001	<0.001	<0.01	0.011
BH05	24/06/2013	7.4	5140	7	1780	<0.01	0.004	<0.05	0.0004	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.015
BH05	31/7/2014	7.43	5170	10.9	2080	<0.01	0.005	<0.05	0.0003	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.008
BH06	20/11/2010	8.3	642	8.3	67	0.29	0.047	<0.05	<0.0001	<0.010	<0.001	0.016	<0.0001	0.003	<0.01	<0.005
BH06	08/07/2012	7.42	568	9.2	64	0.03	0.013	<0.05	<0.0001	0.002	<0.001	0.015	<0.0001	0.001	<0.01	<0.005
BH06	24/06/2013	7.42	776	10.3	96	1.36	0.014	<0.05	<0.0001	<0.001	0.001	0.009	<0.0001	0.002	<0.01	0.01
BH06	31/7/2014	7.29	1500	15.2	320	3.14	0.018	<0.05	<0.0001	<0.001	0.002	0.005	<0.0001	0.003	<0.01	0.006
BH07	20/11/2010	8	5290	6.3	1540	0.02	0.008	<0.05	0.0032	<0.010	0.005	0.051	<0.0001	0.026	<0.01	0.241
BH07	23/08/2011	7.12	5120	7.4	1540	0.03	0.004	<0.05	0.0002	<0.001	0.013	0.001	<0.0001	0.012	<0.01	0.031

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH07	20/09/2011	6.81	5000	6.9	1470	0.02	0.013	<0.05	0.0002	<0.001	0.014	0.001	<0.0001	0.013	<0.01	0.052
BH07	08/07/2012	6.9	5070	7	1570	0.02	0.005	<0.05	0.0005	0.002	0.015	0.004	<0.0001	0.015	<0.01	0.038
BH07	24/06/2013	7.44	5250	10	1440	<0.01	0.049	<0.05	<0.0001	<0.001	0.004	<0.001	<0.0001	0.002	<0.01	0.01
BH07	31/7/2014	7.25	5360	12.8	1740	<0.01	0.017	<0.05	<0.0001	<0.001	0.003	0.002	<0.0001	0.002	<0.01	0.024
BH08	20/11/2010	7.5	118	0.5	13	0.04	0.018	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	0.001	<0.01	0.056
BH08	22/08/2011	5.31	110	<0.1	12	0.02	0.003	<0.05	<0.0001	<0.001	0.001	0.005	<0.0001	0.002	<0.01	0.045
BH08	20/09/2011	5.39	118	0.1	12	0.02	0.002	<0.05	<0.0001	<0.001	0.002	0.002	<0.0001	0.002	<0.01	0.02
BH08	08/07/2012	6.06	123	0.2	15	0.03	0.006	<0.05	0.0001	0.002	0.002	0.005	<0.0001	0.003	<0.01	0.029
BH08	24/06/2013	6.14	154	0.8	24	0.04	0.013	<0.05	0.0001	<0.001	<0.001	0.002	<0.0001	0.004	<0.01	0.04
BH08	31/7/2014	6.56	210	1.4	35	<0.01	0.022	<0.05	<0.0001	<0.001	<0.001	0.004	<0.0001	0.005	<0.01	0.04
BH09	20/11/2010	6.56	104	<0.1	<1	0.29	<0.001	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	<0.001	<0.01	0.027
BH09	22/08/2011	5.39	99	<0.1	1	0.03	<0.001	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.013
BH09	20/09/2011	5.45	98	<0.1	1	0.02	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
BH09	08/07/2012	5.27	113	<0.1	1	0.03	<0.001	<0.05	<0.0001	0.002	<0.001	0.003	<0.0001	<0.001	<0.01	0.008
BH09	24/06/2013	5.13	114	0.2	2	0.04	<0.001	<0.05	<0.0001	<0.001	<0.001	0.003	<0.0001	<0.001	<0.01	0.016
BH09	31/7/2014	5.64	107	<0.1	2	<0.01	0.002	<0.05	<0.0001	<0.001	<0.001	0.008	<0.0001	<0.001	<0.01	0.017
BH10	20/11/2010	7.92	2670	2.4	1280	<0.01	0.02	<0.05	<0.0001	<0.010	0.02	0.002	<0.0001	0.006	<0.01	0.035
BH10	22/08/2011	7.36	2700	2.9	1260	<0.01	0.012	<0.05	<0.0001	<0.001	0.019	0.001	<0.0001	0.005	<0.01	0.03
BH10	20/09/2011	7.16	2680	2.9	1190	<0.01	0.004	<0.05	0.0001	<0.001	0.007	0.001	<0.0001	0.008	<0.01	0.078
BH10	08/07/2012	7.15	2730	3	1290	<0.01	0.003	<0.05	<0.0001	0.002	0.014	0.002	<0.0001	0.005	<0.01	0.015
BH10	24/06/2013	7.28	2580	3.2	1250	<0.01	0.008	<0.05	<0.0001	<0.001	0.003	0.002	<0.0001	0.008	<0.01	0.043
BH10	31/7/2014	7.26	2530	3.7	1230	<0.01	0.047	<0.05	<0.0001	<0.001	0.015	0.002	<0.0001	0.007	<0.01	0.015
BH11	20/11/2010	8.1	370	2.4	51	<0.01	0.054	<0.05	<0.0001	<0.010	<0.001	0.002	<0.0001	0.002	<0.01	0.043
BH11	22/08/2011	7.47	358	2.9	51	0.01	0.058	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.005
BH11	20/09/2011	7.13	353	2.9	49	<0.01	0.054	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	0.001	<0.01	0.008
BH11	08/07/2012	7.04	429	3	49	0.01	0.059	<0.05	<0.0001	0.002	<0.001	0.005	<0.0001	0.001	<0.01	0.016
BH11	24/06/2013	7.62	331	3.2	54	<0.01	0.064	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.006
BH11	31/7/2014	7.37	343	3.8	53	<0.01	0.082	<0.05	<0.0001	<0.001	<0.001	0.004	<0.0001	<0.001	<0.01	0.008
BH12	20/11/2010	8.44	1400	4.2	186	<0.01	0.024	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	<0.001	<0.01	0.025
BH12	22/08/2011	7.69	1380	4.9	182	<0.01	0.019	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.022
BH12	20/09/2011	7.4	1390	4.6	173	<0.01	0.017	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH12	08/07/2012	7.39	1490	4.6	191	<0.01	0.019	<0.05	<0.0001	0.003	<0.001	0.002	<0.0001	<0.001	<0.01	0.008
BH12	24/06/2013	7.53	1450	4.6	174	0.01	0.017	<0.05	<0.0001	<0.001	<0.001	0.004	<0.0001	0.004	<0.01	0.014
BH12	31/7/2014	7.39	1540	5.2	200	<0.01	0.094	<0.05	<0.0001	<0.001	0.015	0.002	<0.0001	0.003	<0.01	0.009
SY1	20/11/2010	7.01	51	<0.1	<1	0.04	0.002	<0.05	<0.0001	<0.010	0.001	<0.001	<0.0001	<0.001	<0.01	0.04
SY1	23/08/2011	6.02	60	<0.1	<1	<0.01	0.003	<0.05	<0.0001	<0.001	0.003	<0.001	<0.0001	0.001	<0.01	0.009
SY1	20/09/2011	5.81	55	<0.1	<1	0.02	<0.001	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.001	<0.01	0.009
SY1	08/07/2012	5.63	64	<0.1	2	0.01	<0.001	<0.05	<0.0001	0.002	0.002	0.002	<0.0001	<0.001	<0.01	0.011
SY1	24/06/2013	5.7	58	0.2	1	0.01	<0.001	<0.05	<0.0001	<0.001	0.001	0.002	<0.0001	0.001	<0.01	0.02
SY1	31/7/2014	6.66	65	<0.1	2	<0.01	0.001	<0.05	<0.0001	<0.001	0.001	0.004	<0.0001	<0.001	<0.01	0.016
GBMB1	20/11/2010	7.91	533	1.7	110	<0.01	0.012	<0.05	<0.0001	<0.010	<0.001	0.002	<0.0001	<0.001	<0.01	0.035
GBMB1	23/08/2011	7.62	498	1.7	81	0.03	0.037	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
GBMB1	20/09/2011	6.67	694	2.2	165	0.01	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
GBMB1	08/07/2012	7.21	716	2.3	150	0.01	0.027	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.016
GBMB1	24/06/2013	7.2	632	2	133	0.02	0.015	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.013
GBMB1	31/7/2014	7.17	580	2.4	143	<0.01	0.019	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.014
GBMB3	11/07/2010	6.71	233	<0.1	1	0.15	0.009	<0.05	<0.0001	<0.010	<0.001	0.003	<0.0001	<0.001	<0.01	0.114
GBMB3	23/08/2011	6.25	103	<0.1	<1	0.07	0.016	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	<0.001	<0.01	0.006
GBMB3	20/09/2011	5.84	61	<0.1	<1	0.21	0.016	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.001	<0.01	0.014
GBMB3	08/07/2012	5.88	53	<0.1	<1	3.76	0.003	<0.05	<0.0001	0.002	0.001	<0.001	<0.0001	0.002	<0.01	0.5
GBMB3	24/06/2013	7.2	501	0.4	4	0.71	0.013	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	0.001	<0.01	0.02
GBMB3	31/7/2014	6.52	218	<0.1	1	2.2	0.038	<0.05	<0.0001	<0.001	0.007	0.001	<0.0001	0.004	<0.01	0.018
GBMB6	11/07/2010	6.21	138	0.1	2	<0.01	0.03	<0.05	<0.0001	<0.010	0.001	0.002	<0.0001	0.002	<0.01	0.143
GBMB6	23/08/2011	6.9	247	0.2	1	<0.01	0.096	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.002	<0.01	<0.005
GBMB6	20/09/2011	6.2	158	0.2	2	<0.01	0.087	<0.05	<0.0001	<0.001	0.001	<0.001	<0.0001	0.002	<0.01	<0.005
GBMB6	08/07/2012	6.9	276	0.3	<1	<0.01	0.093	<0.05	<0.0001	0.003	0.002	<0.001	<0.0001	0.003	<0.01	0.006
GBMB6	24/06/2013	7.19	498	0.6	1	<0.01	0.079	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.002	<0.01	0.005
GBMB6	31/7/2014	6.93	233	<0.1	<1	<0.01	0.116	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.002	<0.01	0.016
EA Trigger Level		6.0 to 7.5	250			0.055	0.013	0.37	0.0002	0.001	0.0014	0.0014	0.0006	0.011	0.011	0.008
EA Contaminant Limit		5 to 9	5970	2	1000	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

ATTACHMENT B WATER

QUALITY GRAPHS

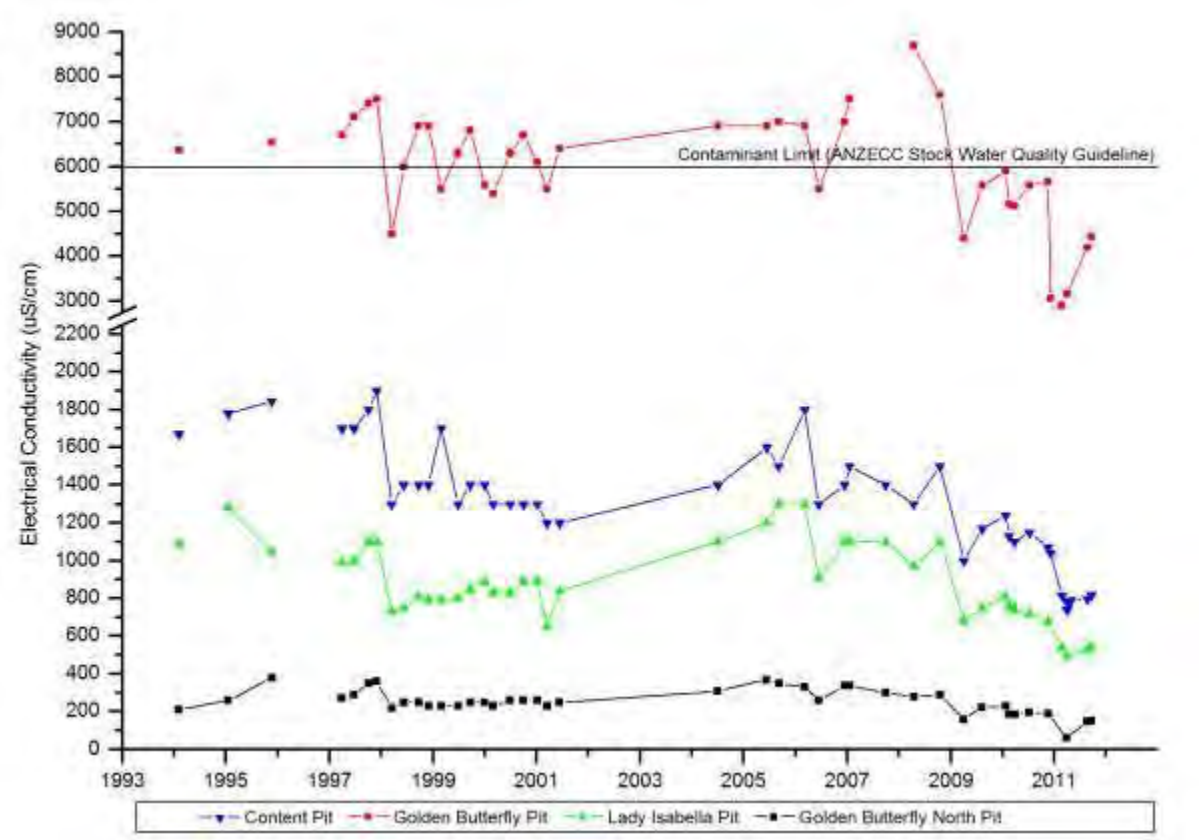

Figure 7: Croydon Pit Lake Electrical Conductivity Time Series Graph

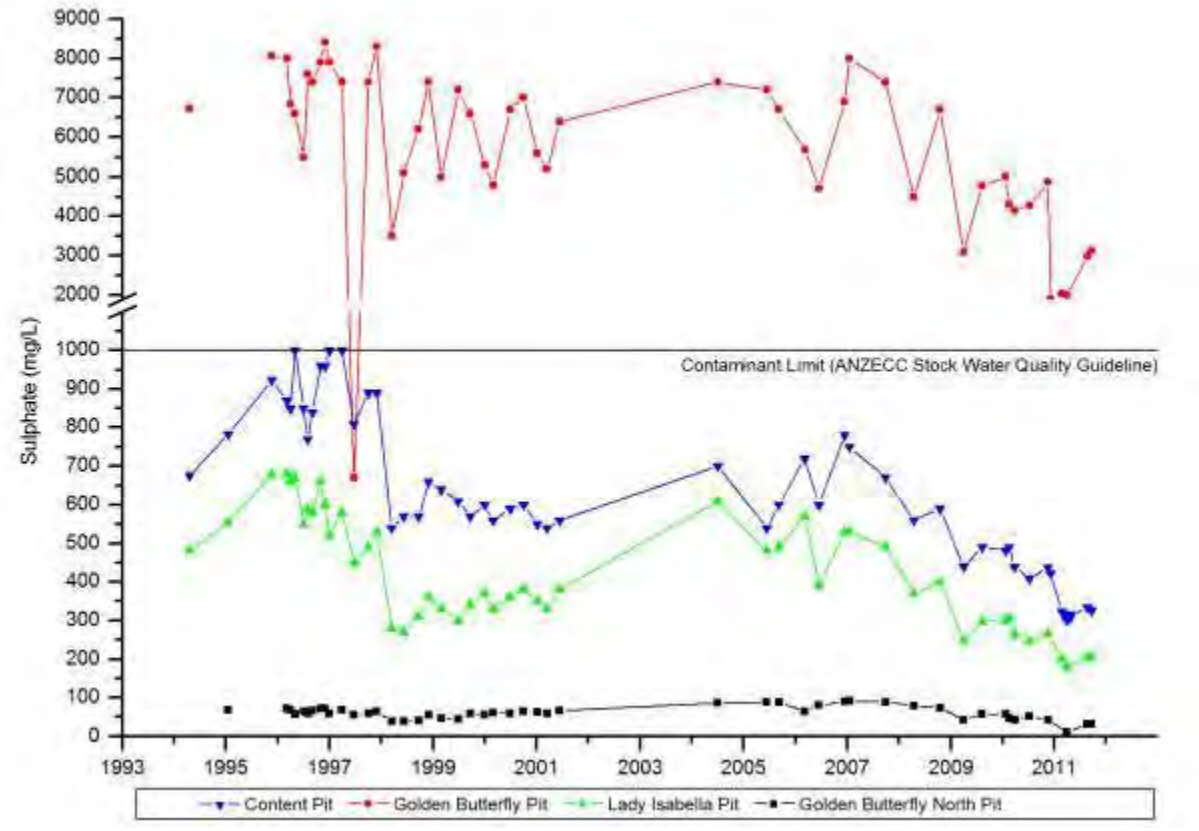

Figure 8: Croydon Pit Lake Sulfate Concentration Time Series Graph

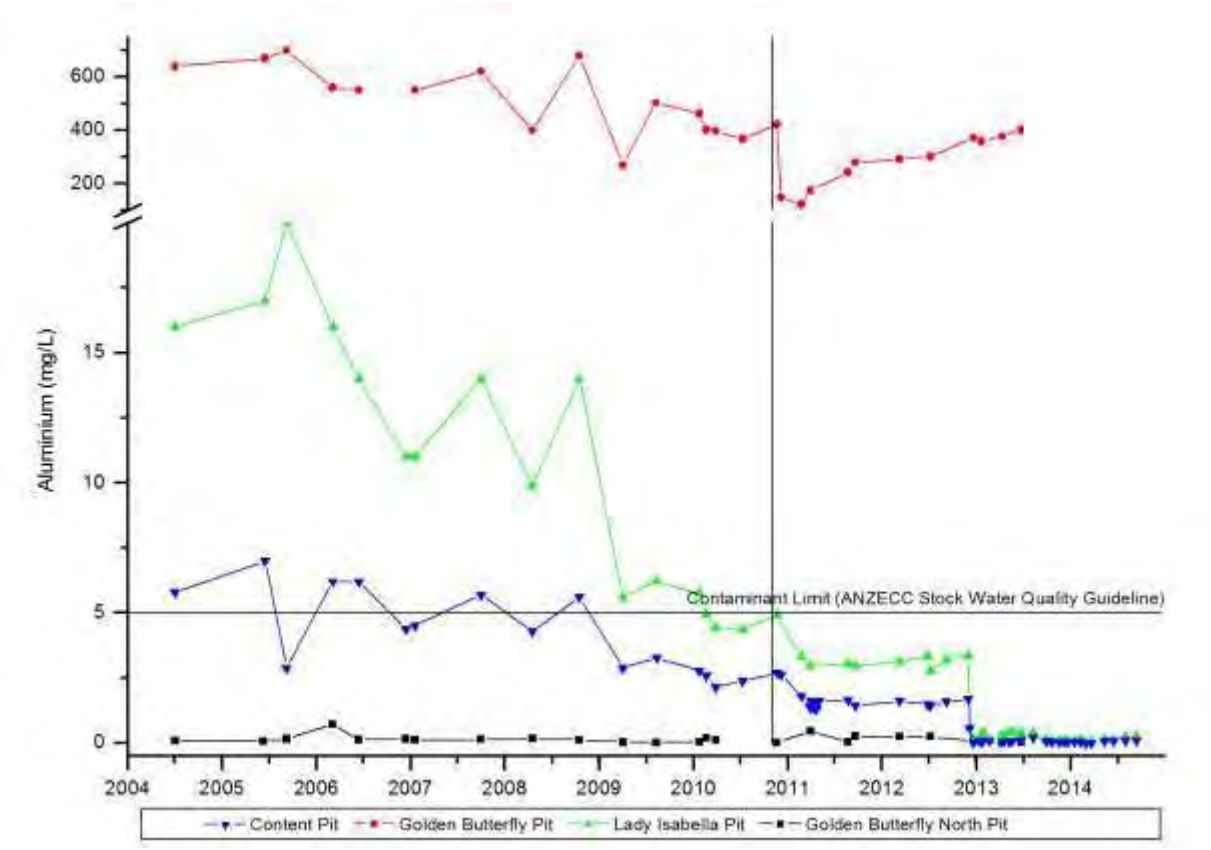

Figure 9: Croydon Pit Lake Aluminium Concentration Time Series Graph

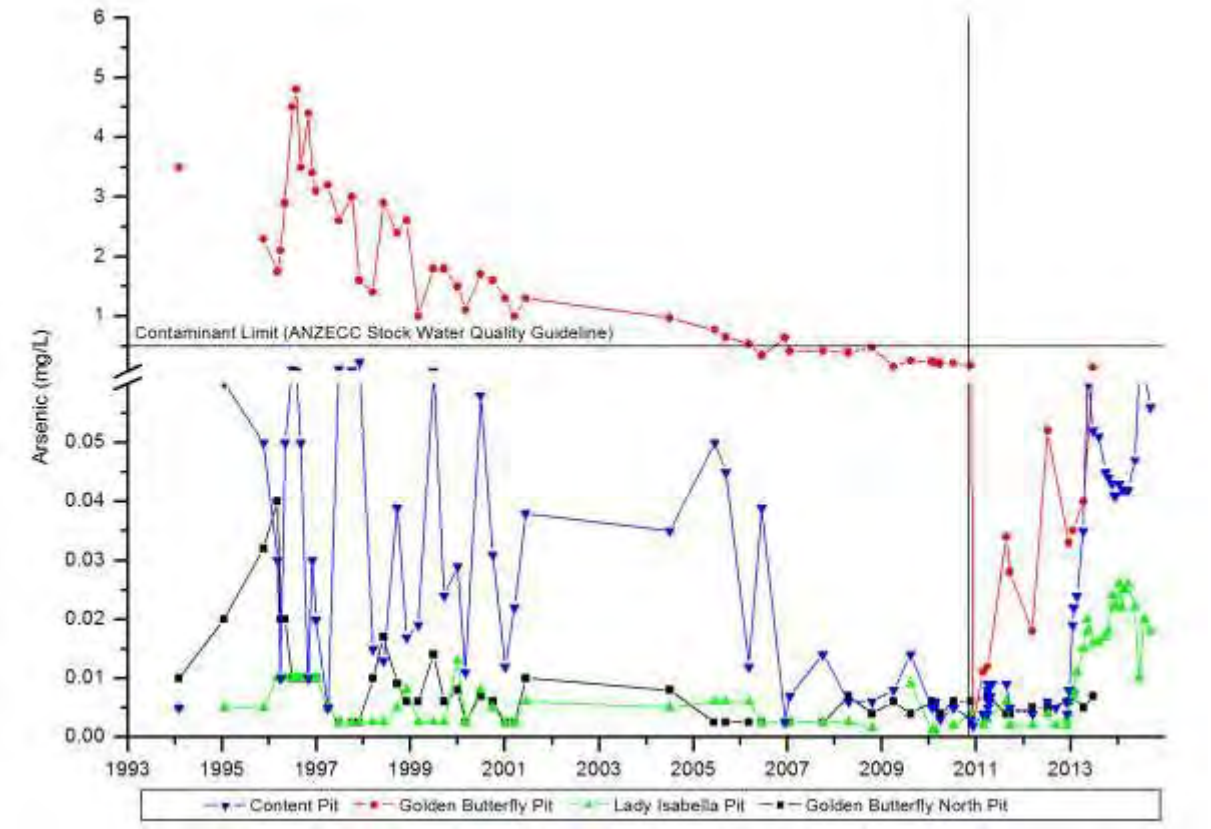

Figure 10: Croydon Pit Lake Arsenic Concentration Time Series Graph

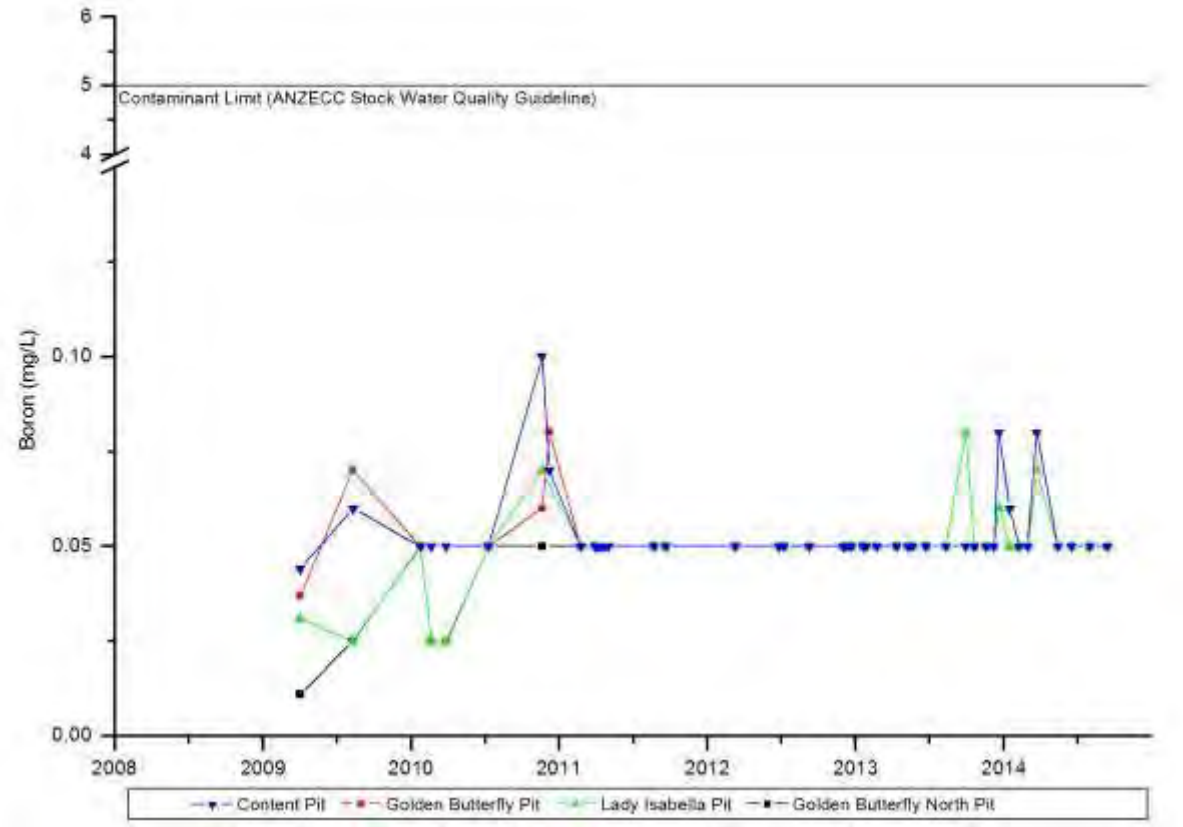

Figure 11: Croydon Pit Lake Boron Concentration Time Series Graph

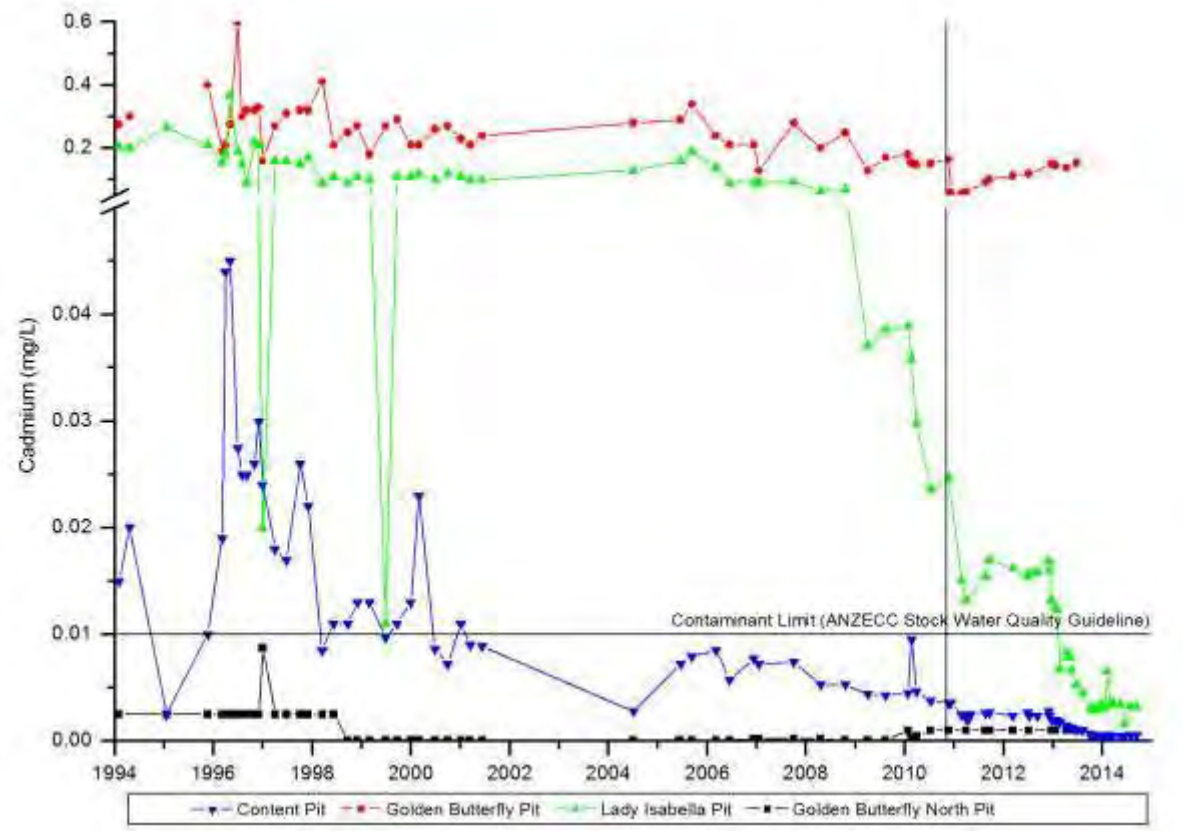

Figure 12: Croydon Pit Lake Cadmium Concentration Time Series Graph

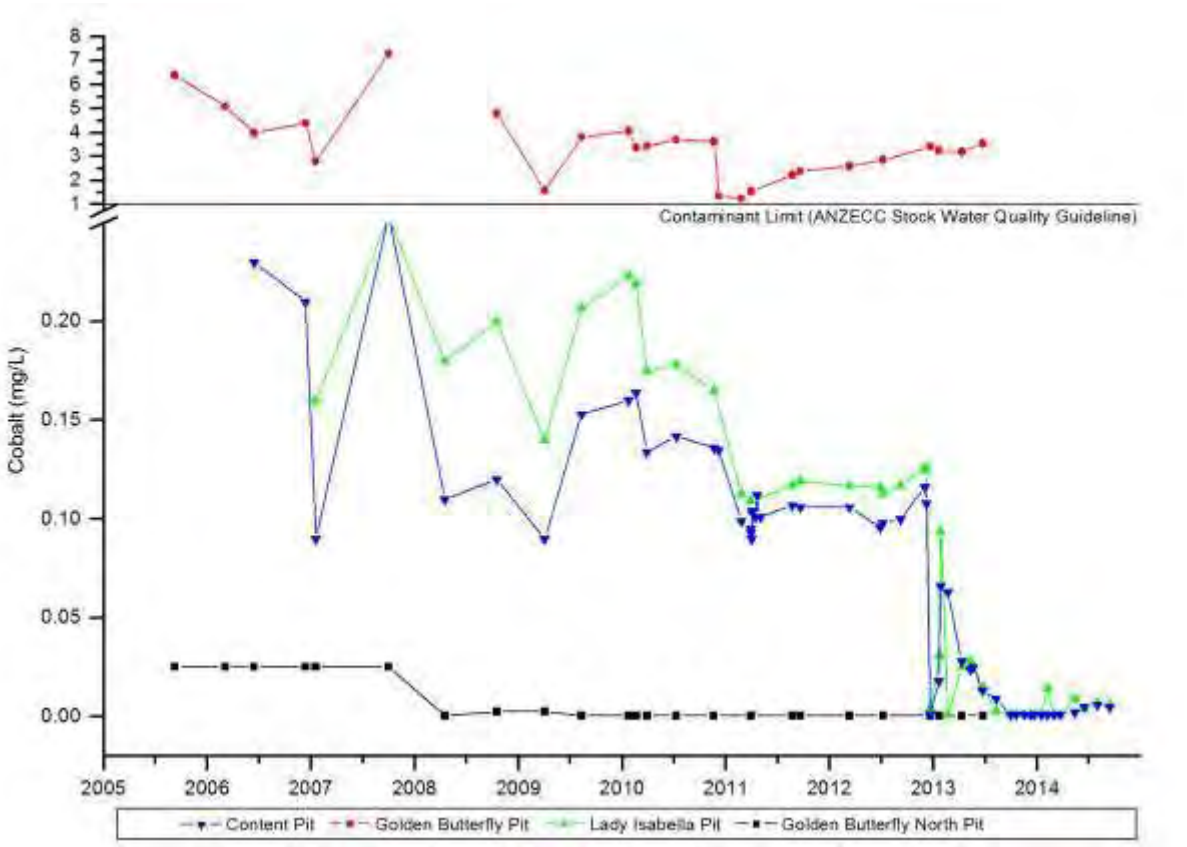

Figure 13: Croydon Pit Lake Cobalt Concentration Time Series Graph

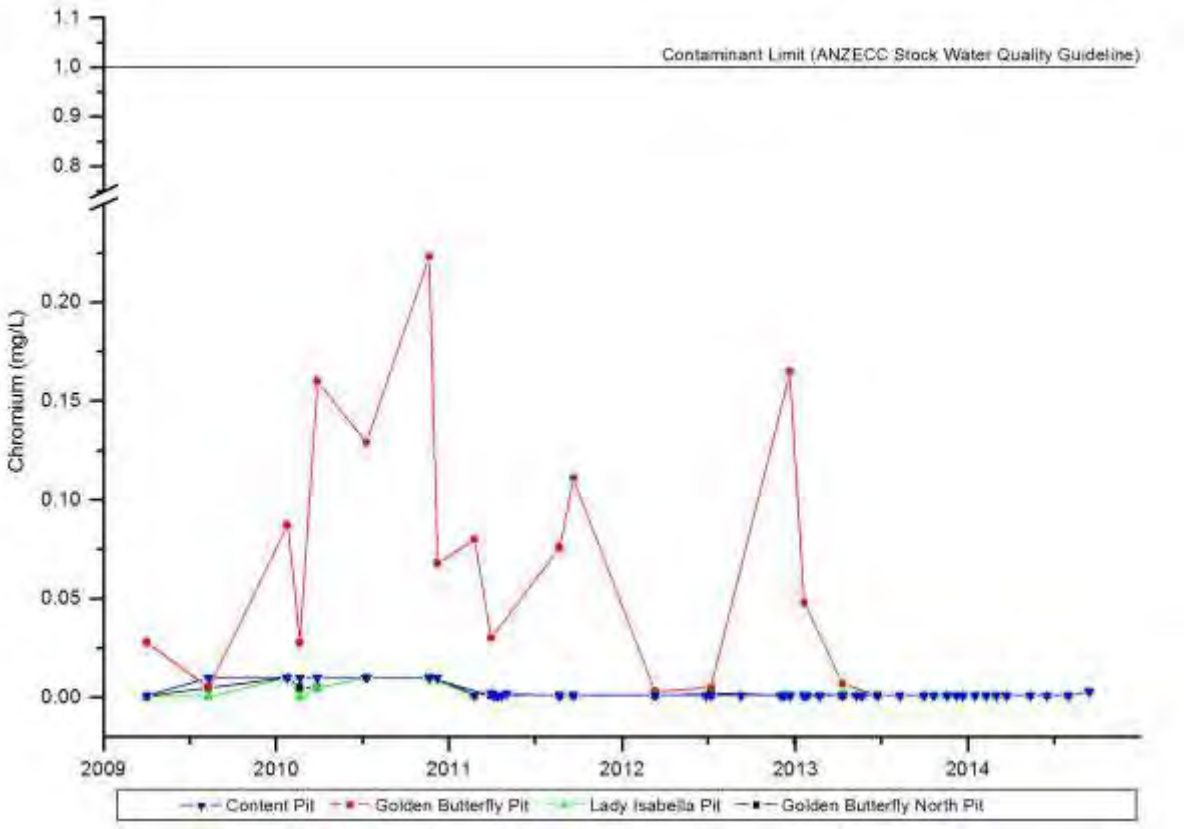

Figure 14: Croydon Pit Lake Chromium Concentration Time Series Graph

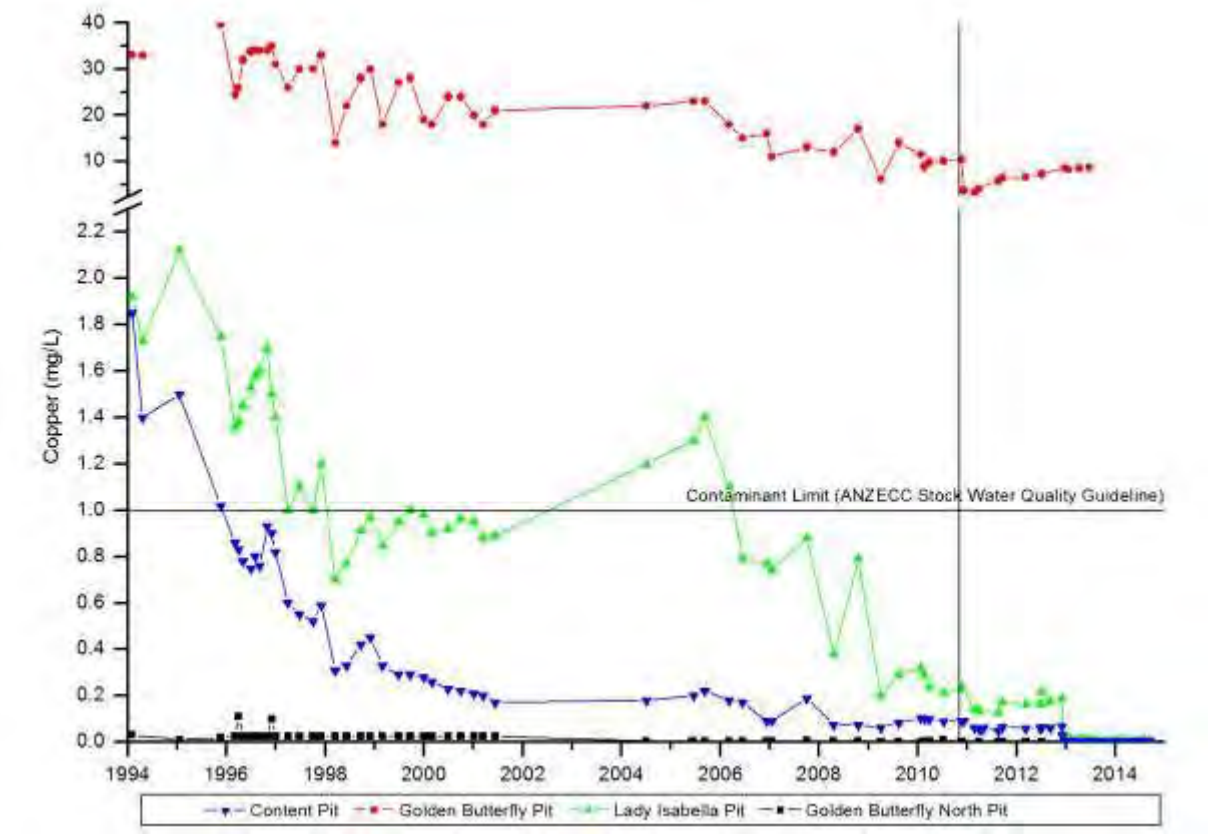

Figure 15: Croydon Pit Lake Copper Concentration Time Series Graph

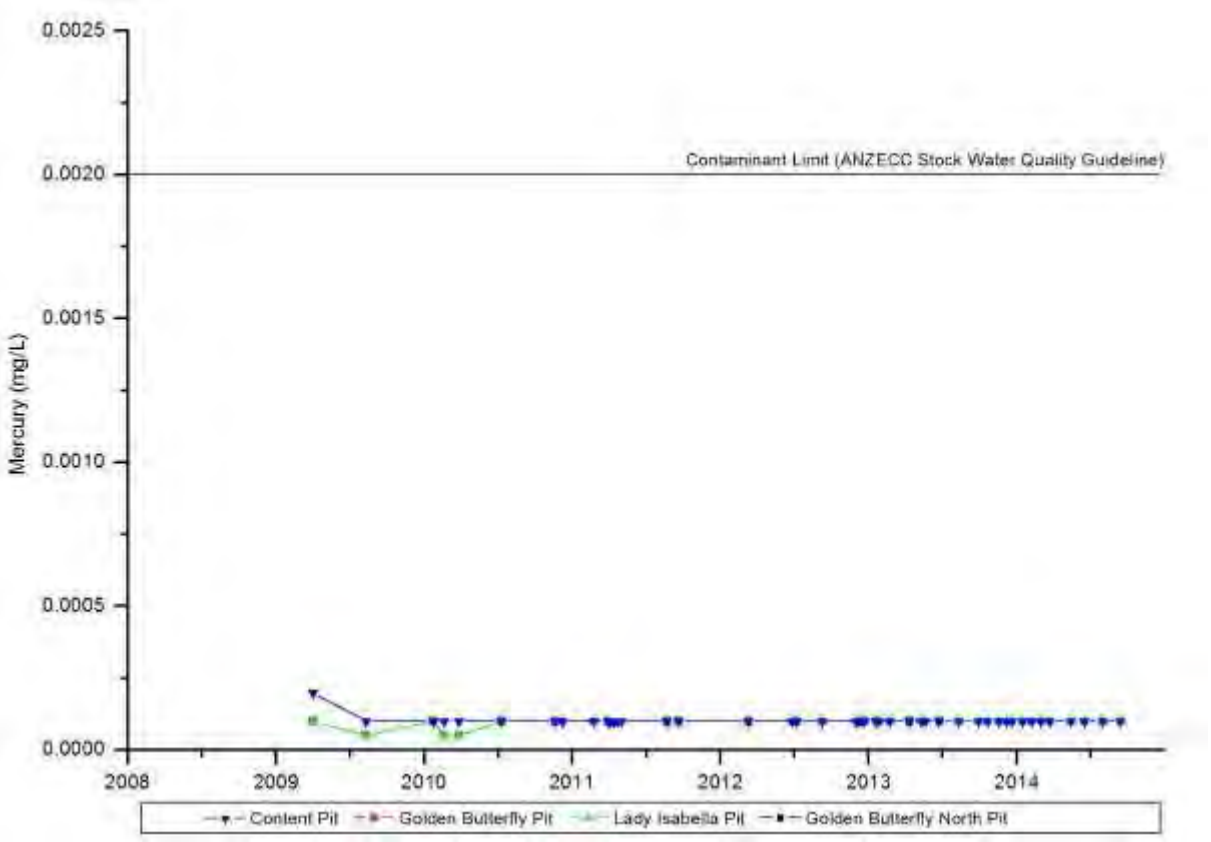

Figure 16: Croydon Pit Lake Mercury Concentration Time Series Graph

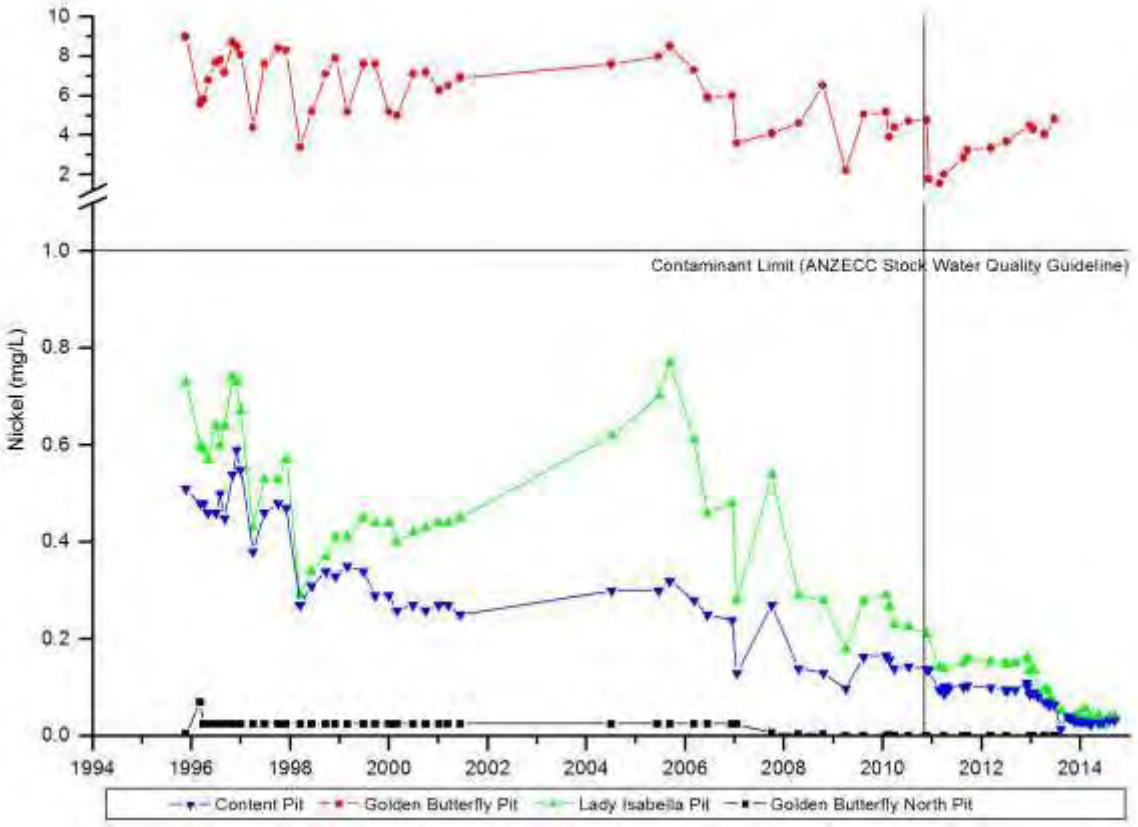

Figure 17: Croydon Pit Lake Nickel Concentration Time Series Graph

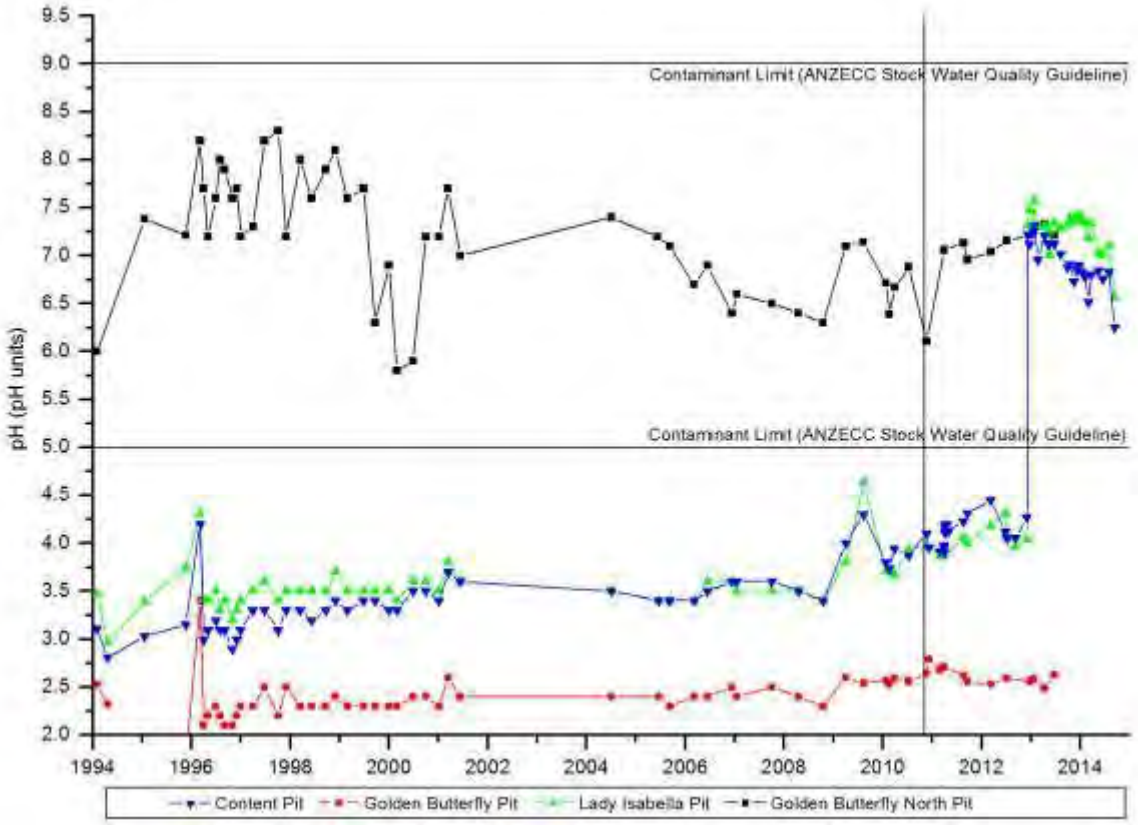

Figure 18: Croydon Pit Lake pH Time Series Graph

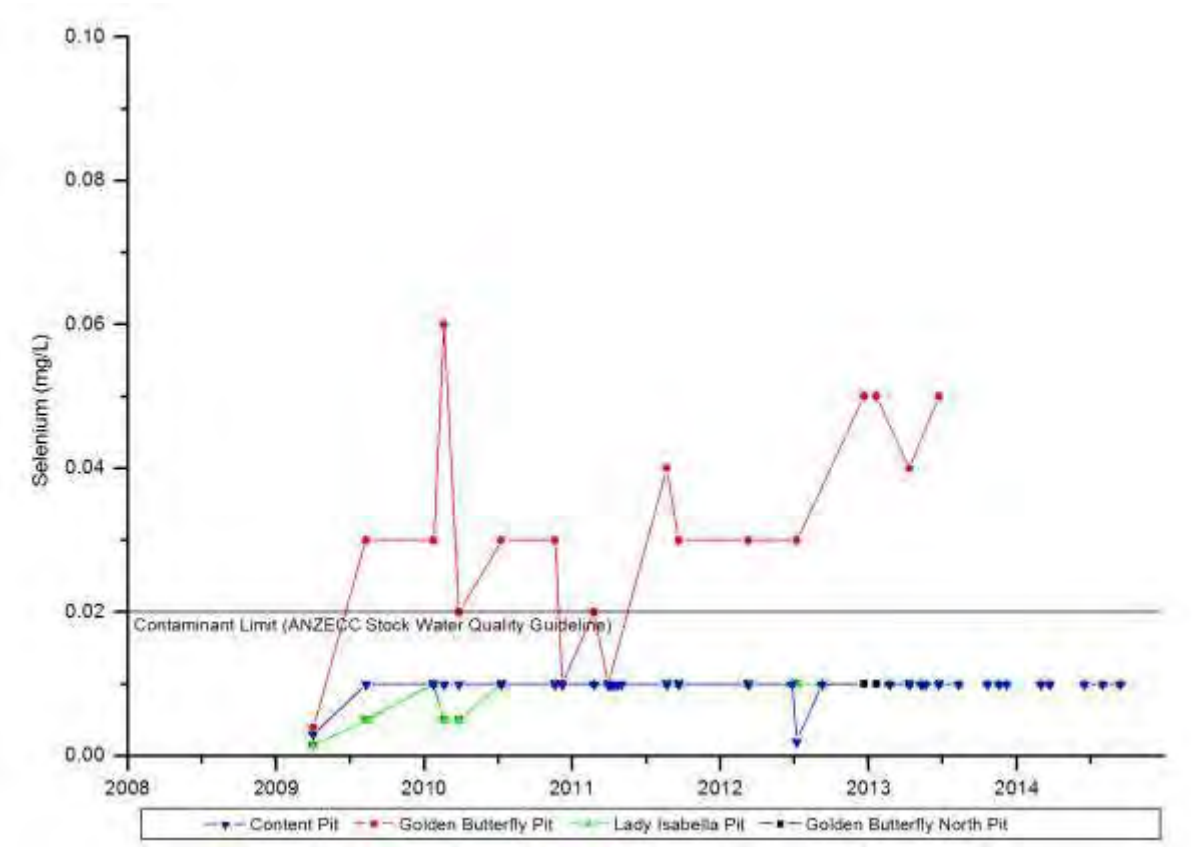

Figure 19: Croydon Pit Lake Selenium Concentration Time Series Graph

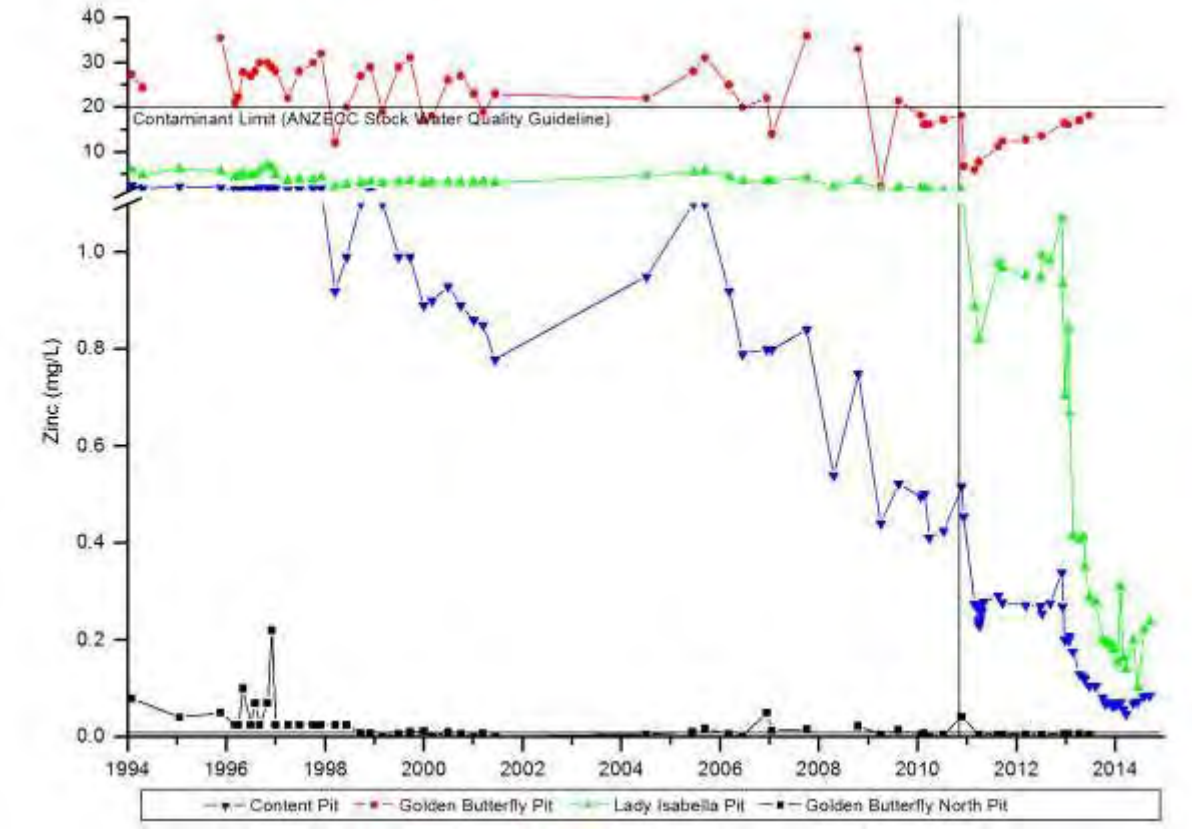

Figure 20: Croydon Pit Lake Zinc Concentration Time Series Graph

APPENDIX I CROYDON GOLD MINE 1996 (AMENDED) DECOMMISSIONING PLAN

PANCONTINENTAL MINING LIMITED

PANCON

✓ CARMS

CNS 5741.3

CNS 8.6933

CROYDON GOLD MINE

1996 (AMENDED) DECOMMISSIONING PLAN FOR ML5248

Released by DES RTI Act 2009

Prepared by Woodward-Clyde
May 1997

Project No A32/0280/0005
Document No. R002-B. Doc

Woodward-Clyde
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Rele

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PANCONTINENTAL MINING LIMITED ACN 009 712 092

19 May 1997
Project No. A3200280\0005

Department of Mines and Energy
159 Walsh Street
MAREEBA QLD 4880

PANCON

Attention: **Dr. Mike Gilbert**

Dear Mike

RE: CROYDON GOLD MINE 1996 (AMENDED) DECOMMISSIONING PLAN (ML 5248)

As you are aware, RGC Limited (RGC), on behalf of Pancontinental Mining Limited (Pancon), has initiated an upgraded rehabilitation program on ML 5248, associated with the Croydon Gold Mine. You will also be aware that prior to these additional works, the site was subject to the requirements of the Department of Mines and Energy (DME) approved 1993 Decommissioning Plan which outlined a proposed lease relinquishment program based on a detailed environmental monitoring plan. However, upon acquisition of the controlling interest in Pancon, RGC recognised that the 1993 Decommissioning Plan was inadequate to achieve satisfactory lease relinquishment conditions based on RGC's corporate environmental standards. Following a detailed site assessment, an upgraded Decommissioning Plan has been prepared and is attached.

It is proposed that the 1996 (Amended) Decommissioning Plan supersedes the 1993 plan and that the criteria contained within it be used by the DME to assess the success of the rehabilitation works. RGC, on behalf of Pancon, hereby seeks DME approval of the 1996 (Amended) Decommissioning Plan and attach herein three copies of the document.

Should you have any queries in relation to the above, please contact the undersigned.

Yours faithfully
Pancontinental Mining Limited

CTPI 49-Sch4

CTPI 49-Sch4

CTPI 49-Sch4

General Manager - Environment

CC. - Croydon Shire Council
- Department of Lands
- CTPI 49-Sch4
- CTPI 49-Sch4

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1.0
INTRODUCTION

Pancontinental Mining Limited (Pancon) is the holder of ML 5248 situated immediately to the west of Croydon township. ML 5248 formed part of the Croydon Gold Project and was mined during the late 1980s subject to mining lease conditions contained in Appendix A. In 1995, RGC Limited (RGC) acquired a controlling interest in Pancon and immediately commenced reviewing the environmental performance of all Pancon sites.

Upon reviewing the rehabilitation status of ML 5248, RGC found that the rehabilitation works conducted to date were not adequate in meeting RGC's corporate environmental standards. In addition, it was found, based on these corporate standards, that the 1993 Decommissioning Plan (Woodward-Clyde, 1993) did not comprehensively address the environmental issues or meet the overall rehabilitation objectives for the site. This review provided the catalyst for updating the existing 1993 Decommissioning Plan.

The overall rehabilitation objective adopted for ML 5248 is:

- to secure the site for the long term by inhibiting the formation of Acid Mine Drainage (AMD) and subsequent release of AMD products into the surrounding environment; and
- to enhance the overall stability and sustainability of the developed landforms.

This objective is to be achieved by isolating AMD producing material either through disposal in open pits, or capping with low permeability constructed covers, and in conjunction with these works, to reprofile the existing landforms, as appropriate, and to revegetate final surfaces (either covered or uncovered). Additionally, all practical measures are to be taken to ensure the safety of the site for the public and livestock. A rehabilitation works program was carried out within ML 5248 in 1996 based on these general rehabilitation requirements.

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This document has been prepared to support the process for relinquishment of ML 5248, and incorporates the following:

- a description of the 1996 rehabilitation works program including descriptions of site assessments carried out to confirm key rehabilitation design criteria, of options identified for rehabilitation of the mining-related landforms and of the basis for selection of the adopted works program;
- specification of an environmental monitoring program to assess the environmental performance of the rehabilitation works completed and appropriate performance criteria, as the basis on which relinquishment of the lease will be sought; and
- an outline of relevant requirements of the Department of Mines and Energy (DME) and Department of Environment (DoE) related to environmental security of the site and contaminated lands issues.

It is intended that this document be known as the 1996 (Amended) Decommissioning Plan for ML 5248, that it replaces the existing 1993 Decommissioning Plan, and that all commitments made in the 1993 plan be superseded by those detailed in this document. It is also intended that this document fulfills the role of an Environmental Management Overview Strategy (EMOS) and Closure Plan for the site.

To address the various requirements of the document, as outlined above, the 1996 (Amended) Decommissioning Plan has been structured as follows:

Section 2.0: provides a description of the site, including underlying land use and land capability;

Section 3.0: provides a description of the mining activities undertaken within the site;

Section 4.0: describes the site assessment that has been carried out to define the current rehabilitation works program for ML 5248, and the criteria and constraints on which the design of these rehabilitation works was based;

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Section 5.0: details the environmental monitoring program that will be maintained to objectively assess the performance of the rehabilitation works;

Section 6.0: defines the proposed lease relinquishment criteria;

Section 7.0: describes the documentation that will be prepared and submitted to DME to support the application for lease relinquishment; and

Section 8.0: outlines the organisation and management details for the rehabilitation project.

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2.0
SITE CHARACTERISTICS

2.1 SITE LOCATION AND DESCRIPTION

ML 5248 is located to the north west of the township of Croydon in North Queensland (refer Figure 1). The lease comprises an area of some 1.7 km^2 and extends along a corridor adjacent to the south side of the Normanton Developmental Road.

The lease area is dominated by mining related landforms, including pits and waste dumps. Generally these landforms (with the exception of the pits) have revegetated with grasses and shrubs (either from past sowing activities or by natural colonisation). These landforms, however, have been subject to some disturbance through erosion and livestock or vehicle trafficking. All open pits hold water, recharged either through direct rainfall, runoff or from groundwater entry. Each pit is surrounded by earthfill safety bunding and outer fencing.

Undisturbed areas surrounding the mining landforms, but within ML 5248, are generally grassed and/or partially covered with trees.

ML 5248 is located within the catchment of Slaughteryard Creek. This catchment drains a number of smaller tributaries, including Town Creek (from the Croydon township) and Belmore Creek (located within Belmore Station to the west). The site drainage is as follows:

- Eastern portion - southward, directly via Slaughteryard Creek.
- Western portion - generally westward via minor drainages to Belmore Creek thence into Slaughteryard Creek to the south west of Croydon.

An area of higher relief between the eastern and western portions of the lease acts as a drainage divide between these areas.

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2.2 LAND TENURE

The owners of the land underlying ML 5248 are:

- Eastern Portion — Town Common, Croydon Shire Council (CSC)
- Western Portion — Crown Land, Department of Lands (DoL)

These landholders have indicated a desire to retain control over these land areas following relinquishment.

2.3 LAND USE AND CAPABILITY

The pre-mining land use within ML 5248 comprised cattle grazing on the western portion of the lease, with low levels of grazing on the eastern portion. Some cattle grazing continues in the western portion of the lease.

An assessment of pre-mining land capability was undertaken by Woodward-Clyde and reported in Woodward-Clyde (1993), in accordance with Rosser et al (1974). The assessment comprised inspection and sampling of soils not disturbed through mining within and adjacent to ML 5248. Based on this assessment, the pre-mining land capability of ML 5248 was determined as Class VII. Rosser et al (1974) defines Class VII as land which is not suitable for cultivation but on which pastoral use is possible only with careful management and for which pasture improvement on Class VII land involving the use of machinery is considered impracticable.

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From 1990 to 1995 the Croydon Shire Council (CSC) used water contained within the Golden Butterfly North Pit (refer Figure 1) to supplement the existing town water supply, which was based on a borefield located on Slaughteryard Creek downstream from the lease area. Water was pumped from the pit to a tank (Town Tank) located on a hill at the south-eastern boundary of the lease area, for reticulation to the township. During 1995, a new water supply dam was constructed to the north of Croydon and is now used as the town water supply. The Golden Butterfly North Pit and the borefield are no longer used to supply water to the township. However, the water supply reticulation system from the borefield, including water pipes, tank and pumps, has been retained.

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3.0
PROJECT DESCRIPTION

The Croydon Gold Project was operated between 1987 and 1990 by an unincorporated joint venture between Central Coast Exploration NL (CCE) and Pancon. Mining took place on several leases, including ML 5248, to the west and north-west of Croydon. Ore processing was carried out at facilities located on CCE leases. Mining and ore processing on both Pancon and CCE leases was carried out by Barrick Mine Mangement (BMM).

The Pancon operation commenced in December 1988 with mining from the Golden Butterfly Pit, located within the eastern portion of ML 5248, as shown on Figure 1. The mining operation was subsequently expanded with the development of the Golden Butterfly North Pit (adjacent to Golden Butterfly) and the Content and Lady Isabella pits located within the western portion of the lease area. Pancon's mining operation at Croydon ceased in April 1990, with processing of ore from these leases completed in August 1990. In total, approximately 445 000 tonnes of ore was treated to produce some 63 000 ounces of gold.

Following the cessation of mining in 1990, a portion of the original lease area was relinquished by Pancon. Only those areas covering the open pits and waste dumps, plus a connecting corridor, were retained. The current lease area is indicated on Figure 1.

On completion of mining, ML 5248 comprised the following mining related landforms:

- Golden Butterfly Pit and surrounds;
- Golden Butterfly North Pit;
- Golden Butterfly Waste Dump;
- Content Waste Dump;
- Content Pit and surrounds; and
- Lady Isabella Pit.

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The locations of these landforms are shown on Figure 1.

In addition, mining hardstand areas (including old ore stockpile and crusher pad areas), a haul road and numerous open exploration drill holes related to the Pancon operations remained within the lease area. A number of open shafts from historical (i.e. pre-1900) mining activities were also present within the area.

The locations of the mining related landforms, as described above with respect to land tenure are described in Table 1 below.

TABLE 1
Underlying Land Tenure For Mining Related Landforms

LOCATION	MINING LANDFORM	BACKGROUND LAND TENURE
Eastern Portion of Lease Area	Golden Butterfly Pit Golden Butterfly North Pit Golden Butterfly Waste Dump	Town Common, Croydon Shire Council
Western Portion of Lease Area	Content Pit Lady Isabella Pit Content Waste Dump	Crown Land, Department of Lands

Hardstand areas, the haul road, drill holes and shafts occur within both land tenure areas.

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4.0
REHABILITATION

4.1 BACKGROUND

Planning for rehabilitation of ML 5248 commenced in November 1992 at a site meeting involving representatives from Pancon, DME and Woodward-Clyde. During this meeting the key environmental concerns relating to the lease area were identified, as follows:

- development of acidic water within open pits;
- discharge of acidic water into Slaughteryard Creek from the Golden Butterfly waste dump and adjacent areas;
- off-lease movement of groundwater from the Golden Butterfly pits; and
- erosion and potential instability of existing mining related landforms.

Pancon committed, at that time, to address each of these concerns. In 1993, Pancon initiated a rehabilitation program which involved the following works:

- Golden Butterfly Waste Dump - reprofiling of the waste rock dump surface, including flattening of batters to a nominal slope of 3(H) to 1(V); construction of cover layers over plateau areas of the waste dump; construction of drainage runoff control areas and construction of stormwater diversion bunds.
- Content Waste Dump - reprofiling of the western batters to a nominal 3(H) to 1(V) slope; construction of cover layers over this batter and clean-up of waste rock piles adjacent to the dump.
- Open pits (Golden Butterfly, Golden Butterfly North, Lady Isabella and Content) - construction of peripheral safety bunds and fencing around each pit and erection of warning signs.

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Revegetation of the waste dump surfaces was carried out by hand broadcasting of seed following completion of the earthworks portion of the program. Species used included improved pasture grasses and legumes and native shrubs.

4.2 SITE ASSESSMENT

Environmental monitoring carried out within the site following Pancon's initial (1993) rehabilitation program (monitoring data reported in Woodward-Clyde, 1994 and 1996) indicated that these works were inadequate to achieve the rehabilitation objective as outlined in Section 1.0, with evidence of continuing acid drainage and erosion from the waste dumps. Upon acquisition of the controlling interest in Pancon, RGC commissioned a detailed site assessment to identify the nature and extent of the problem areas. This site assessment formed the basis for design and implementation of a revised and upgraded rehabilitation works program.

The scope of the site assessment was as follows:

(i) identification of acid producing materials within the existing waste dumps and identification of other visible areas of potentially acid producing material, including former ore stockpile and associated hardstand areas;

(ii) characterisation of surface and groundwater within the site, with particular emphasis on discharge from the southern portion of the lease; and

(iii) review of the existing environmental monitoring program currently in place for the tenement (contained within the 1993 Decommissioning Plan).

The site assessment was carried out in December 1995 and April 1996 by Woodward-Clyde, on behalf of RGC.

A description of the methodology and results of these works is provided below.

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4.2.1 Waste Rock Characterisation

The purpose of this program was to identify the various rock types within the waste rock dumps and surrounding areas and, based on field and laboratory testing, to assess the acid producing potential of these materials.

The investigation was concentrated within areas that were known or suspected to contain acid producing materials. These areas included:

- Golden Butterfly waste dump and near surrounds; and
- Content waste dump and near surrounds.

The waste dump surrounds incorporate former hardstand and ore stockpile areas and drainage alignments which have been potentially impacted by waste dump areas.

The program comprised excavation of forty-nine (49) test pits within the above areas. Materials recovered from each pit were geologically logged, and tested for pH and electrical conductivity (EC) in the field. Representative samples of each identifiable waste rock unit were collected for laboratory analysis. Analysis for total sulphur and acid neutralising capacity (ANC) was carried out on these samples for estimation of the maximum potential acidity (MPA) and net acid producing potential (NAPP).

Classification of the waste rock materials into three broad categories was carried out using procedures developed through Canadian research (Brodie *et al.*, 1991; Smith & Barton-Bridges, 1991; Ferguson & Morin, 1991; and Ferguson & Robertson, 1994). The three categories used are as follows:

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MPA : ANC Ratio	Net Acid Producing Potential
> 1:1 and total sulphur > 0.25%	Potentially Acid Producing
Between 1:3 and 1:1	Indeterminate
< 1:3 and total sulphur <0.25%	Non Acid Producing

Note: Where waste rock has been exposed to oxidisation, as in the case of the Croydon site, the testwork is unable to accurately gauge the degree to which the waste has already oxidised. As a result, sulphate oxidation products which are no longer acid producing are included in the maximum potential acidity. Therefore the net acid producing potential (NAPP) may be over estimated.

These categories, in conjunction with the field testing (pH and EC) results, have been used to characterise the waste rock materials sampled during the investigation program. The relationship developed between lithology and acid producing potential is described below:

4.2.1.1 Golden Butterfly Waste Dump

Four waste types were identified within the Golden Butterfly dump. These waste types, and acid producing potential are described as follows:

Red Sand/Sandstone waste

This unit exhibited a range in paste pH and EC across the dump, from 2.3 to 5.5 and 21 to 1770 µS/cm, respectively. One test pit was excavated to the north of the dump in what was considered to be the natural soil profile. The pH of this material was 5.2 and the EC, 9 µS/cm.

Laboratory testwork was conducted on two samples from this unit. Both samples had low total sulphur and ANC with a corresponding NAPP of - 0.19 kg H_2S0_4. Due to the very low total sulphur content, this unit was classified as *non acid producing*.

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White Granite waste.

Paste pH and EC results for this waste unit ranged from 3.9 to 5.7 and 50 to 150 µS/cm, respectively. The laboratory testwork indicates a low total sulphur content (<0.01%) and ANC (<0.5 kg H_2SO_4/tonne). The NAPP of the samples tested indicates an *indeterminate acid producing potential* due to the very low total sulphur content.

Clay

The clay materials were encountered over the surface of the dump. Field testing for paste pH and EC indicated a range of 4.5 to 6.7 and 160 to 600 µS/cm, respectively for these materials. No samples were collected from this unit. Due to the close proximity of the layer to the surface and the expected resulting oxidation and soil leaching processes, it is expected that this unit would be *non acid producing.*

Grey Granite waste

Paste pH and EC results for this unit ranged from 2.3 to 5.2 and 130 to 5210 µS/cm, respectively. This unit was highly variable in the degree of oxidation, grain size and colour. Visible sulphide mineralisation was common, as were oxidation products (iron oxides, sulphates etc.). The initial rehabilitation program has placed oxidised acidic material, previously on the surface, under clay and sand capping. The effectiveness of this capping is difficult to assess because the condition of the waste prior to capping is not known. However, the material under the capping in the test pits was generally acidic, moist and showed signs of sulphide oxidation. Surface outcropping of this waste type occurred within the northern portion of the dump.

Laboratory analysis of this unit indicates relatively high total sulphur content (0.45 to 1.81%) and low acid neutralising capacity (<0.5 kg H_2S0_4 / tonne). Both samples tested recorded positive NAPP results placing them in the *potentially acid producing* category.

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4.2.1.2 Content Waste Dump

Three waste types were identified within the Content Waste dump area. These waste types and associated acid producing potential are described below. The results of field pH and EC are noted for each of these materials.

Brown Sandy Topsoil.

The field pH and EC of this unit ranged from 4.1 to 5.3 and 14 to 15 µS/cm, respectively. Laboratory testwork on one sample from the unit indicated a low total sulphur content (<0.05%) and low ANC (2.5 kg H_2S0_4/tonne). Calculation of the NAPP shows an *indeterminate acid producing potential* for the sample tested.

Red Gravelly Clay

Field pH and EC ranged from 2.9 to 4.9 and 136 to 1053 µS/cm, respectively for the unit. It appears that one test pit has possibly been contaminated by acidic leachate from the granite waste immediately below the red gravelly/clay layer, accounting for the elevated EC and low pH. Laboratory testwork undertaken on a sample of this waste type indicated low total sulphur and ANC. The NAPP category for the sample tested is *indeterminate*.

Grey Granite waste

Paste pH and EC ranged from 1.9 to 5.5 and 67 to 4570 µS/cm, respectively for this unit although the colour and degree of oxidation varied across the dump. This may be due to mixing of wastes from both the Content and Lady Isabella pits.

Two test pits located on the south west batter exhibited low pH and high EC. Laboratory testwork on a sample from this area showed an elevated sulphur content and a corresponding positive acid producing potential. The wastes within this area of the dump may be described as *potentially acid producing*. Conversely, samples of this waste rock type from other areas of the dump showed higher pH, lower EC and can be classified as *non acid producing*.

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The heterogeneous nature of the dump and possibility that the waste rock has been sourced from two different pits indicates that isolated pockets of acid producing waste may be present within the dump.

4.2.1.3 Other Areas

Stockpile Area

The stockpile area is located to the west of the Golden Butterfly pit, between the pit and Slaughteryard Creek (refer Figure 1). It drains directly to the creek immediately upstream of the lease boundary. The soil profile consisted of red sand/sandstone up to 1.5m deep overlying granite waste. The red sand/sandstone exhibited similar characteristics to the Golden Butterfly dump sand/sandstone waste unit (refer Section 4.2.1.1) and is considered to be of *indeterminate acid producing potential*. The granite unit recorded field paste pH and EC of 3.4 and 200 µS/cm, respectively. These results and observed physical characteristics of the grey granite unit suggests similarities with the Golden Butterfly dump grey granite waste unit. It is expected that this material would be *potentially acid producing*.

Haul road.

The haul road runs in a northerly direction between the Golden Butterfly and Content pits. One test pit was excavated into the haul road to the north east of the Golden Butterfly dump. Compaction of the haul road area restricted excavation to a maximum depth of 0.5 metres. The material used for the construction of the haul road appeared to be a mixture of granitic waste, sand and red gravelly clay. The field paste pH and EC was 4.0 and 300 µS/cm, respectively. The granitic material at the site tested is expected to be *potentially acid producing*.

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Western side of the Content Pit

This area is located to the west of the Content Waste Dump and was levelled during reshaping of the Content Waste Dump. This area is located adjacent to the Content waste dump batter from which acidic discharge has been previously noted. Granite waste covers the surface of this area to a depth of up to 1 m with some surface salt crusting also noted.

The paste pH and EC of the granite wastes varied from 3.1 to 5.3 and 166 to 445 µS/cm, respectively. These wastes are similar to the grey granite wastes noted within the Content waste dump and are therefore considered to be *potentially acid producing*.

Beneath the granite waste, the natural soil profile was encountered (sandy A horizon and gravelly B horizon). Laboratory analysis of the granite waste from this area indicated that the sample tested has a low total sulphur (0.03%) and ANC (2.5 kg H_2SO_4/tonne) and is *non acid producing*.

This entire area is acting as a collection area for acidic leachate previously generated from the Content dump and may contain some pockets of material which are *potentially acid producing*.

Drainage channel.

A drainage channel (tributary of Slaughteryard Creek) is located on the eastern edge of the Golden Butterfly Dump. This channel acts as a collection area for drainage from the Golden Butterfly Dump. Test pits were excavated within the channel, and the materials encountered ranged from red clay to brown sandy clay. The paste pH and EC ranged from 2.3 to 2.7 and 800 to 17,200 µS/cm, respectively. Laboratory testwork indicates the red clay on the surface of the channel has a relatively high total sulphur content (1.2%). It also contains ions which have the potential to contribute to acid generating reactions. These soils are considered to be affected by the drainage from the waste dump, contaminated by by-products of AMD occurring within the dump. Despite this level of introduced contaminants, it is considered that these materials are inherently *non acid producing*.

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Western side of the Content Pit

This area is located to the west of the Content Waste Dump and was levelled during reshaping of the Content Waste Dump. This area is located adjacent to the Content waste dump batter from which acidic discharge has been previously noted. Granite waste covers the surface of this area to a depth of up to 1 m with some surface salt crusting also noted.

The paste pH and EC of the granite wastes varied from 3.1 to 5.3 and 166 to 445 µS/cm, respectively. These wastes are similar to the grey granite wastes noted within the Content waste dump and are therefore considered to be *potentially acid producing*.

Beneath the granite waste, the natural soil profile was encountered (sandy A horizon and gravelly B horizon). Laboratory analysis of the granite waste from this area indicated that the sample tested has a low total sulphur (0.03%) and ANC (2.5 kg H_2S0_4/tonne) and is *non acid producing*.

This entire area is acting as a collection area for acidic leachate previously generated from the Content dump and may contain some pockets of material which are *potentially acid producing*.

Drainage channel.

A drainage channel (tributary of Slaughteryard Creek) is located on the eastern edge of the Golden Butterfly Dump. This channel acts as a collection area for drainage from the Golden Butterfly Dump. Test pits were excavated within the channel, and the materials encountered ranged from red clay to brown sandy clay. The paste pH and EC ranged from 2.3 to 2.7 and 800 to 17,200 µS/cm, respectively. Laboratory testwork indicates the red clay on the surface of the channel has a relatively high total sulphur content (1.2%). It also contains ions which have the potential to contribute to acid generating reactions. These soils are considered to be affected by the drainage from the waste dump, contaminated by by-products of AMD occurring within the dump. Despite this level of introduced contaminants, it is considered that these materials are inherently *non acid producing*.

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Sandy Area to the North of the Golden Butterfly pit.

One pit was excavated in this area to determine the existing soil profile in the vicinity of the dump. The profile consisted of uniform red sand with a pH of 5.2 and low EC (9 µS/cm).

The acid generating potential of this material was not determined; however, based on the non-mineralised nature of the soil, it is likely to be *non acid producing*.

4.2.1.4 Summary of Results

(i) Golden Butterfly Waste Dump

The results of the waste characterisation program within the Golden Butterfly Waste dump area indicate the following relationship between material type and acid producing potential:

Material	Potential for Acid Production
Red Sand/Sandstone	Indeterminate
White Granite	Indeterminate
Clay	Non Acid Producing*
Grey Granite	Potential Acid Producing

* Inferred classification - no confirmation testwork carried out.

The assessment indicates the profile within the waste dump comprises a surface soil layer (clay and red sand) overlying grey granite waste. At a number of sites, sandstone or white granite materials were encountered beneath the surface soils. It is believed that the sandstone and white granites originated from the Golden Butterfly North Pit and that these occur primarily within the south western portion of the dump. However, the investigation indicates that this material is scattered throughout the dump.

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(ii) Content Waste Dump.

A relationship developed between material type and acid producing potential for the Content waste dump, based on the waste characterisation program, is as follows:

Material	Potential for Acid Production
Brown Sandy Topsoil	Indeterminate
Red Gravelly Clay	Indeterminate
Grey Granite	Generally non acid producing but with some localised acid producing areas

The investigation indicates the profile comprises a brown sandy topsoil layer overlying grey granite waste. Thin layers of red gravelly clay were encountered in some areas. Grey granite was encountered at the dump surface in a number of locations.

(iii) Other Areas

Waste rock characteristics within other areas within the lease area are as follows:

Haul Road: Waste rock materials within the haul road comprise a mixture of granite, sand and red gravelly clay. The mixed waste material is considered to be potentially acid producing, however, due to the level of compaction within the haul road formation, these materials are considered to be effectively encapsulated.

Stockpile Area: The stockpile area comprises surficial red sand/sandstone overlying grey granite, similar to those encountered within the Golden Butterfly waste dump. The sand/sandstone are of indeterminate acid producing potential and the granites considered to be potentially acid producing.

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Western Side of Content Pit: This area is underlain generally by grey granite waste, similar to that encountered within the Content dump. Therefore this area is potentially acid producing

Drainage Channel: This tributary of Slaughteryard Creek within the channel area, downstream from the Golden Butterfly waste dump, comprises red clay to brown sandy clay. This channel is considered to be an area of contamination due to acidic drainage from the waste dump. The soils themselves are, however, considered to be non acid producing.

North of Golden Butterfly Pit: The natural soils encountered within this area are considered to be non acid producing.

From the above assessment, estimates of the relative volumes of non acid producing and potentially acid producing (including indeterminate) waste rock have been made and are presented in Table 2. These estimates are inferred on the basis of the area of surface exposure of the individual waste rock units.

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TABLE 2
Estimate of Waste Rock Volumes

Site	Volume Non acid Producing Rock ($x\ 10^3 m^3$)	Volume Potential Acid Producing Rock ($x\ 10^3 m^3$)	Total Volume ($x\ 10^3 m^3$)
Golden Butterfly Dump	980	800	1780
Content Dump	140	220	360
Stockpile Area	-	27	27
Haul Road	n.c.	n.c.	n.c.
Western Side of Content Pit	-	25	25
Drainage Channel	-	12	12
Sandy Area to North of Golden Butterfly Pit	n.c.	n.c.	n.c.

n.c.. Not Calculatable
- Not Present

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4.2.2 Characterisation of Surface and Groundwater Quality

A water quality monitoring program based on the requirements of the 1993 Decommissioning Plan commenced in February 1994. Monitoring was also carried out by (the operator), BMM, during mining with data available from 1989, and by Croydon Shire Council (CSC) with data from 1986. The following describes the surface and groundwater monitoring carried out and provides a brief interpretation of the available data.

4.2.2.1 Surface Water

Surface Water Sampling Sites

Surface water sampling has been carried out from the sites listed in Table 3. These sites are located on Figures 1, 2 and 3.

TABLE 3
Surface Water Monitoring Sites

SAMPLING SITE IDENTIFICATION	LOCATION
SW1	Adjacent borefield causeway on Slaughteryard Creek, downstream of lease.
SW2	Junction of Slaughteryard Creek and MLA boundary
SW3	Upstream of Golden Butterfly Waste Dump on Slaughteryard Creek
SW3A	Adjacent to Golden Butterfly Waste Dump
SW4	Upstream of Golden Butterfly Waste Dump within small CSC dam
Golden Butterfly Pit	Western Edge of Pit
Golden Butterfly North Pit	Western Edge of Pit
Content Pit	Western Edge of Pit
Lady Isabella Pit	Western Edge of Pit

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Monitoring of surface water by CSC was carried out at the following sites:

- Borefield Causeway
- Slaughteryard Creek near bore
- Slaughteryard Creek
- Golden Butterfly Waste Dump Runoff
- Above Golden Butterfly Waste Dump
- Town Creek (200 m above Town Creek and Slaughteryard Creek confluence).

Accurate locations of the above sampling sites are not available and therefore they have not been indicated on the figures.

Surface Water Quality Analyses and Data Quality

Surface water quality analyses for each of these sites included the following suite of parameters:

pH
Total Dissolved Solids
Calcium
Magnesium
Total Solids
Nitrate
Sulphate

Arsenic
Cadmium
Copper
Iron
Lead
Manganese
Mercury
Molybdenum
Nickel
Zinc

The pre-1993 data was collected by either the mine operator or CSC and has been compiled from unconsolidated data sheets and reports. No detail on sampling procedures and chain of custody protocols used during this sampling is available and therefore the

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quality of the data obtained is unknown. Accordingly, these data are used for comparison only, and not for interpretation.

The post-1993 sampling has been carried out in accordance with the procedures contained in the 1993 Decommissioning Plan. As a result, consistent and appropriate handling protocols and laboratory analyses were used (with relevant documentation available). Post-1993 surface water quality data are therefore considered of adequate quality to allow interpretation.

Surface Water Quality Interpretation

A compilation of surface water quality data for the above sample sites and sampling periods is provided in Appendix F. Graphical representation of selected analytes based on this monitoring data is also provided in Appendix F. Interpretation and comparison (as appropriate) is provided below.

(i) Surface Drainages

From the post-1993 monitoring, the surface drainages located downstream of the Golden Butterfly Waste Dump (SW1, SW2 and SW3A) indicate similar water quality trends. Typically, these waters are characterised by low pH and high conductivity, with elevated levels of arsenic, cadmium, copper and iron, generally in excess of ANZECC (1992) guidelines for livestock (cattle) watering. This water quality indicates the presence of acidic drainage, which is considered to be sourced principally from the Golden Butterfly Waste Dump. It is noted also that surface water quality improves with distance from the Golden Butterfly waste dump. This appears to be a result of dilution from flow events in Slaughteryard Creek.

Two surface water sampling sites, SW3 and SW4, located upstream of the Golden Butterfly Dump on Slaughteryard Creek, were established in 1993 and 1996 respectively. One sampling event was carried out at each of these sites as part of the recent site assessment. (No sampling had previously been carried out at either site.) Surface water sampled at both sites was fresh (neutral pH and low conductivity) with no elevated metals.

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This water complies with ANZECC (1992) guidelines for livestock (cattle) watering. It is considered that these water qualities would be characteristic of background conditions.

In general, the pre-1993 monitoring results are similar to more recent monitoring at Sites SW3 and SW4 and therefore are considered representative of background conditions. Many of these sites were located on Slaughteryard Creek downstream from the Golden Butterfly waste dump, and were monitored during or prior to 1988 (i.e. pre-mining). Therefore they were not subject to deterioration as a result of the mining activity. However, a distinct deterioration of water quality was recorded during this pre-mining period specifically at the Borefield Causeway and the Slaughteryard Creek Near Bore sites. There is no indication, however, as to the cause or source of this deterioration in water quality.

(ii) Pits

Golden Butterfly Pit- Monitoring data indicates that water quality in the Golden Butterfly pit is poor. pH is low and EC high, with elevated metals including copper, zinc, nickel, cadmium and arsenic. Water quality appears to remain relatively stable between monitoring events. It is concluded that this poor water quality is triggered by oxidation of sulphides within exposed pit walls and dumped material within the confines of the pit.

Golden Butterfly North Pit- Water quality in the Golden Butterfly North pit is neutral to slightly acidic and fresh, with negligible levels of metals. (This water has been used in the past to supplement the Croydon township water supply.)

Content Pit- Content pit water has been acidic and brackish over the period of monitoring. Metals including cadmium and copper are slightly elevated. However, overall water quality is generally within livestock (cattle) watering guidelines (ANZECC, 1992).

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Lady Isabella Pit- Similar water quality trends to the Content pit have been observed, with low pH, elevated conductivity and slightly elevated metals. This water quality, however, is generally within livestock (cattle) watering guidelines (ANZECC, 1992).

4.2.2.2 Groundwater

Sampling Sites

Six groundwater monitoring bores, labelled GBMB1 to GBMB6, were established in early May 1989 to monitor any possible hydraulic connection between the Golden Butterfly Pit and the Slaughteryard Creek borefield. These bores are located to the south of ML 5248 along a line sub-parallel to Slaughteryard Creek, as shown on Figure 1.

In addition to the GBMB series bores, two bores (labeled BH1 and BH2) were installed in November 1995 on either side of the Golden Butterfly Pit, as shown on Figure 2. These bores were installed to monitor groundwater quality proximal to the pit.

Groundwater Quality Analyses and Data Quality

Groundwater quality analysis for each of these sites included the following suite of parameters:

pH	Arsenic
Total Dissolved Solids	Cadmium
Conductivity	Copper
Chloride	Iron
Nitrite	Lead
Sodium	Manganese
Carbonate	Mercury
Sulphate	Zinc

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As with surface water quality, pre-1993 data (i.e. prior to the 1993 Decommissioning Plan) are "uncontrolled", and therefore the quality of the data obtained is unknown. Accordingly, these pre-1993 data are used for comparison only and not for interpretation.

Post -1993 data have been collected using the sampling procedures and chain of custody protocols as identified in the 1993 Decommissioning Plan. These data are therefore considered of adequate quality to allow interpretation.

Groundwater Quality Interpretation

A compilation of groundwater quality data for the above sample sites and sampling periods is provided in Appendix F. Graphical representation of selected analytes, based on this monitoring data, is also provided in Appendix F. Interpretation of the post-1993 groundwater quality data and comparison with the pre-1993 data is provided below.

(i) GBMB Series Bores

The GBMB Series bores intersect the sandstone unit associated with the Slaughteryard Creek borefield. This unit differs from the granite sequences in which the Golden Butterfly Pit is located. Distinctively, the granite unit comprises an isolated volcanic plug or vent in which mineralisation has occurred, and is considered to be of significantly lower permeability than the sandstones. In a regional context, the granite unit is of considerably lesser extent than the sandstones.

Groundwater quality from the GBMB Series bores can be characterised generally as being near neutral to slightly acidic, slightly brackish to brackish with slightly elevated metals concentrations (including copper and iron). Some variation in pH is noted both spatially and temporally, with a range of pH from 5 to 8. No clear explanation for this is apparent, other than potential influence from surface water recharge. (It is noted that a number of the bores are located close to the Slaughteryard Creek channel and therefore subject to inundation during flow events).

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The following observations are made from a comparison between the pre- and post-1993 data:

GBMB1- Groundwater was more acidic in the pre-1993 period with greater levels of arsenic, iron and zinc.

GBMB2 - Sulphate levels were generally lower in the pre-1993 period.

GBMB3 - Slight reductions in TDS, arsenic and sulphate were noted in the post - 1993 period. (pH and conductivity during the March 1994 sampling were anomalous against the other recorded parameters and the indicated trends of the previous monitoring. These results are therefore considered suspect.)

GBMB4 - Slight pH variations were recorded post-1993 (as with other sites). Sulphate levels were elevated, however, with no corresponding increase in metals concentrations.

GBMB5 - Generally groundwater quality pre-1993 and post-1993 is consistent. However, similar to GBMB4, in March 1994, the pH and conductivity are both higher than the pre-1993 trends.

GBMB6 - Pre-1993 and post-1993 water quality data are generally consistent.

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(ii) BH Series Bores

Groundwater levels within bores BH1 and BH2 show a considerable difference. The water level in BH1 appears to correspond broadly with the water level within the Golden Butterfly pit. The groundwater level within BH2 corresponds to the groundwater depth in GBMB1 located approximately 50 m to the southwest in Slaughteryard Creek and suggests a shallow, unconfined aquifer. Although both bores were constructed within granite, BH1 intersected competent, intact sequences while the granites within BH2 were highly fractured. (It is inferred that BH2 is located near the contact between the granite and sandstone units.) It is therefore indicated that the bores intersect two different and possibly unconnected aquifers. It is therefore likely that BH2 intersects the aquifer which hosts the Slaughteryard Creek borefield system.

Groundwater quality measured from these bores indicate near neutral pH for BH1 and low pH for BH2. Low salinity was observed in both bores, with slightly elevated sulphate levels. All other parameters were of similar magnitude and generally of the same order as the existing bores GBMB1 to GBMB6.

Given the similar water level between BH1 and the Golden Butterfly Pit, hydraulic connection may be assumed. However, due to the significant difference in pH levels, it is considered that the extent of mixing is limited, therefore, low permeabilities within the granite sequences are indicated (although no explanation can be given as to the reason for lower pH within BH2 than BH1). Furthermore, there is no similarity in water quality between BH2 and the Golden Butterfly Pit, other than pH. Indeed, due to the higher water level in BH2, nett groundwater movement from the area of BH2 towards the pit would be likely.

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4.2.2.3 Summary

(i) Acidic drainage is occurring from the Golden Butterfly waste dump. This is reflected in surface water quality within Slaughteryard Creek downstream of the dump, which is of low pH, high conductivity and elevated metals. This water quality does not meet ANZECC (1992) guidelines for livestock (cattle) watering, and is of poorer quality than surface water quality monitored in Slaughteryard Creek upstream of the dump.

(ii) AMD is occurring in the Golden Butterfly, Content and Lady Isabella pits, characterised by low pH and elevated conductivity. Water quality is poorest in the Golden Butterfly pit.

(iii) Groundwater quality within the sandstone aquifer located within the Slaughteryard Creek drainage area downstream from ML 5248 (i.e. host sequence of the Slaughteryard Creek borefield) indicates marginal water quality from a water supply perspective. However, the data available indicate no deterioration of groundwater quality since the time of mining, which suggests that connection between the aquifer and the Golden Butterfly pit does not exist.

(iv) It is considered, based on relative groundwater levels, that there is possible groundwater flow towards the Golden Butterfly pit area from the surrounding sandstone aquifer. It is indicated, however, that the granite unit, in which the pit is formed, is of low permeability, therefore the rate of groundwater movement would be low.

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4.2.3 Review of Existing Environmental Monitoring Program

The environmental monitoring program contained within the 1993 Decommissioning Plan is summarised in Table 4 and reviewed below:

TABLE 4
1993 Decommissioning Plan Environmental Monitoring Program

ITEM	PROCEDURES	MONITORING INTERVAL
Surface Water Quality	Sampling and analytical analysis	Monthly during wet season months (January to April) and on an event basis during dry season months (May to December) and/or high intensity storms
Groundwater Quality	Sampling and analytical analysis	Half yearly
Vegetation	Line intercept transects Quadrate surveys Use of photo-point stations	Assessment pre and post wet season
Erosion	Visual observations Photo point stations Measure of depth of gullies	Quantitative assessment monthly during wet season months (January to April) and on an event basis during dry season months (May to December) and/or high intensity storms.

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Surface Water Quality

(i) Until December 1995, surface water quality sampling had been confined to three sites (SW1, SW2 and SW3A). These sites provide an indication of water quality within Slaughteryard Creek downstream of the Golden Butterfly waste dump. Although a site was nominated upstream of the waste dump (SW3) to provide an indication of background water quality, no monitoring was carried out at this location prior to December 1995.

(ii) No surface water quality monitoring has been carried out within the western portion (Content and Lady Isabella pit area) of ML 5248.

Groundwater Quality

(i) No groundwater monitoring within the lease area was included in the monitoring program. As a result, no data are available on the groundwater regime around the Golden Butterfly pit area, its potential connection with adjacent aquifers, or the potential for recharge or drainage from the Golden Butterfly waste dump to groundwater.

Vegetation

(i) Vegetation monitoring sites on the waste rock dumps were destroyed in the 1996 rehabilitation program. As a result, appropriate new sites will need to be installed.

(ii) The vegetation control points (VC51 to VC55) are located on flat land surrounding the dumps. These sites do not represent topographic units similar to the recontoured waste dump batters, therefore new/supplementary sites are to be identified.

Erosion

(i) Existing erosion monitoring sites were destroyed in the 1996 rehabilitation program.

(ii) Erosion has not been monitored at the vegetation control points. New sites will be identified which will include land units with similar slope to the waste dump batters.

4.3 REHABILITATION ISSUES AND OPTIONS

Based on the site assessment described in Section 4.2, the following significant rehabilitation issues were identified:

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(i) Acid drainage from the Golden Butterfly waste dump area was occurring. This was due to the quantity and nature of the potentially acid producing waste rock within the dump. Based on the characteristics of the Content waste dump material, there was some limited potential for acid drainage from this area, however, there was no surface water monitoring within the area to confirm this condition.

(ii) AMD was occurring within the Golden Butterfly, Content and Lady Isabella pits; the most severe case being within the Golden Butterfly pit.

(iii) The existing environmental monitoring program was considered by RGC to be inadequate to support a comprehensive assessment of the performance of the existing or any future rehabilitation works, based on RGC's corporate environmental standards.

It was therefore considered that additional rehabilitation works were required within ML5248 to ensure compliance with the rehabilitation objective as outlined in Section 1.0. In conjunction with these works, the existing environmental monitoring program would also need to be upgraded.

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4.3.1 Rehabilitation Options

Based on the identified significant rehabilitation issues outlined above, a list of rehabilitation options for the mining related landforms within ML5248 area was compiled. These options are tabled below:

Landform	Rehabilitation Options
Waste Dumps	(i) Do Nothing (ii) Drainage Re-direction (iii) Reprofiling and Capping (iv) Removal
Pits	(i) Do Nothing (ii) Backfilling
Other Areas *	(i) Do Nothing (ii) Removal

*Includes stockpile areas, Haul Road, western side of the Content Dump, Drainage Channel and Sandy area to the north of the Golden Butterfly Pit.

A brief review of these options follows:

Waste Dumps

It is considered that the "Do Nothing" and "Drainage Re-direction" options would not assist in compliance with the adopted rehabilitation objectives. The site assessment described in Section 4.2 indicates that under the "Do Nothing" option, continuing acid drainage from the Golden Butterfly waste dump and possibly the Content waste dump continues to occur. There would be opportunity to drain both waste dumps into adjacent pits, however, such discharge would likely lead to further deterioration in pit water quality, as well as creating a condition that would require ongoing management. Both of these options have been discounted, primarily due to the inability of either to control the poor quality discharge from the waste dump areas.

The two rehabilitation options considered viable for the waste dumps are:

(i) Reprofiling and Capping
(ii) (Waste Dump) Removal

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Pits

The two pit rehabilitation options identified (i.e. "Do Nothing" or "Backfilling") are considered viable.

The water quality assessment carried out and summarised in Section 4.2 indicates limited potential for nett outward movement of Golden Butterfly pit water into the surrounding shallow groundwater system (although the impact on deeper aquifers was not assessed). For the other pits, it is considered that, due to the quality of the pit water, any mixing with surrounding groundwater would have lesser impacts on background groundwater quality than the Golden Butterfly pit. Provided that the pits do not overtop, therefore, the "Do Nothing" option for all pits is considered to be appropriate.

The "Backfilling" option would be carried out in conjunction with the "Removal" option for the waste dumps, with waste rock being directly backfilled to the pits. The issues to be considered in relation to this option are the potential release of pit water through overtopping during the rehabilitation works, as well as post-rehabilitation.

Other Areas

The site assessment identified areas that were potentially acid forming or that were contaminated from AMD. Although their contribution to overall environmental impact on the lease is not clear, it is considered prudent that material from these areas that is considered suspect be removed, while other materials could remain in place. The "Do Nothing" option is not considered appropriate for these areas, unless it can be identified that no potentially acid producing material occurs within the area.

Based on the above, the rehabilitation options considered appropriate for ML 5248 are as follows:

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Landform	Appropriate Rehabilitation Option
Waste Dumps	Reprofiling and Recapping
Waste Dumps/Pits	Backfilling (Waste Dump to Pit)
Pits	Do Nothing
Other Areas	Removal (of suspect material)

4.3.2 Engineering Assessment of Rehabilitation Options

Engineering assessment of each of the rehabilitation options for ML 5248, identified in Section 4.3.1, has been undertaken. These assessments formed the basis for design of the selected options. A brief outline of these assessments is provided in Appendix B with a summary of each outlined below.

Waste Dumps - Reprofiling and Recapping Option

This option would comprise:

(i) reprofiling of waste dump batters and regrading of surfaces;

(ii) capping of waste dump surfaces and batters using compacted clay layers overlain by surface protection layer consisting of benign rock fill.

The key issues in relation to design of this option include the following:

(i) The reprofiled surface needs to be designed to enhance geotechnical stability, to enable controlled surface water drainage and to allow construction of capping systems. Geotechnical and hydrological analyses were carried out in conjunction with this design.

(ii) The capping layer needs to be designed (thickness and configuration) to limit ingress of water and oxygen into the dump, such that AMD potential is

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mitigated. Hydrological (infiltration) modelling was carried out to support this design.

Design features of the reprofiling and recapping options are as follows:

(i) Reprofiling Works

Batter slopes of 3(H):1(V) minimum are required, with benches of some 5 m width provided at 50 m (maximum) vertical spacing.

(ii) Waste Dump Cover Configuration

Laser Type Surface	Waste Dump Surface	Waste Dump Batters
Capping Layer	Clay Fill - 600 mm thickness - Permeability $<10^{-8}$ m/s*	Clay Fill - 450 mm thickness - Permeability $<10^{-8}$ m/s*
Surface Protection Layer	Rock Fill - 400 mm thickness	Rock Fill - 400 mm thickness

* Recompacted to 98% of standard maximum dry density at -2% to +3% of optimum.

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Waste Dump/Pits - Backfilling Option

The possible pit backfilling strategy for ML 5248 is:

(i) Golden Butterfly waste dump to Golden Butterfly pit; and

(ii) Content waste dump to Content pit and/or Lady Isabella pit.

The key issues related to the design of the backfilling option are as follows:

(i) The backfilling option is controlled by the available pit volume;

(ii) The pits currently contain significant quantities of water which may affect the achievable volume efficiency of the void, as well as contribute to possible pit overtopping; and

(iii) Possible seepage discharge from the backfilled void resulting from saturation of the emplaced waste rock.

Based on the estimated available pit volumes and inferred compatibility properties of the waste rock materials, the following considerations have been made:

(i) The Golden Butterfly pit will not fully contain, beneath the pit rim, the volume of material within the Golden Butterfly waste dump. Mounding of the finished surface will therefore be required.

(ii) The Content pit void volume is slightly lower than that required for containment of the Content waste rock volume. Slight surface mounding will therefore be necessary.

(iii) The Lady Isabella pit possesses limited void capacity and therefore would not have application under the pit backfilling option.

Hydrological modelling has been carried out to assess the effectiveness of the pit backfilling scenarios. Modelling was completed to define pit overtopping potential both during backfilling works and under service conditions. These analyses indicate the following:

(i) the potential for pit overtopping during the construction phase would be marginal, depending on the level of compaction achieved within the backfill material; and

(ii) it is possible that water levels within the backfilled pits will rise sufficiently to overtop the pit rim and migrate as a seepage front appearing at the toe of the mounded dump.

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Pits - "Do Nothing"

The most significant engineering issue to be considered in relation to this option is the potential for overtopping of the pit rim. A basic hydrological analysis has been carried out to assess the condition, and indicates that pit overtopping is unlikely to occur.

Detailed assessment of the long term environmental impact of this option has not been undertaken, although, based on available groundwater monitoring data from the Golden Butterfly pit areas, no pit water migration has been indicated (refer Section 4.2.2.2). It is possible, however, that long-term equilibrium groundwater levels are higher than current pit water levels, therefore, the analysed pit overtopping and potential groundwater movement conditions, as described above, may vary with time.

Other Areas - Removal

Due to the potential for acid producing material existing within the stockpile, hardstand, and drainage areas located within the lease area, suspect materials should be removed and dumped into pits.

4.3.3 Selected Rehabilitation Options

Based on the engineering assessment, as summarised above and outlined further in Appendix B, RGC elected to offer four rehabilitation options to tender to obtain accurate details on costs and logistics. This information was combined with identified environmental and engineering considerations to determine the preferred option. From that assessment, the following rehabilitation scenario was selected by RGC for ML 5248:

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Landform	Favoured Rehabilitation Option
Waste Dumps	Reprofiling and Capping
Pits	Do Nothing
Other Areas:	
- Stockpile Area	Remove
- Haul Road	Do Nothing
- Western side of Content Pit	Remove
- Drainage Channel	Remove
- North of Golden Butterfly Pit	Do Nothing

4.4 OTHER REHABILITATION ISSUES

In conjunction with rehabilitation works for ML 5248, the following additional rehabilitation issues require consideration:

- Background landholder requirements; and
- Contaminated Lands Act provisions.

4.4.1 Background Landholders Requirements

As stated in Section 2.2, the existing background landholders (i.e. DoL and CSC) will assume the management of the former ML 5248 on relinquishment by DME. Consultation between Pancon and these parties was initiated during the 1993 rehabilitation works and has continued through to the current stage. The outcomes of these discussions are summarised below:

Queensland Department of Lands (DoL)

Landholder requirements were received in 1993 from the DoL Regional Operations Manager of Land Services, Cairns (as contained in Appendix C) and were confirmed verbally in 1996. The desired post-mining land use as indicated by DoL is grazing. Specific rehabilitation requirements include the following:

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- that road areas be rehabilitated with natural vegetation cover using endemic species, apart from minimal access roads suitable for local usage. (The location of the access tracks should be ascertained by reference to CSC);

- DoL has no specific requirements with regard to fencing around reserves but advises that the replacement or maintenance of any fencing damaged/removed/erected in the mining process be reviewed in consultation with the landowners in the locality, with their legal boundaries taken into consideration;

- areas used for grazing be revegetated with improved pasture;

- all foreign equipment and rubbish removed; and

- suitable vegetation be established to control soil erosion where necessary.

Croydon Shire Council (CSC)

Landholder preferences (Appendix C) were received in October 1993 from CSC and revised following discussions in 1996. The desired post-mining land use as indicated by the CSC is Town Common with a portion of the site being allocated as town water supply catchment (with grazing being discouraged within these areas). In addition, the following specific requirements were indicated:

- Maximisation of watershed catchment into Golden Butterfly North Pit (although CSC is not likely to require this resource again since the construction of a new water supply dam).
- Retention of access to Golden Butterfly North, Lady Isabella and Content pits; and
- Use of native tree species in the revegetation program.

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Further to these requirements, CSC has confirmed that restrictions to livestock access within the Town Common area would be continued. CSC would take responsibility for control of access through fencing, and maintenance as required.

4.4.2 Contaminated Lands Act Provisions

RGC's understanding of the Contaminated Lands Act provisions are outlined below. This outline indicates the desired outcome of the lease decommissioning process as it relates to the Contaminated Lands Act.

The Contaminated Lands Act, 1992 (CL Act), is triggered upon the Mining Lease surrender. Currently there is no final agreement between the DME and DoE to allow the DME to administer the provisions of the CL Act and the Environmental Protection Act (EP Act). The current Queensland Government plans to amalgamate the CL Act into the EP Act but with no indicated fundamental changes to the provisions of the Act. The DoE, upon lease surrender, will review a site contamination report and assess the sites classification status. Site classifications are:

- *Probable*
- *Former*
- *Restricted*
- *Released.*

The Minerals Resources Act, 1987 requires a Final Rehabilitation Report (FRR) in which key elements include:

- *Site Assessment/Investigation Report;*
- *Site Risk Assessment Report;*
- *Site Management Plan.*

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Until a memorandum of understanding (MOU) is signed between the DME and DoE on departmental administering roles, the FRR will need to be submitted to both departments.

The DME will use the FRR to allow surrender of the Mining Lease while the DoE will utilise the report for classification purposes, registering and deeming the adequacy of the Site Management Plan.

4.5 DETAILS OF UPGRADED REHABILITATION WORKS PROGRAM

An upgraded rehabilitation works program for ML 5248 was commenced in August 1996 by RGC and completed in December 1996. This program comprised the following works:

- Golden Butterfly Waste Dump

  Clay fill capping and rock fill surface protection of the entire waste dump surface, including construction of a key trench around the dump perimeter;

- Content Waste Dump

  Reprofiling of batter slopes (other than the western batter), with clay fill capping and rock fill surface protection of the entire dump surface;

- Other lease area activities, including:

  (i) Removal of potentially acid producing waste rock within hardstand areas adjacent to the Golden Butterfly and Content Waste dumps, with disposal of the excavated waste to adjacent open pits;

  (ii) Removal of channel bed sediments within the reach of the Slaughteryard Creek tributary which drains the Golden Butterfly waste dump;

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In addition, miscellaneous rehabilitation works, that have not yet been addressed in this document but are necessary to complement the above major activities or to comply with specific background landholder requirements, are as follows:

(i) Backfilling of open drill holes and removal of associated rubbish;

(ii) Construction of surface drains and a pond to collect surface water drainage from the Content Waste Dump site (for the purpose of surface water sampling);

(iii) General site clean-up;

(iv) Backfilling of open mine shafts;

(v) Removal of AMD producing material from an area adjacent to the lease which had the potential to affect that part of the Belmore Creek catchment on ML5248. (This material was discovered during the course of the rehabilitation works program, was a significant AMD source, and had the potential to mask any benefit from the works around the waste dump site.)

(vi) Revegetation of disturbed areas including rehabilitated waste dumps.

The extent of the upgraded rehabilitation works within ML5248 (as-constructed) is shown in Appendix G.

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4.6 REVEGETATION WORKS

The objective of the revegetation program is to establish a sustainable vegetative cover and provide long-term stabilisation and protection of waste dump surfaces and other disturbed areas on ML 5248. The revegetation work carried out comprised of sowing with a seed mix of native tree and shrub species similar to those found in the surrounding native woodland communities. A description of the revegetation works program is provided in Appendix H.

5.0
MONITORING

Environmental monitoring to objectively assess the performance of rehabilitation works within ML5248 forms the basis for determining the success of the 1996 (Amended) Decommissioning Plan. The environmental monitoring program has been designed to facilitate on-going, systematic monitoring addressing the following issues:

- Surface water quality;
- Groundwater quality;
- Vegetation; and
- Erosion.

It has been identified, as a result of the recent site assessment as described in Section 4.0, that the initial rehabilitation works carried out within ML 5248 were inadequate to effectively control AMD on the site. It was further identified that the environmental monitoring program included in the 1993 Decommissioning Plan was lacking, based on RGC's corporate environmental standards, and considered unable to support a comprehensive analysis of the performance of any ongoing rehabilitation works.

Accordingly, to provide substantiation for an application to relinquish the lease area, RGC decided to review and upgrade the environmental monitoring program. The details of this revised program are summarised in Table 5.

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TABLE 5
Environmental Monitoring Schedule for ML5248

Category	Location	Site Description (refer Figures 1, 2 & 3)	Frequency
Surface Water-Pits	Golden Butterfly Golden Butterfly North Content Lady Isabella	Western Edge Eastern Edge Western Edge Western Edge	Quarterly for all pits. (Samples to be taken in December, March, June and September - beginning of the month)
Surface Drainage Sites	SW1	Adjacent to the borefield causeway on Slaughteryard Creek approx. 1.5 km downstream of ML 5248 boundary.	All sites monthly subject to the availability of water. **December 1996 to April 1997** All sites twice monthly subject to the availability of water (flowing only). (Monthly sampling to be done at the beginning of the month. Twice monthly sampling to be done at the beginning of the month and at mid-month).
	SW2	Junction of Slaughteryard Creek and the lease boundary.	
	SW3	Upstream of Golden Butterfly Waste Dump on Slaughteryard Creek.	
	SW3A	Drainage channel adjacent to the eastern side of Golden Butterfly Waste Dump.	
	SW4	Water storage dam on Slaughteryard Creek east of Golden Butterfly Dump.	
	SW5	Drainage control pond west of Content Waste Dump.	
Groundwater	GMB1, GMB2, GMB3, GMB4, GMB5, GMB6.	South of ML 5248 running in a line sub-parallel to Slaughteryard Creek.	All groundwater sites quarterly. (Samples to be taken in December, March, June and September - beginning of the month.)
	BH1, BH2.	Northern and southern sides of Golden Butterfly Pit.	
	BH3, BH7.	East of Golden Butterfly Waste Dump.	

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TABLE 5 (Continued)
Environmental Monitoring Schedule for ML5248

Category	Location	Site Description (refer Figures 1, 2 & 3)	Frequency
Vegetation	Golden Butterfly and Content waste dumps and adjacent revegetated areas	Permanent vegetation monitoring transects set up in representative vegetation units in undisturbed control areas. Permanent transects and quadrates installed on the waste dumps and adjacent disturbed areas. Transects and quadrates will be monitored for species richness (number of species per unit area), species frequency, plant density, and growth rate. Any weed species observed will be recorded. Perennial grasses will be recorded and their cover and amounts of litter will be estimated. Permanent photo monitoring points will be installed in both the control and revegetated areas.	Initial monitoring visit late in financial year 1996/97, then late dry-season each year, commencing 1997.
Erosion	Golden Butterfly and Content waste dumps.	Soil surface condition will be monitored using Landscape Function Analysis. Permanent transects and quadrates will be installed. Typically they will be orientated laterally across the site. Significant erosion observed will be described, measured and photographed. Permanent photo monitoring points will be installed.	Initial monitoring visit late in financial year 1996/97, then late dry-season each year, commencing 1997.

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The following sections provide a detailed description of the monitoring sites and procedures associated with this program.

5.1 SURFACE WATER QUALITY

The surface water quality monitoring program involves sampling and laboratory analysis of surface water from the pits and at surface flow/drainage sites.

5.1.1 Sampling Sites

Pits

Surface water contained within the four open pits, located within ML 5248, will be monitored. Water in these pits is a combination of direct rainfall, groundwater inflow and limited runoff from the area within the perimeter bunds.

Sampling will be carried out in accordance with the procedures outlined in Appendix D. Samples will be taken from the edge of the water body contained within each pit. Specific sampling locations are summarised below:

Golden Butterfly Pit	Western edge
Golden Butterfly North Pit	Eastern edge
Lady Isabella Pit	Western edge
Content Pit	Western edge.

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Surface Flow/Drainage Sites

Six (6) sampling locations, labelled Sites SW1 to SW5 and SW3A, are established at surface flow/drainage sites within or surrounding the lease area. Sites SW1, SW2 and SW3 were nominated in the 1993 Decommissioning Plan. Site SW3A was established subsequently, and Sites SW4 and SW5 have been established by RGC as part of augmentation of the environmental monitoring program. These sampling sites are indicated on Figures 1, 2 and 3 and are described below:

- SW1 is located adjacent to the borefield causeway on Slaughteryard Creek approximately 1.5 km downstream of the ML 5248 boundary;
- SW2 is located at the junction of Slaughteryard Creek and the lease boundary;
- SW3 is located upstream of the Golden Butterfly Waste Dump on Slaughteryard Creek;
- SW3A was established in 1994 and is located in the drainage channel adjacent to the eastern side of the Golden Butterfly Dump;
- SW4 was established in March 1996 and is located in the water storage dam on Slaughteryard Creek east of the Golden Butterfly Dump, some 200 m downstream from SW3; and
- SW5 was established in May 1996 and is located in a shallow drainage control pond down-gradient and to the west of the Content Dump area.

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The nominated surface water quality compliance point[1] is SW1 for the Golden Butterfly/Golden Butterfly North catchment. This compliance point will be maintained. However, RGC aims to achieve compliance criteria at SW2 on the lease boundary. There is no nominated compliance point for the Content/Lady Isabella catchment, therefore RGC has established a monitoring point (SW5) for that area, at which it aims to achieve the compliance criteria. The nominated background surface water quality site is SW3 for the lease area, with SW4 acting as a supplementary site, as it is a more permanent water body.

Sampling from these surface flow/drainage sites will be carried out in accordance with the procedures outlined in Appendix D.

5.1.2 Sampling Frequencies

Surface water will be sampled at the following frequencies:

- Pits — Quarterly
- Surface Drainage Sites — Monthly, subject to availability of water. During the first wet season (December 1996 to April 1997), the frequency of monitoring for these sites will be twice monthly (subject to the availability of water).

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[1] The sites at which the target surface water quality as described in Section 5.0 will be achieved.

5.1.3 Analyses

Surface water samples collected will be handled in accordance with the Chain of Custody requirements as detailed in Appendix D, and will be delivered to a NATA registered laboratory. Laboratory analyses will be carried out on the following analytes:

pH	Arsenic
Total Dissolved Solids (TDS)	Cadmium
Electrical Conductivity (EC)	Copper
Calcium	Iron
Magnesium	Lead
Sodium	Manganese
Sulphate	Nickel
	Zinc

The above list of analytes is a modified suite based on a review of the 1993 Decommissioning Plan parameter list and the results of past monitoring. An explanation of the changes to the suite of analytes is provided in Section 6.1.

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5.2 GROUNDWATER QUALITY

5.2.1 Groundwater Sampling Sites

The groundwater quality monitoring program will involve monitoring from ten (10) bores located within or on the surrounds of the lease area.

Six groundwater quality monitoring sites, labelled GBMB1 to GBMB6, were nominated in the 1993 Decommissioning Plan. These six sampling sites were installed in May 1989 and are located to the south of ML 5248, running in a line sub-parallel to Slaughteryard Creek, as shown in Figure 1. These bores were installed prior to decommissioning of the mine to monitor the potential impact of the operation on Croydon's water supply at that time (associated with the Slaughteryard Creek borefield).

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Two (2) groundwater monitoring bores were installed in November 1995 on the northern and southern sides of the Golden Butterfly Pit (BH1 and BH2 respectively), as shown on Figure 2. These bores were installed to monitor the groundwater depth and quality proximal to the pit and to assess any relationship between pit water quality and quality of the surrounding groundwater.

Five (5) pre-existing shallow bores (BH3 to BH7) were established as monitoring points in May 1996 adjacent to the Golden Butterfly Waste Dump (refer Figure 2) to monitor possible shallow groundwater influences within the Slaughteryard Creek area resulting from drainage from the waste dump. Two of these bores, BH3 and BH7, will be sampled as part of the environmental monitoring program.

Sampling from the nominated groundwater monitoring sites will be carried out in accordance with the procedures outlined in Appendix D.

5.2.2 Sampling Frequency

Groundwater monitoring bores will be sampled quarterly.

5.2.3 Analyses

Groundwater samples collected will be handled in accordance with the Chain of Custody requirements as detailed in Appendix D, and will be delivered to a NATA registered laboratory. Laboratory analyses will be carried out on the following analytes:

- pH
- Total Dissolved Solids (TDS)
- Electrical Conductivity (EC)
- Calcium
- Magnesium
- Potassium
- Sodium
- Sulphate
- Chloride
- Arsenic
- Cadmium
- Copper
- Iron
- Lead
- Manganese
- Nickel
- Zinc

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The above list of analytes is a modified suite based on a review of the 1993 Decommissioning Plan parameter list and the results of past monitoring. An explanation of the changes to the suite of analytes is provided in Section 6.2.

The parameter suite carried out on the BH series bore samples (i.e. from BH 1, BH 2, BH3 and BH7) will include the following:

pH
Total Dissolved Solids (TDS)
Electrical Conductivity (EC)
Sulphate
Iron

This suite is intended to provide an indication of trends in superficial groundwater quality in areas adjacent to the Golden Butterfly Waste Dump.

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5.3 VEGETATION

Vegetation and erosion monitoring will be based on a method being developed by the CSIRO called Landscape Function Analysis (LFA). The application of LFA is described in CSIRO (1997. The basis of LFA is to measure how well a rehabilitated landscape is using water and nutrients, its ability to resist erosion and the landscape's progress towards becoming a stable self-sustaining unit, in comparison with selected control sites with similar topography.

Additionally, the following parameters will be measured and recorded:

- species richness (number of species per unit area);
- species frequency (% of quadrates in which that species is recorded);
- plant density; and
- growth rate.

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Any occurrence of weeds will be recorded and control methods determined, where necessary.

Monitoring will involve the setting up of permanent transects and quadrates on both rehabilitated areas and control sites in the surrounding woodlands. The number of quadrates and transects installed will be determined by statistical requirements. A series of permanent photo monitoring points will also be installed. Typical sites are shown on Figures 2 and 3.

An initial monitoring visit will be made in May/June 1997 to measure the establishment of vegetation. Subsequently, annual monitoring visits will be made late in the dry season (October/November), also commencing in 1997.

The annual monitoring visits will be used to collect data to record the performance of the revegetated areas and plot their progress towards achieving completion criteria. The raw data collected and a data summary and analysis will be included in the annual monitoring report.

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5.4 EROSION

LFA measurements of the rehabilitation areas, which includes Soil Surface Condition Classification (SSCC) as described in Tongway and Hindley (1995), will be used as a component of the erosion monitoring program. SSCC looks at ten soil surface features. Data from classifying these features are broken into three categories which focus on surface stability, infiltration, and nutrient cycling as indicators of landscape surface condition. Data from each of these categories are converted to percentage values to enable comparison.

Erosion monitoring will use the same network of transects, quadrates and photo monitoring points installed for the vegetation monitoring. The procedure will describe the geographic setting of the site, characterise the spatial pattern of soil and vegetation, and soil microtopography and texture. Forms of erosion will be described, measured and photographed, and cover of perennial grasses and litter will be estimated. Remedial earthworks will be prescribed for major erosion areas.

Using the methods described above, it will be possible to assess the rehabilitation success and to make predictions about the rate of development of a sustainable ecosystem.

In addition to monitoring the transects and quadrates, the overall surfaces of Golden Butterfly and Content waste dumps will be inspected and significant erosion observed will be described, measured and photographed.

The monitoring frequency will be the same as that used for vegetation and data collected will be reported in the same way.

5.5 MONITORING AND REPORTING

The environmental monitoring program will be maintained by RGC utilising a local representative and external consultants.

All data collected from the site will be compiled, analysed and reported to the DME annually. In addition, an annual inspection of the site will be carried out by RGC.

As part of the site relinquishment application, RGC will submit a Final Rehabilitation Report to DME (as outlined in Section 4.4.2), detailing the results of the environmental monitoring program and demonstrating successful attainment of the lease relinquishment criteria as defined in Section 6.0.

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6.0
LEASE RELINQUISHMENT TARGET CRITERIA

Nominated target criteria by which lease relinquishment will be assessed were established in conjunction with DME and were included in the 1993 Decommissioning Plan. These lease relinquishment criteria have been revised by RGC to ensure they accurately reflect the effect of the rehabilitation works on the environmental condition of the lease and its surrounds.

A summary of these revised criteria is provided in Table 6 below. These criteria are described in detail in the following sections.

TABLE 6
Summary of Lease Relinquishment Criteria

Category	Location	Parameters	Compliance Levels/Target Criteria
Surface Water - Pits	Golden Butterfly and Golden Butterfly North, Content and Lady Isabella	pH, TDS, EC, Calcium, Magnesium, Sodium, Sulphate, Arsenic, Cadmium Copper, Iron, Lead, Manganese, Nickel, Zinc	No compliance criteria
Surface Drainage Sites	SW Series Sites	pH, TDS, EC, Calcium, Magnesium, Sodium, Sulphate, Arsenic, Cadmium Copper, Iron, Lead, Manganese, Nickel, Zinc	Livestock watering guidelines - beef cattle (ANZECC, 1992) or 115% of background surface water quality, whichever is greater.
Groundwater	1) GBMB Series Bores	1) pH, TDS, EC, Calcium, Magnesium, Potassium, Sodium, Sulphate, Chloride, Arsenic, Cadmium, Copper, Iron, Lead, Manganese, Nickel, Zinc	I) GBMB Series Bores: Maintain existing water quality measured during the period 1990 to 1993.
	2) BH Series Bores	2) pH, TDS, EC, Sulphate, Iron	2) BH Series Bores: No compliance criteria

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TABLE 6 (Continued)
Summary of Lease Relinquishment Criteria

LOCATION		PARAMETERS	COMPLIANCE LEVELS/TARGET CRITERIA
Vegetation	Golden Butterfly and Content Waste Dumps and adjacent revegetated areas	• Landscape Function Analysis (LFA) Species richness (No. of species per unit area). • Species frequency (% of quadrates in which that species is recorded). • Plant density. • Growth rate.	• Capture and decomposition of leaf litter. • Vegetation structural complexity trending towards control sites. • Vegetation compositional complexity trending towards control sites. • Habitat complexity trending towards control sites.
Erosion	Golden Butterfly and Content Waste Dumps and adjacent revegetated areas	• Integrity of bank/trough systems on waste dump sloping. • Erosion gully stability and depth.	• Erosion depth not greater than 300 mm.

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6.1 SURFACE WATER QUALITY

Pits

As no beneficial use has been established for the pits, it is proposed not to set relinquishment criteria for the quality of contained water. However, pit water quality will continue to be monitored and any trends examined, particularly with respect to trends in groundwater quality within adjacent monitoring bores.

Surface Drainage Sites

The surface water relinquishment criteria included in the 1993 Decommissioning Plan comprised the ANZECC (1992) guidelines for livestock watering (beef cattle). A suite of parameters was derived against which comparison of these guidelines was made. Based on the results of past monitoring, this suite of parameters was reviewed and revised. Mercury, molybdenum, nitrite and nitrate have been removed from the list of parameters as they have been at or below detection limits and compliance levels for the sites monitored during all monitoring events. Electrical conductivity (EC) has been added in order to provide a more complete indication of surface water chemistry. The laboratory analysis suites outlined in Sections 5.1.3 and 5.2.3 have been adjusted to reflect these changes.

A complete suite of surface water quality parameters adopted for the 1996 (Amended) Decommissioning Plan is provided in Table 7. Acceptable criteria for each analyte within this suite, based on ANZECC (1992) livestock watering guidelines, are also listed.

To reflect as accurately as possible the acceptable performance of the rehabilitation works, whilst taking into consideration the regional (upstream) land use activities, the adopted relinquishment criteria for surface water quality are as follows:

- ANZECC (1992) livestock watering guidelines (beef cattle); or
- 115% of background water quality;

whichever is higher. The background water quality plus 15% relinquishment criteria will be used to prevent RGC being required to ameliorate fluctuations in existing background quality as a result in change of land use or associated activities.

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TABLE 7
Summary of ANZECC (1992) Livestock Watering Guidelines

PARAMETER	SYMBOL	UNIT	CRITERIA
pH	pH	-	NGR
Electrical Conductivity	EC	µS/cm	NGR
Total Dissolved Solids	TDS	mg/L	4000
Sodium	Na	mg/L	NGR
Calcium	Ca	mg/L	1000
Magnesium	Mg	mg/L	600
Sulphate	SO_4	mg/L	1000
Arsenic	As	mg/L	0.5
Cadmium	Cd	mg/L	0.01
Copper	Cu	mg/L	5
Iron	Fe	mg/L	NGR
Lead	Pb	mg/L	0.1
Manganese	Mn	mg/L	NGR
Nickel	Ni	mg/L	1.0
Zinc	Zn	mg/L	20

NGR = No guideline recommended

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As discussed in Section 5.1.1, background surface water quality for the site will be measured at Sites SW3 and SW4.

The adopted surface water compliance point for ML 5248, SW1, is located adjacent to the borefield causeway on Slaughteryard Creek (refer Figure 2) outside of the lease area. However, RGC aims to achieve the above water quality standards at the point where Slaughteryard Creek intersects the lease boundary (i.e. SW2), and at SW5 in the Content/Lady Isabella catchment.

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6.2 GROUNDWATER QUALITY

GBMB Series Bores

Groundwater monitoring results for monitoring bores GBMB 1 to GBMB 6 over the period 1989 to 1990 were provided to the DME (formerly Department of Resource Industries), in 1990 (Australian Groundwater Consultants, 1990). DME reviewed these results and concluded that, based on the available results, "no immediate problems exist for the township water supply", which at that time was sourced from the Slaughteryard Creek borefield. Subsequent groundwater monitoring between 1990 and 1993 suggested that there had been no deterioration in groundwater quality within that period. As a result, the 1993 Decommissioning Plan established that the target criteria for groundwater quality for these bores would be to maintain the water quality monitored over the period 1990 to 1993.

For the purpose of the 1993 Decommissioning Plan a suite of parameters, against which comparison of the above guidelines would be made, was derived, principally based on the parameter suite that had been historically adopted. Based on the results of monitoring since that time, this suite of parameters has been reviewed and revised for inclusion in the 1996 (Amended) Decommissioning Plan. From this review, mercury and nitrate have been removed from the list of parameters as they have been at or below detection limits for all bores on all occasions. Major cations, calcium and magnesium, have been added in order to provide a more complete indication of the groundwater chemistry. The laboratory analysis suite outlined in Section 5.2.3 has been developed to reflect these changes.

BH Series Bores

No data are currently available for the BH Series bores and therefore no compliance criteria have been adopted for these sites. As discussed in Section 5.2.3, it is intended that the data obtained from sampling of these sites be used to indicate trends in groundwater quality.

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Lease relinquishment criteria for groundwater monitored within the site will be as follows:

GBMB Series Bores — Maintain the groundwater quality within the GBMB series bores monitored over the period 1990 to 1993. No criteria are available for the analytes added to the suite (as discussed above). Relinquishment criteria are summarised in Table 8.

BH Series Bores — No relinquishment criteria. Water quality trends from these bores will be observed and analysed to monitor any influences of adjacent landforms.

TABLE 8
Summary Results of GBMB Series Bore Monitoring -Period 1990 to 1993 as Basis for Relinquishment Criteria

PARAMETER	UNITS	GBMB1	GBMB2	GBMB3	GBMB4	GBMB5	GBMB6
pH	-	3.6-6.15	7.3 - 8.15	6.65-7.25	5.95-6.5	5.6-6.95	5.85-6.85
Total Dissolved Solids (TDS)	mg/L	390-520	1290-2040	280-500	150-240	40-100	110-150
Electrical Conductivity (EC)	µS/cm	590-610	1970-2040	410-445	190-225	68-73	98-305
Sodium (Na)	mg/L	17-91	350-400	72-76	27-31	9.3-11	7-14
Sulphate (SO_4)	mg/L	170-240	500-580	11-110	11-65	0.8-7.9	2.8-22
Chloride	mg/L	7-55	190-370	107-130	13-42	11-30	16-26
Arsenic	mg/L	0.01-0.06	0.03-0.07	0.01-0.04	0.02	0.01-0.02	0.01-0.06
Cadmium	mg/L	<0.01-0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	mg/L	0.01-0.05	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	mg/L	2.1-6.2	1-1.8	1.8-3.7	2.2-2.6	1.3-3.6	1.7-2.9
Lead	mg/L	0.08-0.23	0.12-0.70	0.02-0.54	0.07-0.16	0.12-0.24	0.05-0.18
Manganese	mg/L	0.45-0.55	0.44-0.68	0.05-1.3	<0.01-0.04	<0.01-0.04	<0.01-0.03
Zinc	mg/L	0.04-0.34	0.02-0.15	<0.01-0.24	<0.01-0.45	0.05-0.19	0.03-0.18

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6.3 VEGETATION

The objective of revegetation of ML 5248 is to achieve long term stabilisation and protection of the capped waste dump surfaces, minimising the potential for erosion and subsequent passage of water through the dump core.

The success of the revegetation program and erosion control systems will be measured by using a method developed by the CSIRO called Landscape Function Analysis (LFA), which is described in CSIRO (1997). This method includes Soil Surface Condition Class (SSCC) assessments. LFA involves the measurement of five indicators: integrity of the bank/trough system, litter buildup, tree growth, vegetation composition, and habitat complexity. From these measurements it is possible to determine if stable resource capturing landscapes have been created and determine their progress towards matching the control sites.

Completion criteria terms are defined as follows:

- Vegetational structural complexity - A measure of how well the tree layer is developing, determined by measuring tree diameter at breast height (DBH);
- Vegetation compositional complexity - The measure of how well the site is developing the mix of plant species found on the control sites;
- Habitat complexity - A measure to demonstrate how well vegetation structures and other landscape features, and their suitability as sites for wildlife, are developing.

Completion criteria for revegetation will be the following:

- Litter is being captured and is decomposing within the troughs created by ripping;
- Vegetation compositional complexity, as determined by development of a tree layer, will demonstrate a trend towards that of the control sites;
- Habitat complexity is trending towards that of the control sites.

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6.4 EROSION

The objective for erosion control is similar to that for vegetation in Section 6.3; to achieve long term stabilisation and protection of the capped waste dump surfaces, and minimise erosion and subsequent passage of water through the dump core.

Completion criteria for erosion control will be the following:

- Integrity of the bank/trough systems on the waste dump slopes.
- Any erosion features that do form become stable and, on Golden Butterfly and Content waste dumps, erosion gullies do not exceed 300 mm in depth.

6.5 SUMMARY OF COMMITMENTS

RGC is committing to a range of actions and goals in order to achieve the rehabilitation objectives and completion criteria for lease relinquishment. These are summarised in Appendix E, together with a description of compliance at this stage.

The list of commitments will be detailed as part of the formal annual inspection of the lease by RGC, and a compliance report in the format of Appendix E will be included in the Annual Monitoring Report.

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7.0
LEASE RELINQUISHMENT DOCUMENTATION

RGC proposes to continue monitoring the site for two wet seasons following completion of the 1996 rehabilitation work, i.e. 1996/1997 and 1997/1998. At that time, it is expected that the site's performance will demonstrate achievement of the rehabilitation objectives and completion criteria. Subject to that achievement, lease relinquishment will be sought.

In preparation for the lease relinquishment, a Final Rehabilitation Report (FRR) will be submitted to DME outlining the following:

- Scope of the monitoring program;
- Monitoring program results; and
- Reconciliation against target criteria.

The objective of the document would be to substantiate a request by RGC to the DME for the relinquishment of ML 5428.

Section 309 (1) of the Mineral Resources Act, 1989 requires the holder of a mining lease to apply for the surrender of the mining lease or any part of the land comprised therein at any time before the expiration of the mining lease term. To facilitate this process there is a requirement for a Final Rehabilitation Report (FRR) and Environmental Audit Statement (EAS) determining if the leaseholder has met the rehabilitation requirements outlined within the EMOS or Decommissioning Plan.

For RGC, the function of the FRR is to examine commitments made within the Decommissioning Plan made regarding protection and rehabilitation of the mine site. The FRR then assesses if these goals and specified relinquishment criteria have been met.

The FRR will be prepared in accordance with the Draft DME Policy for "Environmental Impact Assessment and Management for Mining in Queensland", 1994.

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The FRR will be accompanied by an EAS in respect of the final rehabilitation status, confirming the technical validity of the FRR and that all statutory requirements have been met.

As part of an acceptable FRR where any residual land contamination occurs an appropriate site classification will be determined in accordance with Section 4.4.2. For the Croydon Gold Mine (ML 5248), it is considered that the most likely classification will be a "Former" and/or "Restricted" site.

An associated Site Management Plan (SMP) would be contained within the FRR and will describe on-going requirements. It is proposed that an annual audit/assessment of a landform stability, rehabilitation and water quality be conducted.

Currently the Memorandum of Understanding (MOU) to delegate administrative duties for the *Environmental Protection Act, 1994* (EP Act) and *Contaminated Lands Act, 1991* (CL Act) has not been signed. It is recognised that under the current CL Act, a site investigation or site contamination report is required. The SAR component of the FRR will be submitted to the DoE upon lease surrender if the MOU has not been signed at that time.

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8.0
ORGANISATION AND MANAGEMENT

8.1 RGC ORGANISATION

The RGC representative responsible for the Croydon Mine ML 5248 rehabilitation program was CTPI 49-Sch4 who reported to RGC's General Manager, Environment. The on-site RGC representative, and person responsible for the on-going sampling during the decommissioning phase is currently CTPI 49-Sch4 The contact for CTPI 49-Sch is as follows:

CTPI 49-Sch4
C/- Reigate Station
Croydon Qld 4871
Phone CTPI 49-Sch4

RGC will engage specialist external consultants as required.

8.2 REHABILITATION PROVISION

Upon assumption of the lease, RGC increased the provision for rehabilitation of ML 5248 from $365,000 to $2.65M to cover all decommissioning costs through to lease relinquishment. This provision account is reviewed on a regular basis.

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9.0
REFERENCES

Australian Groundwater Consultants (January 1990). *Golden Butterfly Mine Area Water Quality Monitoring Data to January 1990.* Report No. 4015/2.

Australian Groundwater Consultants (March 1990). *Croydon Gold Mine Golden Butterfly Operations Regional Surface and Groundwater Monitoring Program.* Report No. 4015/7.

ANZECC (1992) *Australian Water Quality Guidelines for Fresh and Marine Waters.* Australia and New Zealand Environment and Conservation Council, Canberra.

Brodie, M.J., Broughton, L.M. and MacRobertson, A. (1991). *A Conceptual Rock Classification System for Waste Management and a Laboratory Method for ARD Prediction from Rock Piles.* In: Proceedings of the Second International Conference and the Abatement of Acidic Drainage, September 16 to 18, Montreal, Quebec.

CSIRO Division of Wildlife and Ecology (1997). *LFA Survey of RGC Pine Creek Goldfields Minesite, Preliminary Draft Report.* Unpublished.

Ferguson, K.D. and Morin, K.A. (1991). *The Prediction of Acid Rock Drainage - Lessons from the Database.* In: Proceedings of the Second International Conference on the Abatement of Acidic Drainage, September 16 to 18, Montreal, Quebec.

Ferguson, K.D. and Robertson, J.D. (1994). *Assessing the Risk of ARD.* In: Proceedings of the International Land Reclamation and Mine Drainage Conference and Third International Conference of the Abatement of Acidic Drainage, April 24 to 29, Pittsburgh, PA.

Rosser J., Swartz, G.L., Dawson, N.M. and Briggs, H.S. (1974). *A Land Capability Classification for Agricultural Purposes.* QDPI Technical Bulletin No. 14.

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Smith, A. and Barton-Bridges, J.B. (1991). *Some Considerations in the Prediction and Control of Acid Mine Drainage Impact on Groundwater from Mining in North America.* In: Proceedings of the EPPIC Water Symposium, May 16-17, Johannesburg, South Africa.

Tongway, D. J. and Hindley, No I. (1995). *Manual: Assessment of Soil Condition of Tropical Grasslands,* ISBN 0 643 05779 X, CSIRO Division of Wildlife and Ecology, Canberra.

Woodward-Clyde (1993). *Pancontinental Mining Limited - ML 5248 Mine Decommissioning Plan.* Report No. 4371 December 1993.

Woodward-Clyde, (1994). *ML 5248 Mine Decommissioning - Croydon 1994 Annual Inspection Report,* May 1994.

Woodward-Clyde, (1996). *Croydon Gold Mine 1996 Monitoring Report ML 5248.* Report No. 280/0005 October 1996.

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FIGURES

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APPENDIX A

DETAILS OF MINING LEASE 5248 AND AMENDMENTS

QUEENSLAND DEPARTMENT OF MINES

G.P.O. BOX 194 BRISBANE 4001, Q.

QUEENSLAND MINERALS AND ENERGY CENTRE, 61 MARY STREET, BRISBANE. TELEPHONE: (07) 224 2111 FACSIMILE: (07) 229 7770 TELEX: AA43040

Your Ref: MCH:gah
Our Ref: ML No. 4124, Mareeba

CTPI 49-Sch4
(070) 523 300

23rd December, 1988

Dear Sir,

Re: Mining Lease No. 4124, Mareeba

New ML 5428

I refer to your letter of 28th November, 1988 with which you submitted a description of operations as required under Special Condition No. 5 attached to the above Lease.

Approval of that part of the description of operations referring to construction of the haul road was given on 9th December, 1988.

Approval of the remainder of the description of operations was given on 22nd December, 1988, for the period ending 30th June, 1989, with the following future requirements:

Approval is now also given to erection of the crushing plant on the Lease to treat minerals won from the Lease, in accordance with Special Condition No. 4.

For operations beyond 30th June, 1989, amendments to the description of operations must be submitted for approval including:

(a) a waste-rock management plan, to ensure that water draining from sulphide-bearing waste does not pollute the waters of the State, and that sulphide-bearing waste is adequately covered. To assist planning, sampling of the material between 45 and 65 metres depth in the pit should be conducted as soon as practicable.
(b) a further management plan for pit water and other waters on the Lease, containing details of groundwater monitoring carried out;
(c) a report on the effects on neighbouring properties of blasting, noise and dust from the operations conducted and the results of any monitoring;
(d) a review of the tailings disposal facilities on Mining Lease No. 3166, Mareeba, particularly in relation to the effect of the mining on Mining Lease No. 4124, Mareeba.

GEB

C.c Barrack Mine Management Pty Ltd,
Suite 3, A.F.T. House,
135 Abbott Street,
CAIRNS. QLD 4871

CTPI 49-Sch4
General Manager (technical) - Mining,
Pancontinental Mining Limited,
AMP Centre,
50 Bridge Street,
SYDNEY. NSW 2000

For your information.

for Director-General
28/12/88

World Expo 88

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It is understood that control, and where necessary monitoring, of the matters referred to in (a), (b), (c), (d) will be instituted immediately.

You are further requested to give an undertaking to retain geotechnical expertise, and to undertake geotechnical investigations of slope stability and blast monitoring to ensure that the proposed workings do not affect the town water supply, the water tank, the railway or the Northern Development Road.

Approval of this description of operations does not in any way affect your obligation to comply with the Special Conditions attaching to the Lease or with the Mining Act 1968-1986.

The description of operations now approved forms an integral part of the Lease conditions. Any departure from the description will constitute a breach of those conditions unless specific approval has been sought and obtained to amend the description.

Yours faithfully,

CTPI 49-Sch4

for Director-General

CTPI 49-Sch4

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SF98/28861

OPERATIONS DIVISION

DIST			DIST		
CWO	✓	CTPI 4	ACD		
			PSF		
DJG					
MCH	✓	CTPI 4	SEF		
RWN			CEH		
JGW			JRW		
BFH			GCL	✓	CTPI 4
SJL			PEC		
RWL			CJM		
			JMP	✓	CTPI 49
Executive			GWN	✓	CTPI 49
Corp Devl			AMC		
Expl			JTC		
Marketing			DFT		
Admin			GMT		
Legal					
FILE	S01 - 2				

CTPI 49-Sch4

Replied 11/1/89

Copied also + discussed action w.M

CTPI 49-Sch4 10/1/89

Gauge - we have Strat review pit plans + drill orientation suitable scale for further waste channels studies for 45-65 mill depth.

501·2.

MCH.

QUEENSLAND DEPARTMENT OF MINES

G.P.O. BOX 194 BRISBANE 4001, Q.

QUEENSLAND MINERALS AND ENERGY CENTRE, 61 MARY STREET, BRISBANE. TELEPHONE: (07) 224 2111 FACSIMILE: (07) 229 7770 TELEX: AA43040

Your Ref:
Our Ref:

CTPI 49-Sch4
224 7292

Issued to CTPI 49-Sch4 18/8/88

He with:- ① Acknowledge receipt of Lease to Dept of Mines
② Pay rental ($27,473.96)

5th August, 1988

Dear Sir,

Re: Mining Lease No. 4124 - Mareeba (243) New ML 5428

The abovestated Lease has been granted by the Governor in Council and the details of such grant are set out hereunder:-

Date of Minister's Recommendation	:	1st August, 1988
Date of Grant	:	4th August, 1988
Term	:	21 years commencing from 1st September, 1988.
Rental	:	$23 per hectare per annum payable at this rate in advance not later than 31st December, for each year of the term of the lease.
Lessee:	:	Pancontinental Mining Limited
Area	:	1194.52 ha (approximately - subject to survey)
Conditions:	:	Subject to all covenants and conditions applying to all Mining Leases and subject also to the prescribed special conditions as detailed on the attached annexure.

A copy of the sketch plan indicating the boundaries of lease area and surface area is attached.

General Manager (Technical)-Mining,
Pancontinental Mining Limited,
AMP Centre,
50 Bridge Street,
SYDNEY. NSW 2000

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Variation in shape was approved on 28th July, 1988.

The surface of any road Reserve as defined in Section 7 of the Mining Act 1968 - 1986 cannot be disturbed unless the consent of the Governor in Council is first had and obtained. It should be noted that consent to disturb the surface of road comprised in this Lease has not been obtained.

The Bank Guarantee submitted has been accepted.

Yours faithfully,

CTPI 49-Sch4

for Director-General

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OPERATIONS DIVISION

DIST		DIST		
CWO	✓ CTPI 4	ACD		
BJG				
MCH	✓ CTPI			
RWN	✓ CTPI 4			
JGW				
BFH			✓ CTPI 49	
SJL				
RWL				
Executive		GWV	✓ CTPI	
Corp Devl TPR	Copy CTPI			
Expl - Lands	Copy CTPI			
Marketing				
Admin	CTPI	GW		
Legal	Copy			

FILE 7-600 - 13.17.2

CTPI 49-S Copy.

Bruce Edwards.
Please enter on Land Mgmt. System & then pass to Operations CTPI 49-

CTPI

ANNEXURE "D"
MINING LEASE NO. 4124, MAREEBA

Special Covenants:

1. The Lessee shall Pay all Local Authority rates applicable to the Lease when they become due and Payable.

2. The Lessee covenants and agrees to comply with any order or direction given by the Minister for the purpose of obtaining compliance with these covenants and conditions.

Special Conditions:

1. Where in these special covenants and conditions the term "approved" is used, it shall be read and construed as meaning "approved by the Minister in writing".

2. The Lessee shall at all times cause all steps and things to be taken and done to prevent mineralized or impure water or sludge or mining debris resulting from mining operations within the boundaries of the Lease from unlawfully polluting, obstructing, damaging or interfering with the sea, any watercourse, lake or reservoir or any land. Where such unlawful pollution, obstruction, damage or interference results from mining operations within the boundaries of the Lease, the Lessee shall, as and when required by the Minister, cause such mining operations to cease and not be resumed until all further steps and things are taken and done as will prevent such unlawful pollution, obstruction, damage or interference.

3. The Lessee shall at all times cause all steps and things to be taken and done as the Minister from time to time specifies with respect to mining operations within the boundaries of the Lease, and the impounding, retention, treatment and disposal of mineralized or impure water or sludge or mining debris, with a view to preventing unlawful pollution or obstruction of, damage to, or interference with the sea, any watercourse, lake or reservoir or any land.

4. Unless otherwise approved, the Lessee shall not:

   (a) erect or operate any plant on the Lease for the purposes of treating or concentrating minerals won under the Lease;

   (b) dispose of mill tailings within the boundaries of the Lease;

   (c) erect or use buildings for domestic residence purposes within the boundaries of the Lease.

5. Prior to commencing initial mining operations on the area, and thereafter when so directed by the Minister, the Lessee shall submit for the approval of the Minister a description of operations to be carried out on the area of the Lease.

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The description shall consist of:

(a) a plan showing the location of all the proposed activities within the area of the Lease;

(b) a general description of the nature and scale of all the proposed operations;

(c) a description of the physical and chemical natures of waste materials resulting from the proposed mining and the methods proposed for their disposal and storage;

(d) a description of the measures proposed to monitor and control:

(i) surface and ground water contamination; and
(ii) erosion;

(e) a description of:

(i) soil type and depth;
(ii) vegetation;
(iii) aboriginal artifacts; and
(iv) surface water quality and quantity;

(f) a statement of the proposed post-mining land use, and a description of the rehabilitation methods proposed to achieve this land use;

(g) a description of any arrangements proposed for residential purposes, the storage of water, and construction of roads on the area of the Lease; and

(h) a nominated term.

6. When a description of operations is required to be submitted pursuant to condition 5, the Lessee shall not mine other than in accordance with an approved description of operations.

7. Prior to the commencement of any clearing of any land on the Lease, or in a right of way relating to the Lease, the Lessee shall inform the owner of the timber, being the Department of Forestry in the case of timber on Crown Land, in sufficient time for the effective removal of timber, and the Lessee shall not commence clearing operations until the written permission of such owner or the Department of Forestry, as the case may be, is first had and obtained.

8. When, in the opinion of the Minister, a significant depth of organically enriched soil occurs on the area to be mined, or on an area where overburden or waste rock is to be deposited the Lessee shall:

(a) Remove such organically enriched soil within a depth of three hundred millimetres below the surface; and

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(b) Stack such soil so that it will not erode, and so that it will be available for the rehabilitation of the mined and disturbed area and for no other purpose.

9. The Lessee shall grade and contour the mined area, overburden and waste rock dumps progressively, so that:

(a) final voids are landscaped and connected to the drainage pattern in the area for best practical advantage for use as water storage areas;

(b) rock and overburden dumps are contoured to conform as nearby as is practicable to the adjoining land forms in terms of slopes and slope lenghts; and

(c) all distrubed areas are stabilized against the natural forces of erosion.

10. After an area has been contoured in accordance with condition 9 the Lessee shall:

(a) Cover the surface of the contoured area with the soil removed in compliance with condition 8; and

(b) Take such measures as the Minister may direct to promote the stabilization of the area and the regrowth of vegetation during the term of the Lease.

11. The Lessee shall ensure that the area of the Lease left unrestored as defined in conditions 9 and 10 at any one time does not exceed forty (40) hectares.

12. The Lessee shall:

(a) Prior to the commencement of deposition of overburden or waste rock on any area of the Lease, satisfy the Minister that such area is suitable for such purpose; and

(b) Satisfy the Minister that adequate precautions have been taken to prevent water that may leach, drain, or wash from any overburden or waste rock flowing into any natural watercourse or reservoir, or satisfy the Minister that such water will be adequately treated.

13. When the Minister so requires, the Lessee shall ensure that overburden or waste rock dumps that react with water to produce substances toxic to animal and plant life are covered by an approved layer of inert material.

14. All fences on the Lease shall be kept intact at all times, except that, where the Lessee requires to remove a fence an alternative fence of a standard equal to or better than the displaced fence shall be provided by the Lessee.

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15. All roads, tracks, and rights of way on the Lease area shall be maintained by the Lessee such that those persons who have a right to use such roads, tracks, and rights of way shall have access at all times, and if the Lessee desires to mine through the path of an existing road, track or right of way, an alternative road, track or right of way shall be provided by the Lessee and maintained at a standard at least equal to that of the original road, track or right of way. Nothing in this condition shall be read or construed so as to negate the provisions of Section 44 of the Mining Act 1968-1986.

16. The Lessee shall only construct dams on the Lease area in accordance with an approved method. This condition shall not be read or construed as negating the Lessee's duties and responsibilities under the provisions of the Water Act 1926-1987.

17. The Lessee shall maintain the Lease area in a tidy state and, prior to the termination of the Lease, remove all machinery and plant unless otherwise approved.

18. The Lessee shall observe at all times the provisions of the Rural Lands Protection Act 1985, Clean Waters Act 1971-1982, Cultural Record (Landscapes Queensland and Queensland Estate) Act 1987 and the Rural Fires Act 1946-1984, as they relate to the Lessee and to the Lease.

19. The Lessee shall ensure that the amount of noise, dust, gases and ground vibration generated on the Lease and affecting areas within or outside the boundaries of the Lease shall be at levels acceptable to the Minister, and when directed by the Minister, the Lessee shall take all steps necessary to reduce such noise, dust, gases and ground vibration to levels nominated by the Minister.

20. The Lessee shall not affect the use of the water tank operated by the Croydon Shire Council without the prior written permission of that Council first had and obtained. (ANNEXURE ENDS)

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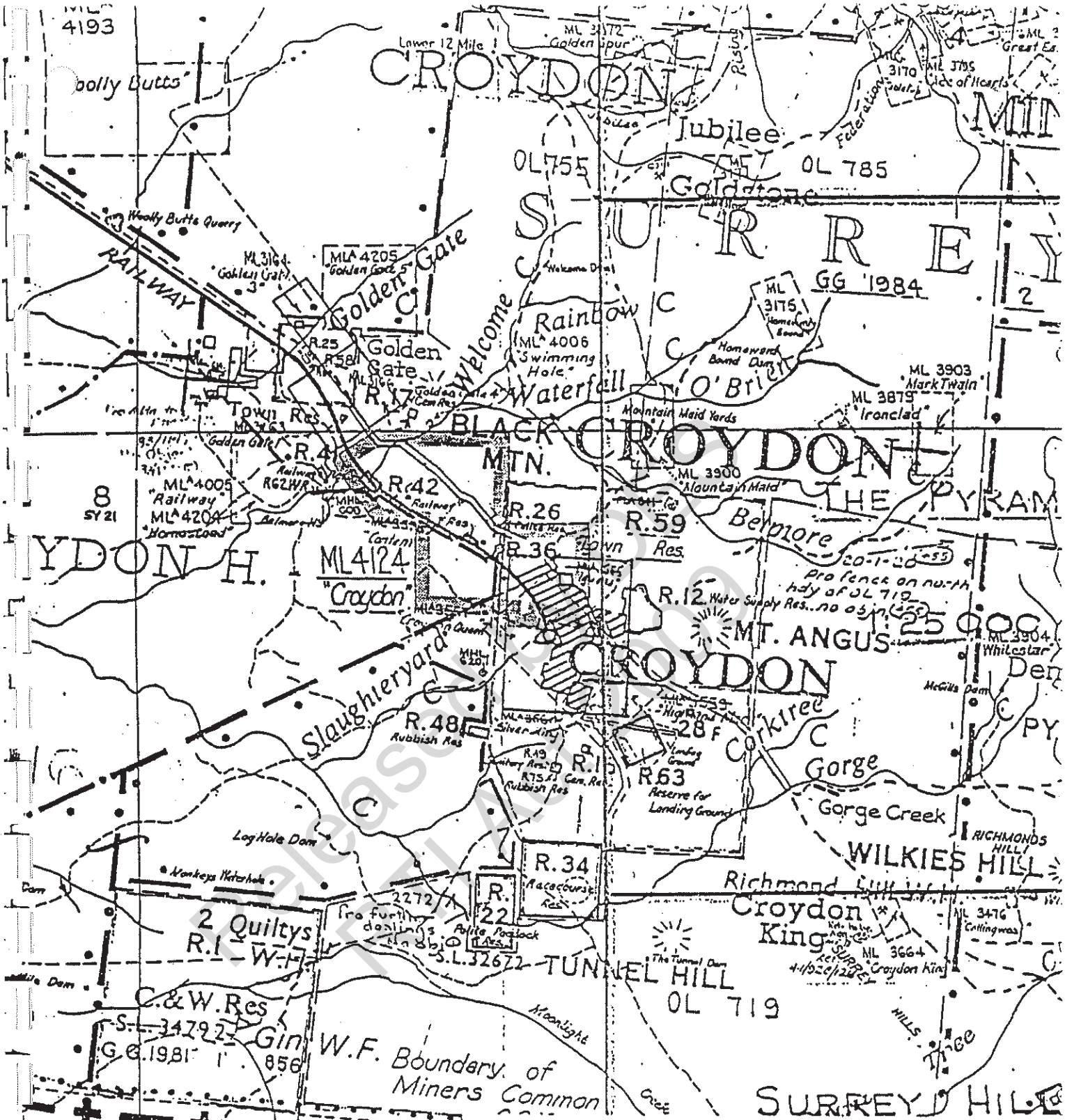

DEPARTMENT OF MINES QUEENSLAND

LEASE LOCATION SKETCH

ML 4124 Mining District MAREEBA

Ref. Map Croydon Scale 1:100,000

Background Tenure MH 868, R59 (Town Reserve) R29 (Pound Reserve) R64 (Aboriginal Reserve) R72 (Museum Res.) R31 (Public Purps Res) R39, 40, 41 & 42 (Railway Res) Roads, VCL & Croydon Holding

Surface Area Approx 1170 ha (Excludes MH 868 & Reserves 29, 31, 39, 40, 41, 42, 64 & 72)

Subject to Survey

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APPENDIX B

ENGINEERING ASSESSMENT OF REHABILITATION OPTIONS

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B1.0
WASTE DUMPS - REPROFILING AND RECAPPING OPTION

B1.1 PHILOSOPHY OF WASTE DUMP CAPPING DESIGN

To achieve the adopted rehabilitation objective as stated in Section 1.0 of the 1996 (Amended) Decommissioning Plan, the primary features of this rehabilitation option would consist of:

(i) reprofiling of waste dump batters and regrading of surfaces (within areas not previously reprofiled) to enhance geotechnical stability, to enable controlled surface water drainage, and to allow the construction of capping systems;

(ii) capping of the waste dump surface and batters to reduce ingress of water and oxygen into the dump (i.e. two key components of AMD generation), using compacted clay, and a surface protection layer comprising benign rock fill. Revegetation of this surface would also be undertaken

B1.2 DESIGN ISSUES

The relevant design issues of this strategy are as follows:

(i) A capping layer would possess characteristics (i.e. permeability and serviceability) that would substantially reduce the potential for infiltration of surface water and O_2 into the waste dump. These characteristics are dependent on the geotechnical properties of the capping material and the adopted construction specification.

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(ii) Related issues that would affect the performance of the capping layers are the subgrade condition (i.e. required to be of suitable quality to enable construction standards within the capping layer to be achieved), and the exposure conditions following construction (i.e. suitable protection/surface treatment required to reduce desiccation or weathering and erosion of the capping layer). Availability of construction materials would also be an issue.

B1.3 HYDROLOGICAL MODELLING

(i) Capping Design

Hydrological modelling was undertaken as the basis for selecting the configuration and thickness of surface capping for the Golden Butterfly and Content waste dumps.

The HELP (Hydrologic Evaluation of Landfill Performance) computer model was used as the basis for this capping layer design. The model provides estimates of infiltration through earthfill covers. The model divides the waste dump profile into a number of segments. As an initial condition, the model assumes the moisture content in each layer to be equal to the moisture content that would exist in the soil under drained conditions (i.e. field capacity). For each day of simulation, the model performs a water balance over the waste dump profile, monitoring the moisture content variation. Compared with the field moisture capacity of the material, the model calculates the volume of free water. Based on the permeabilities of these layers, the rate of flow is then estimated. This process is repeated over the various layers within the model.

The initial phase of the analysis was to "test" the sensitivity of the model to variations in the thickness of the evapotranspiration zone. These analyses indicated that an evapotranspiration zone of 1.0 m would be appropriate.

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The second phase of the modelling was performed to test the effect of permeability and compacted clay layer thickness on the degree of infiltration through the cover system. A number of simulations were performed for a range of permeabilities, incrementing the thickness of the compacted layer with each simulation. The modelling showed that the permeability of the compacted layer has a significant effect on the simulated infiltration.

Compacted layer thicknesses and permeabilities can be selected to restrict infiltration to an appropriate level. For the purpose of design, it is considered that infiltration limited to 5% of total rainfall would be appropriate. On this basis, a minimum capping layer thickness of 0.6 m and possessing a maximum permeability of 10^{-8} m/s is considered a minimum requirement. The thickness of the compacted layer not only affects the amount of infiltration into the waste dump but contributes to the overall depth of cover (i.e. capping layer and rock mulch layer) over the waste dump material. At least 1.0 m of cover is desirable to isolate the materials from the evapotranspiration process. In addition to the 0.6 m compacted layer, therefore, an additional surface layer is required to achieve this minimum thickness of cover. This surface layer would comprise a select rock fill which would be used for erosion protection of the underlying compacted layer.

(ii) Drainage and Stability Design

An important consideration of the rehabilitation works is to facilitate rapid drainage away from the waste dump areas to limit the potential for infiltration into the dump.

Final waste rock dump landforms have been designed to drain surface water and discharge runoff from ML 5248 in an effective manner. Stormwater diversion bunds and sediment basins have been incorporated as control structures; each hydraulically designed on the basis of a 1 in 100 year, critical duration rainfall event.

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The engineering design for the rehabilitation works incorporate batter slopes on waste rock dumps of 3 (horizontal):1 (vertical). This slope was selected for long-term geotechnical stability, taking into consideration the geotechnical characteristics of the waste rock materials. For long slopes in excess of 50 m length, benches will be necessary to reduce runoff velocities and hence mitigate erosion potential. A minimum bench width of 5 m is considered acceptable.

B1.4 SUMMARY

The analyses outlined above indicate that a waste dump cover system comprising a 0.6 m capping layer (maximum permeability of 10^{-8} m/s) with a 0.4 m layer of select rock fill would represent a minimum requirement to achieve the desired performance. This design would be appropriate for the flat areas of the dumps. It is inferred that on the batters, due to the increased grade, the rate of infiltration potential would decrease significantly (as a consequence of increased surface runoff). As a result, a reduced capping layer thickness would be suitable - a thickness of 0.45 m being selected[1], with a 0.4 m surface protection layer. To improve the effectiveness of the clay capping layer, a clay filled key trench around the waste dump perimeters would be required. This key trench would reduce the potential for either surface water entering the dump area or release of any water or leachate contained within the dumps.

An investigation into potential clay fill borrow areas near the lease identified a source to the west of the Content pit within Belmore Station. Geotechnical testwork on this soil indicated that permeabilities of the order of 10^{-8} m/s could be achieved in the field subject to a compaction standard of 98% of maximum (standard) dry density at -2 to +3% of optimum moisture content.

It will be necessary that rock fill used to form the surface protection layer would comprise benign (i.e. non-acid producing) waste rock sourced from the waste dump areas. The site inspections carried out indicate that sufficient quantities of these materials are available to complete the works.

---

[1] Selected on the basis of constructability rather than infiltration.

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Prior to construction of these capping works, reprofiling of the waste dump surfaces to facilitate effective drainage of the landforms and ensure long term geotechnical stability would be required. Batter slopes of the order of 3(H) : 1V) were thereby adopted, with benches of some 5 m width provided at 50 m (maximum) spacing measured along the batter slopes. Associated drainage structures including stormwater diversion bunds and sediment basins would also be required to manage the release of runoff from the waste dump areas.

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B2.1 PHILOSOPHY AND CONCEPT OF PIT BACKFILLING

The possible pit backfilling strategy for ML 5248 is as follows:

(i) Golden Butterfly Waste Dump to Golden Butterfly Pit; and

(ii) Content Waste Dump to Content Pit and/or Lady Isabella Pit.

Pit backfilling would be carried out by a bulk earthworks program.

B2.2 CONSTRAINTS

The issues related to design and scheduling of the pit backfilling option are:

(i) The capacity of the existing pits will limit the volume of waste that may be contained below the natural ground surface. This volume would also depend on the characteristics of the waste rock and the method of placement;

(ii) The pits currently contain considerable quantities of water. The presence of water will implicate both the volume efficiency of the voids (due to the effects of saturation of the waste rock on placement) and the effects of displacement and possible pit overtopping as a result of waste placement; and

(iii) The potential for saturation of the emplaced waste rock material within the pits and resulting seepage discharges also need to be considered.

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B2.3 VOID CAPACITIES AND REQUIRED VOID VOLUMES

A survey of the pits was carried out as part of this study to estimate voids volumes. A summary of the data is provided in Table B1.

TABLE B1
Summary of Pit Geometry

Pit	Average Surface Area (m^2)	Average Depth to Water Surface** (m)	Total Void Volume *** (m^3)
Golden Butterfly	36 500	25	1 080 300
Content	18 000	22	300 846
Lady Isabella	15 000	12	176 060

* Golden Butterfly North Pit not considered due to past use as water supply.
** From surrounding ground surface
*** Obtained from in-pit survey and includes volume of water contained in pit

Based on a previous survey carried out as part of the initial rehabilitation works, the total volume of waste rock contained within each waste dump was estimated, as follows:

Golden Butterfly Waste Dump	1.78 million m^3
Content Waste Dump	0.36 million m^3.

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Available records show that the total waste rock quantity extracted and placed within the Golden Butterfly waste dump from the Golden Butterfly pit was 3.09 million tonnes. The Golden Butterfly waste dump also contains waste derived from the Golden Butterfly North pit. It is estimated that about 20% of the total dump volume represents Golden Butterfly North material, implying a total quantity of waste in the Golden Butterfly dump of approximately 3.8 million tonnes. Based on a waste rock volume for the Golden Butterfly waste dump of 1.78 million m^3, this represents an average in-dump bulk density of 2.1 t/m^3. Assuming similar densities can be achieved in the pit through the backfilling process within either the Golden Butterfly or Content pits, the following conclusions are made:

- The Golden Butterfly pit will not contain fully the volume of material within the Golden Butterfly waste dump. Mounding of the finished surface of the backfilled pit (above the natural ground level but abutting the adjacent hill) would therefore be required.

- The Content pit possesses a marginally lower volume than is required for containment of the Content waste rock volume. Minor mounding of the backfilled pit (sufficient to facilitate surface drainage) would therefore be required.

- Based on the slope, there is no requirement for the Lady Isabella pit for backfilling purposes.

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B2.4 DESIGN ANALYSES - HYDROLOGICAL MODELLING

Hydrological modelling has been carried out in relation to the pit backfilling strategy to define the following conditions:

- Pit overtopping potential (Backfill scenario - during backfilling works).
- Pit overtopping potential (Backfill scenario - long term condition).

The modelling was carried out in relation to the Golden Butterfly pit, with results assumed to apply for the Content pit.

(i) Pit Overtopping Potential - Backfilled Pit Scenario (Construction Phase)

A simple spreadsheet model was developed to predict water levels in the Golden Butterfly pit, under a rapid backfilling condition. The pit cross-section and water levels assumed were similar to those for the open pit scenario outlined in Section B3.0. A surface area versus storage relationship for the pit was developed on the basis of these characteristics. This relationship indicates that, for a pit water level at a depth of 25 m below ground level, the total contained water volume would be of the order of 300 000 m^3.

The model developed is dependent on the achievable porosity of the backfill material (i.e. ratio of void volume with total volume) to provide storage. It was considered for the purpose of analysis that rainfall, evaporation and groundwater system water inflow were balanced, on an annual average basis, and therefore were ignored (which, due to the considerable excess evaporation over rainfall of Croydon and the expected limited groundwater inflow to the pit, is an appropriate assumption). It was assumed that the pit was backfilled over a period of 90 days (i.e. backfilling would occur rapidly, inferring that no dissipation to the adjacent groundwater systems would occur during the period of backfilling) and that no rainfall occurred over that period.

Using the model developed, as described above, it was indicated that spillage from the backfilled pit could occur if the average porosity of the backfill material was 0.25 or less. Based on observed characteristics of the waste rock and by inference from established geotechnical correlations, it is considered that a porosity of around 0.25 could be obtained with considerable levels of compaction. For uncompacted backfill materials, a porosity of the order of 0.35 would be likely (which is consistent with the bulk density of 2.1 t/m^3 estimated above). Re-analysis of this condition indicates that, over a 90 day backfilling period, the water level would rise to some 9 m below surrounding ground level.

These analyses, indicate that the potential for pit overtopping during the construction phase would be marginal, depending on the level of compaction achieved within the backfill material.

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(ii) Pit Overtopping Potential - Backfilled Scenario (Long Term)

The hydrological process which would contribute to the longer term hydrology of the backfilled pit can be considered as a balance between infiltration and percolation of water into the pit and seepage out of the pit.

Assuming that no capping layer was constructed, the backfilled pit would have a high infiltration capacity (relative to surrounding areas). A significant proportion of incident rainfall would tend to infiltrate through the surface of the dump and move (percolate) rapidly down to the saturated zone or groundwater table within the pit. After the groundwater levels within the pit reach a level consistent with the regional groundwater table, further infiltration would cause groundwater mounding to form and a corresponding increase in outflow from the pit (due to the increasing hydraulic gradient generated by the mound). These processes (infiltration, mounding and outflow to the regional groundwater system) would continue until an equilibrium or balance occurred (i.e. mounding will continue while the rate of infiltration exceeds the rate of water movement out of the pit into the surrounding groundwater).

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To assess the long-term situation which is likely to occur post-pit backfilling, an analytical model developed for simulation of large diameter well hydraulics was used to simulate the long term water levels in pits. The model is represented by the following equation:

$$Q = \frac{\pi K (h_o^2 - (h_o - h_w)^2)}{\ln r_o/r_{pit}}$$

Where

K = Saturated hydraulic conductivity of rocks

h_o = Groundwater level in the pit.

h_w = Height of water table above base of pit (regional groundwater level)

r_o = Radius of influence

r_{pit} = Radius of the pit.

The following assumptions were made in the analysis.

- Infiltration of water through waste and into the pit equal to 30% of average rainfall for Croydon. This translates to an annual infiltration rate of 210 mm.

- Saturated hydraulic conductivity of pit wall rocks of 1 x 10^{-7} to 1 x 10^{-8} m/s (estimated from insitu permeability testing carried out within bores constructed adjacent to Golden Butterfly Waste Dump).

- Maximum available head above regional groundwater level = 25 m (i.e. maximum mounding before outflow occurs).

Results of this analysis indicate that, in the longer term, water levels in the pit are likely to rise sufficiently to overtop the pit and migrate as a seepage front appearing at the toe of the mounded dump. These conclusions are, however, based on the available knowledge of the regional hydrogeology which is fairly limited.

If the bulk permeabilities surrounding the pit were greater than 1 x 10^{-7} m/s and/or if infiltration through the dump was significantly less than 30% of rainfall, it is probable overtopping would not occur. For instance, in the event that nett pit surface infiltration was 20% of incident rainfall (i.e. rate of 140 mm/annum) as a result of construction of a surface capping layer, it is predicted that the final pit water level would rise to 10 m below surrounding ground surface and overtopping would therefore not be likely to occur.

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B2.5 SUMMARY

Potential for overtopping from the Golden Butterfly Pit as a result of waste rock backfilling appears to exist during both construction or in the long term. This potential is affected by the following conditions:

- The higher the level of compaction achieved in backfilled material, the greater the potential for overtopping during construction.

- The greater the surface infiltration within the pit area following construction, the greater the potential for overtopping in the long term. Based on these results, it is considered that the most appropriate backfilling philosophy would be to provide moderate levels of compaction (i.e. essentially to limit the potential for significant ongoing ground surface settlement) and to cap the final ground surface to limit ground surface infiltration potential.

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AMD within the Golden Butterfly Pit, and to a lesser extent the Lady Isabella and Content Pits, is an ongoing process. Poor pit water quality, therefore, prevails within the Golden Butterfly pit, with marginal quality within the Lady Isabella and Content pits. Under a "Do Nothing" scenario for these pits, the most significant issue would be the risk of overtopping, thus causing release of poor quality water. A simple water balance analysis has, therefore, been undertaken in relation to the Golden Butterfly pit, to assess the long term potential for overtopping, with these results extrapolated to the Lady Isabella and Content pits.

The premise under which this analysis was carried out was that all surface water runoff is redirected away from the pit area by the existing safety bunding, with overtopping due predominantly to direct precipitation over the pit area and the inflow of groundwater.

The groundwater inflow rates to the pit would be controlled by the permeability of the exposed sequences within the pit. Based on insitu testing within bores constructed adjacent to the Golden Butterfly pit, the permeability of the pit wall rocks were estimated to be of the order of 10^{-7} to 10^{-8} m/s.

Groundwater inflows to the pit would occur while water levels in the pit were lower than the surrounding groundwater table levels. Inflows would be expected to continue toward the pit until the original groundwater levels were re-established. The original groundwater levels would have been about RL 100 m (i.e. some 10 m below existing ground surface, measured in BH2 - refer Section 4.2.2.2 of the main text). The current water level in the Golden Butterfly pit is around RL 87 (i.e. 25 m below ground level).

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As discussed in Section B2.0, on an annual average basis, the effects of rainfall, evaporation and groundwater inflow are assumed to be balanced (assuming surface runoff is diverted away from the pit area). This condition was reflected in these analysis, and indicated that after equilibrium groundwater levels were restored in the pit, only minor short term mounding of pit waters would likely occur. Under typical wet season fluctuations it is expected that this mounding would not likely exceed 3 m (based on typical wet season rainfall excess at Croydon).

Based on this brief water balance analysis, it is expected that overtopping of the pit, even under the most extreme of wet seasons, would be unlikely.

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B4.0
OTHER AREAS - REMOVAL

As the stockpile area and the western side of the Content pit contain material with potential for acid production, it is considered prudent to remove these materials. Similarly, the drainage channel has been contaminated by seepage from the Golden Butterfly waste dump, and it is considered that the contaminated material should also be removed. It is considered that the haul road could remain intact because of its existing level of compaction.

It is proposed that all removed materials be dumped in the Golden Butterfly or Content pit, as appropriate.

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APPENDIX C

LANDHOLDER REQUIREMENTS
DEPARTMENT OF LANDS AND CROYDON SHIRE COUNCIL

ANDS

EPARTMENT
LANDS

F R NORTH
EGION

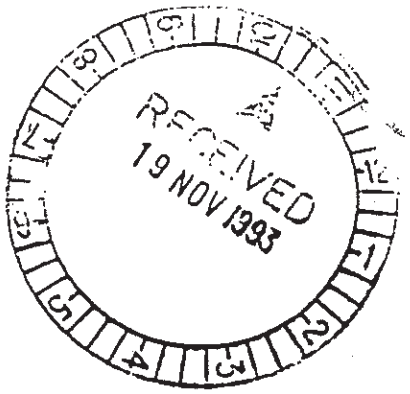
Main Street
erton
OSTAL:
PO Box 250
erton 4880

ONTACT:
Smout

HONE:
3222

AX NO:
2844

Your Ref: David Newton
Our Ref: ATH/Gen



10 November 1993

Woodward Clyde
49 Park Road
Milton Qld

Dear Sir

RE: ML 5248 - Post Mining Land Use

I refer to faxes received on 21 September 1993 and 21 October 1993 concerning post mining land use of land covered by ML 5248.

This Department advises that the Trustees of the various reserves covered by the Mining Lease should be contacted to ascertain their requirements concerning post mining land use.

With regard to the vacant Crown land and any reserves of which this Department is Trustee, the Department refers you initially to the requirements of the Department of Minerals and Energy and their rehabilitation requirements. Apart from reinforcing that Department's requirements this Department requires:

1. that road areas be rehabilitated with natural vegetation cover using endemic species, apart from minimal access roads suitable for local usage. The location of the access tracks should be ascertained by reference to Croydon Shire Council and surrounding landowners.

2. This Department has no specific requirements with regard to fencing around reserves but advises that the replacement or leaving of any fencing damaged/removed/erected in the mining process be reviewed in consultation with the landowners in the locality, with their legal boundaries taken into consideration.

3. areas used for grazing be revegetated with improved pasture

4. all foreign equipment and rubbish removed

5. suitable vegetation to control soil erosion where necessary

Yours faithfully

CTPI 49-Sch4

M Linnan
Regional Operations Manager
Land Services

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PHONE No. (077) 45 6153
(077) 45 6185
FAX No. (077) 45 6147

POST OFFICE BOX No. 446

Croydon Shire Council

ESTABLISHED IN 1909 BY THE CONSOLIDATION OF THE CROYDON DIVISIONAL BOARD (EST. 1888) AND THE CROYDON MUNICIPAL COUNCIL (EST. 1892)

Address all correspondence to
THE SHIRE CLERK

CROYDON 4871
North Queensland

FORWARD TO

COPY TO

RECEIVED
18 OCT 1993

12 October 1993

Manager - Northern Division
AGC Woodward-Clyde Pty Ld
49 Park Road
Milton Qld 4064

Dear Sir

POST-MINE LAND USE OF ML 5248 CROYDON GOLD MINE

I refer to your letter dated 28 September 1993 and our facsimilie dated 6 October 1993 concerning the above matter.

The Golden Butterfly North open cut pit is currently used by the Council as a source of water supply for the township and it is essential for Council to retain access to the pit through the proposed bund wall via the existing access. We would suggest that when the area is fenced a suitable gate be erected to allow easy access for Council employees.

In addition, the adjacent top of the tailings dump and its rock wall acts as a water catchment and directs runoff into the pit through a concrete pipe located under the existing bund wall and it is requested that when the dump is capped, provision be made to retain these features.

With regard to capping material for the dump, an area immediately to the east of the dump face appears to be a suitable source for the loam/clay required for the capping operation. The resulting excavation would provide a catchment storage area for runoff water flowing westward from the northern side of the adjacent bitumen road. The exact location can be obtained from Councils Foreman Ron Diehm.

The Lady Isabelle and Content Pits are also being examined as possible future water supply sources and it is requested that ready access be provided in any intended works at those sites.

With reference to revegetation of the various sites, I will advise you further in that regard once I have consulted further with the Council.

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Rel

I trust the foregoing is of some benefit to you as the proposals contained therein will certainly be of some benefit to the Croydon community.

Yours faithfully

CTPI 49-Sch4

Des Niesler
Shire Clerk

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PHONE No. (077) 46 6185

POST OFFICE BOX No. 449

Croydon Shire Council

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THE SHIRE CLERK

CROYDON 4871
North Queensland

FACSIMILE TRANSMISSION

DATE: 6-10-93

TO: CTPI 49-Sch4

COMPANY/FIRM: WOODWARD - CLYDE

FACSIMILE NO: 07 364 7477

FROM: RON DIEHM

CROYDON SHIRE COUNCIL FAX NO: (077) 456 147

NUMBER OF PAGES (INCLUDING THIS PAGE): THREE

RE: TELEPHONE CONVERSATION

MESSAGE:

ENCLOSING ROUGH PLAN OF WHERE COVER MATERIAL COULD BE OBTAINED.

THIS EXCAVATION COULD BE A BENIFIT TO COUNCIL, AS WE PROPOSE TO EXCAVATE A STORAGE DAM TO HELP REPLENTISH THE WATER LEVEL IN GOLDEN BUTTERFLY NORTH FOR THE TOWN WATER SUPPLY.

COUNCIL WOULD BE PLEASED IF ALL WATER OFF THE WASTE DUMP WENT INTO THE GOLDEN BUTTERFLY NORTH PIT IF NOT EFFECTED BY ANY MINERALS.

COUNCIL WOULD LIKE REVEGETATION TO CONTINUE GROWING ERANO, SECAI AMEGA + BUFFEL, THIS HAS GROWN WELL ERE WILL NOT BE ANY STOCK TO DESTROY THIS

THANKING YOU

CTPI 49-Sch4

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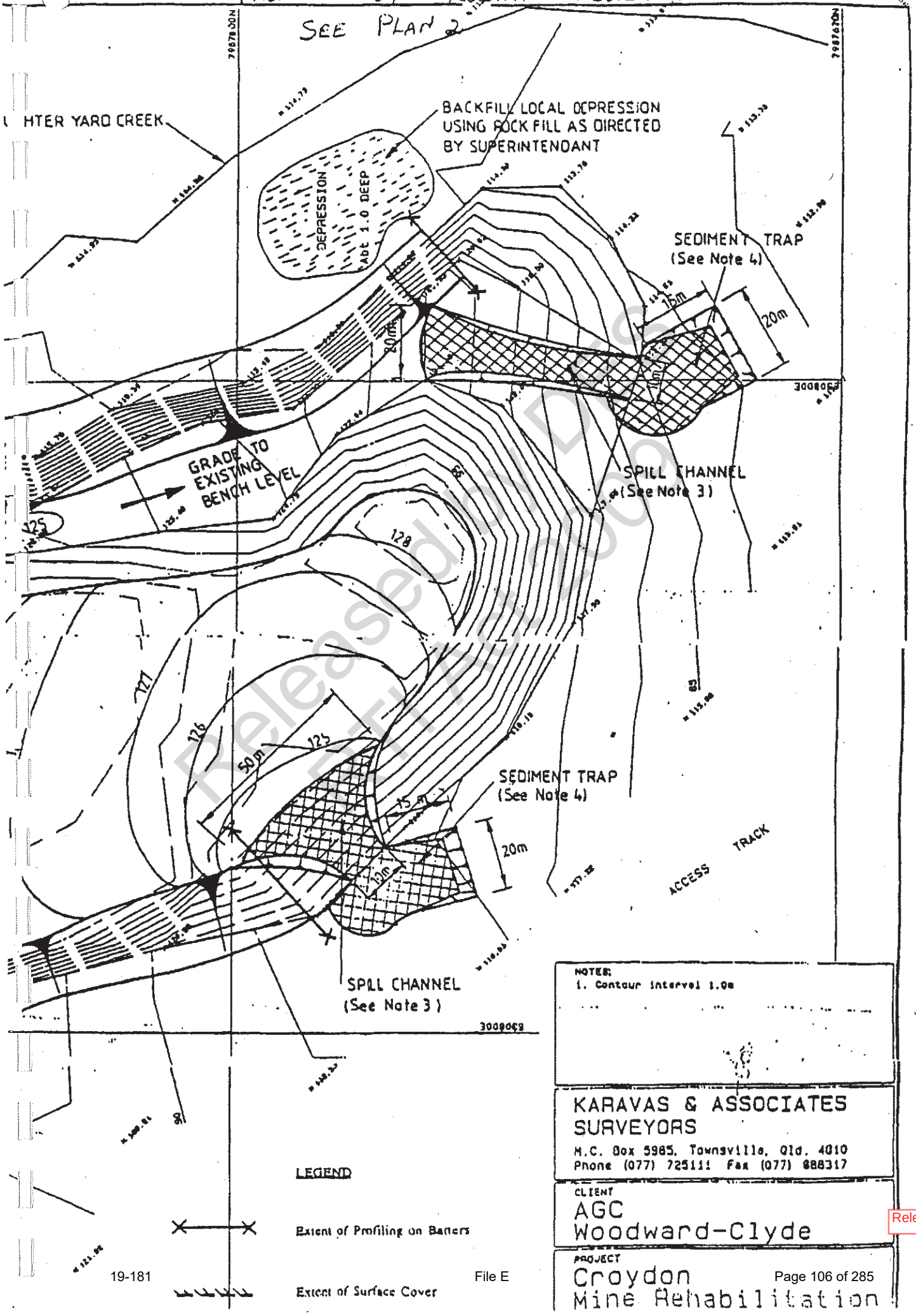
PROPOSED DAM LOCATION & COVER MATERIAL



NOTES:
1. Contour Interval 1.0m

KARAVAS & ASSOCIATES
SURVEYORS
M.C. Box 5985, Townsville, Qld. 4810
Phone (077) 725111 Fax (077) 888317

CLIENT
AGC
Woodward-Clyde

PROJECT
Croydon
Mine Rehabilitation

LEGEND

Extent of Profiling on Banters

Extent of Surface Cover

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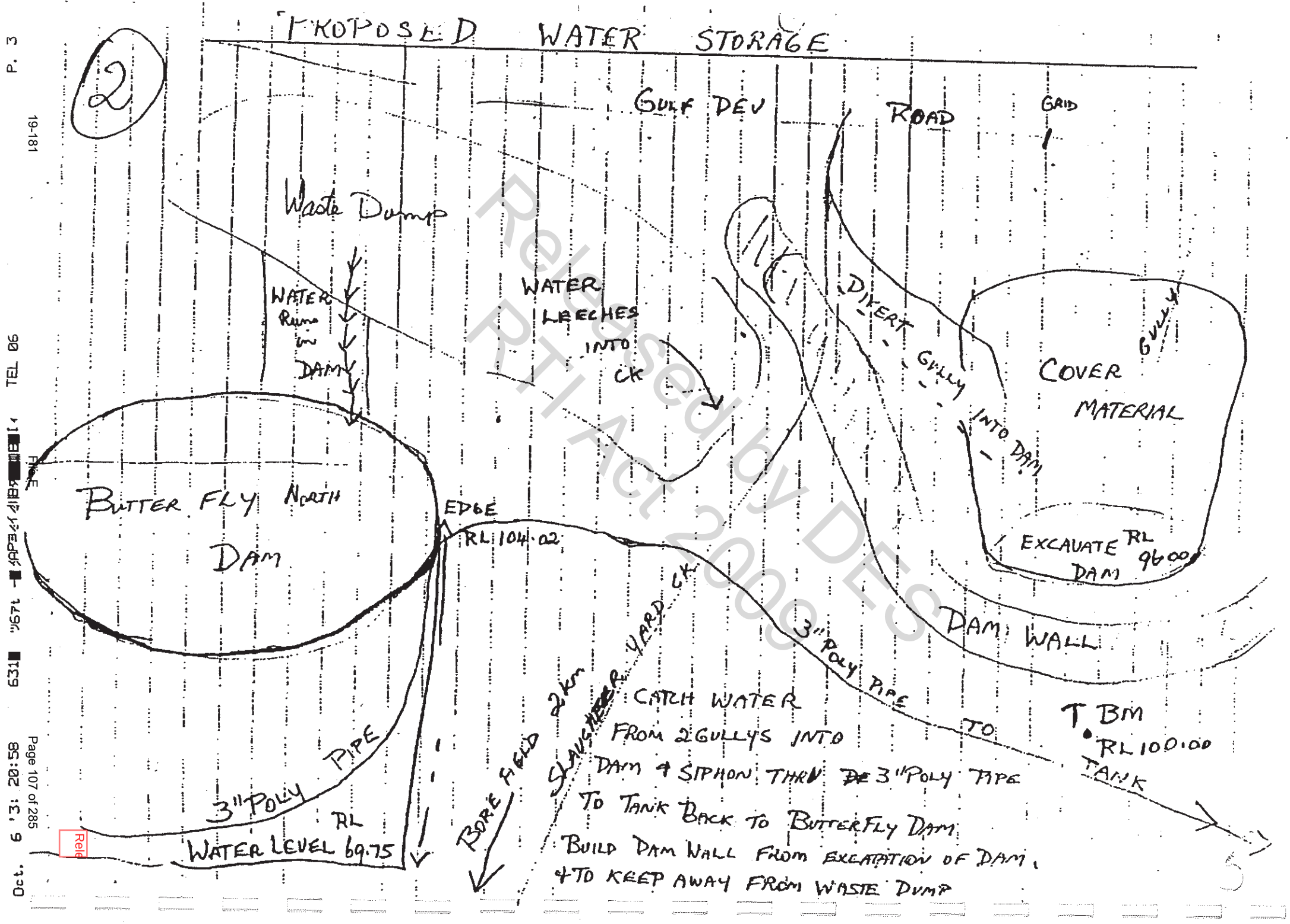

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Oct. 6 '3: 20:58 631 "67L 19-181 TEL 06 P. 3
Page 107 of 285

PHONE No. (077) 45 6153
(077) 45 6185
FAX No. (077) 45 6147

POST OFFICE BOX No. 446

Croydon Shire Council

ESTABLISHED IN 1909 BY THE CONSOLIDATION OF THE CROYDON DIVISIONAL BOARD (EST. 1888) AND THE CROYDON MUNICIPAL COUNCIL (EST. 1892)

RECEIVED
18 OCT 1993

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With reference to revegetation of the various sites, I will advise you further in that regard once I have consulted further with the Council.

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I trust the foregoing is of some benefit to you as the proposals contained therein will certainly be of some benefit to the Croydon community.

Yours faithfully

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Des Niesler
Shire Clerk

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APPENDIX D

SURFACE WATER AND GROUNDWATER SAMPLING AND PRESERVATION INSTRUCTIONS

CROYDON GOLD MINE

SURFACE WATER AND GROUNDWATER MONITORING SAMPLING AND PRESERVATION INSTRUCTIONS

D1.0 INTRODUCTION

The key to achieving accurate monitoring results is to minimise potential contamination of the samples through the adoption of correct sampling procedures and the use of clean sample bottles, clean conditions during collection, correct sample preparation and rapid transport of the samples to the laboratory.

The following instructions provide step by step procedures for taking surface water and groundwater samples.

When practical have an ice filled esky ready before starting a sample collection run, and place the samples into it immediately after collection. It is necessary to chill samples to minimise degradation oft he sample between the time of collection and analysis in the laboratory.

Samples are to be chilled to between 1°C and 4°C as soon as possible after collection.

Only use sample containers that have been prepared and supplied by a laboratory, it is generally impractical for field staff to prepare their own sample containers.

To avoid contaminating the sample, ensure that your hands are clean and the sample containers are clean on the outside before submerging them in the water to be sampled. For the same reason, do not write the sample identification on the container until after the sample has been taken.

Unless avoidable, do not collect samples from the surface of a waterbody, try and collect the sample from at least 20 cm below the surface.

Samples must be despatched to the laboratory as soon as possible after collection to minimise degradation. Whenever possible they should be received by the laboratory within 48 hours of being collected. Ensure that the samples are packed in sufficient ice to maintain their temperature below 4°C during transit - do not freeze the samples.

It may be necessary to alter the sampling schedule to fit in the bus company timetables, to minimise the delay between sample collection and analysis. However, samples should be collected as close as possible to the nominated sampling dates. Note that there is provision on the Field Data Sheet to reuse when no sample is available for collection.

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D2.0 SAMPLE BOTTLE REQUIREMENTS (per site)

No.	Type	Size	Preservation	Label Colour
1	Narrow-mouthed plastic	1 Litre	"natural"	green
1	Narrow-mouthed plastic	250 ml	"acidified" (nitric acid)	red

These bottles can be obtained from Australian Environmental Laboratories (formally Analabs) in Cairns.

D3.0 FIELD DATA RECORDS

An example field data sheet is attached. One sheet is required for each sampling event. The sheet should be used at each site to record the following information:

(i) sample site identification number;

(ii) date of sampling;

(iii) current weather conditions and rainfall in the previous 24 hours;

(iv) for surface water samples - approximate depth of water at deepest point in the stream;

(v) for groundwater samples - the depth from the surface to standing water;

(vi) pH (use pH indicator tabs or pH meter); and

(vii) conductivity (EC) (if a meter is available).

One copy of the completed sheet should be forwarded to Woodward-Clyde and RGE's General Manager Environment, with a copy retained by the sampler.

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D3.1 SURFACE WATER SAMPLES

Step 1 Label sample bottles with sample site identification number and date.

Step 2 Immerse the "natural" bottle (green label) into the water.

Where possible, avoid taking the sample from the surface of the water. Fully immerse the bottle about 20 cm into the water or as far as possible and allow to fill. Attach the cap and shake for 15 seconds. Discard this sample downstream or onto the ground well away from the sample point.

Step 3 Refill the "natural" bottle using the same method and transfer to the "acidified" bottle (red label). Fill the "acidified" bottle completely, but don't cause it to overflow and secure the cap firmly.

Step 4 Refill the "natural" bottle using the same method, fill completely and secure the cap firmly.

Step 5 Measure field pH and EC.

Step 6 Store samples in an esky at or below 4°C (use ice or ice blocks to cool) and transport to the laboratory as soon as possible.

D3.2 GROUNDWATER SAMPLES

Step 1 Label sample bottles with sample site identification number and date.

Step 2 At each monitoring bore, measure the depth to the water level using a water level probe or weighted rope.

Step 3 Remove and discard at least three bore volumes of water using a suitable pump.

Step 4 Fill a bailer and discard three times before sampling on the fourth.

Step 5 Measure field pH and EC.

Step 6 Fill the "natural" bottle, attach the cap, shake for 15 seconds, discard.

Step 7 Refill the "natural" bottle using the same method and transfer to the "acidified" bottle (red label). Fill the "acidified" bottle completely and secure the cap firmly.

Step 8 Refill the "natural" bottle using the same method, fill completely and secure the cap firmly.

Step 9 Measure field pH and EC.

Step 10 Store samples in an esky at or below 4°C (use ice or ice blocks to cool) and transport to the laboratory as soon as possible.

D3.3 CHAIN OF CUSTODY/SAMPLE SUBMISSION RECORD

An example chain of custody/sample submission sheet is attached. One sheet is required for each sampling event. The sheet should be filled out and signed at the time of sample dispatch to the laboratory. It should be used to record the following information :

(i) sampler's name and signature;

(ii) date and time of sampling;

(iii) sample identification number (cross out if not collected);

(iv) number of containers for each sample identification number;

(v) total number of containers;

(vi) date, time and dispatch method used to transport the samples to the laboratory.

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One copy of the record should be forwarded to each of the following:

a) laboratory;
b) Woodward-Clyde;
c) RGE's General Manager Environment; and

one copy is to be retained by the sampler.

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CROYDON GOLD MINE
GROUNDWATER AND SURFACE WATER QUALITY
FIELD DATA SHEET

SAMPLERS NAME:	
DATE:	

WEATHER CONDITIONS:	
RAINFALL (PREVIOUS 24 HRS):	

SURFACE WATER AND PITS	SITE (cross out if not collected)	TIME OF SAMPLING	DEPTH OF WATER (m)	FIELD PARAMETERS		CONTAINERS USED		SAMPLES STORED ON ICE (tick)	SAMPLES DISPATCHED TO ANALABS (tick)	OTHER
				pH	EC (µS/cm)	Natural 1 L (tick)	Acidified 250 ml (tick)			
	SW1									
	SW2									
	SW3									
	SW3A									
	SW4									
	SW5									
	Golden Butterfly Pit		N/A							
	Golden Butterfly North Pit		N/A							
	Content Pit		N/A							
	Lady Isabella Pit		N/A							

GROUNDWATER	SITE (cross out if not collected)	TIME OF SAMPLING	DEPTH TO WATER (m)	BORE PURGED (tick)	FIELD PARAMETERS		CONTAINERS USED		SAMPLES STORED ON ICE (tick)	SAMPLES DISPATCHED TO ANALABS (tick)	OTHER
					pH	EC (µS/cm)	Natural 1 L (tick)	Acidified 250 ml (tick)			
	GBMB1										
	GBMB2										
	GBMB3										
	GBMB4										
	GBMB5										
	GBMB6										
	BH1										
	BH2										
	BH3										
	BH4										
	BH5										
	BH6										
	BH7										

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APPENDIX E

COMMITMENT COMPLIANCE - ML5248

COMMITMENT COMPLIANCE - ML 5248

COMMITMENT	COMPLIANCE STATUS	COMMENTS
Identify background landholder requirements regarding rehabilitation of ML 5248	Completed (refer Section 4.4.1)	
Prepare and implement an upgraded and enhanced site environmental monitoring program.	Upgraded monitoring program proposed and being implemented	
Review environmental monitoring program annually in consultation with the DME to ensure the continued effectiveness of the program.		Review to be undertaken in conjunction with Annual Monitoring Report.
Golden Butterfly Waste Dump - Clay fill covering and rock fill surface protection of the entire waste dump surface and construction of a cut-off key around the dump perimeter.	Completed November 1996.	
Content Waste Dump - Reprofile batter slopes (other than western batter). Clay fill covering and rock fill surface protection of the entire waste dump surface.	Completed November 1996.	
Identify, remove and dispose of potentially acid producing material from the Golden Butterfly hardstand area.	Completed November 1996.	

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COMMITMENT	COMPLIANCE STATUS	COMMENTS
Identify, remove and dispose of contaminated sediments in Slaughteryard Creek adjacent to the Golden Butterfly waste dump.	Completed November 1996.	
Revegetate waste dump surfaces, former hardstand areas and other disturbed areas with native woodland tree species.	Seeding completed January 1997.	Establishment to be monitored in Autumn 1997.
Revegetation performance will be monitored on an annual basis.		First monitoring due mid-1997.
Generation of sediment will be limited by: (I) diversion of upstream runoff and, (ii) sediment traps will be constructed where necessary.	Some works completed in 1993, remainder completed November 1996.	
The effectiveness of sediment control measures will be monitored on a regular basis.	Being inspected regularly by local representative.	
Erosion monitoring on the waste dump surfaces will be undertaken on a regular basis.		First monitoring due mid-1997.
Water monitoring of creek sites will be undertaken at the locations and on the frequencies detailed in the Water Monitoring Schedule for ML 5248.	Monitoring being undertaken in accordance with monitoring schedule.	

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COMMITMENT	COMPLIANCE STATUS	COMMENTS
Water quality at monitoring sites SW1, (Golden Butterfly catchment) & SW5 (Content/Lady Isabella catchment) will comply with ANZECC (1992) Water Quality Guidelines for livestock watering (cattle), or not exceed 115% of background whichever is greater. Background will be measured at sites SW3 & SW4.	Insufficient data available to establish compliance at this stage.	Monitoring, analysis and interpretation continuing.
Water quality monitoring within open pits will be undertaken at the locations and on the frequencies detailed in the Water Monitoring Schedule for ML 5248.	Monitoring being undertaken in accordance with monitoring schedule.	
Pit water quality monitoring data will be reviewed annually, with any deterioration analysed and possible related impacts assessed.		Review to be undertaken in conjunction with annual monitoring report.
Groundwater quality monitoring will be undertaken at the locations and on the frequencies detailed in the Water Monitoring Schedule for ML 5248.	Monitoring being undertaken in accordance with monitoring schedule	
GBMB series groundwater monitoring bores - maintain water quality within the range of water quality data collected for these bores over the period 1990 to 1993.	Generally in compliance.	

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COMMITMENT	COMPLIANCE STATUS	COMMENTS
BH series groundwater monitoring bores - water quality monitoring data will be reviewed annually, with any deterioration analysed and possible related impacts assessed.		Review to be conducted in conjunction with Annual Monitoring Report.
Monitoring data will be collated, interpreted and reported to the DME on an annual basis together with an audit of compliance status against commitments.	1996 Annual Monitoring Report submitted in September 1996.	Regular inspections carried out by local representative. Formal annual lease inspections to be carried out each year as planned.
An annual lease inspection will be carried out by RGC.		Regular inspections carried out by local representative. Formal annual lease inspections to be carried out each year as planned.
Where practicable runoff water will be diverted away from voids via diversion bunds.	Diversion bunds in place.	
Safety bunding and fencing will be erected around open pits.	Safety bunds and fencing in place	
Warning signs will be placed in strategic sites around the lease.	Warning signs in place.	
Abandoned shafts will be identified and backfilled.	Completed November 1996.	
Exploration drillholes will be located, plugged and covered over.	Completed November 1996.	
The lease will be monitored for the outbreak of noxious weeds, any outbreaks will be controlled by DPI recommended methods		Regular inspections carried out by local representative. Issue will be addressed in Annual Monitoring Report.
Submit to the DME a Final Rehabilitation Report		

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APPENDIX F

WATER QUALITY DATA

Site		SW1									
Date		02-Feb-94	09-Mar-94	23-Mar-94	25-Mar-94	19-Jan-95	30-Jan-96	06-Dec-96	31-Dec-96	19-Jan-97	26-Mar-97
Lab Tested At		not recorded	not recorded	not recorded	not recorded	not recorded	ANALABS	AEL	AEL	AEL	AEL
Contained in Report		A32-280-002	A32-280-002	A32-280-002	A32-280-002	A32-280-002	A32-280-005	A32-280-005	A32-280-005	a32-280-005	
Note											
CHEMICAL PROPERTIES											
pH		4.88	2.81	3.02	2.87	6.64	3.9	5.1	6.3	3.6	5
Conductivity	uS/cm	71	1870	690	1030	157					370
Filter Residue TDS	mg/L						300	110	100	430	200
FILTERED CONSTITUENTS											
Arsenic As	mg/L	<0.01	0.97	<0.01	<0.01	0.02	<0.02	<0.02	<0.02	<0.02	<0.01
Cadmium Cd	mg/L	<0.005	0.03	0.01	0.02	<0.005	0.0051	<0.0005	0.0024	0.0078	0.0019
Calcium Ca	mg/L						6.8	3.7	3.4	28	12
Copper Cu	mg/L	<0.01	3.27	0.63	1.84	<0.01	0.38	<0.05	<0.05	0.33	0.06
Iron Fe	mg/L	0.29	102	2.4	0.2	1.9	1.9	5	3.5	1.2	0.08
Lead Pb	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.005	0.022	13	1	<0.002
Magnesium Mg	mg/L					2	7.4	2	1.8	15	7
Manganese Mn	mg/L	0.1	4.65	3.22	2.91	0.08		0.37	0.14	3.2	0.92
Nickel Ni	mg/L						0.13	<0.05	<0.05	0.23	0.06
Sodium Na	mg/L										40
Sulphur as SO4	mg/L					33	200	33	17	330	190
Zinc Zn	mg/L	0.06	2.71	1.2	1.5	0.07	0.45	0.08	<0.05	0.97	0.28

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Site		SW2											
Date		02-Feb-94	09-Mar-94	23-Mar-94	25-Mar-94	19-Jan-95	30-Jan-96	05-Mar-96	30-Oct-96	06-Dec-96	31-Dec-96	19-Jan-97	06-Feb-97
Lab Tested At		not recorded	not recorded	not recorded	not recorded	not recorded	ANALABS	ANALABS	AEL	AEL	AEL	AEL	AEL
Contained in Report		A32-280-002	A32-280-002	A32-280-002	A32-280-002		A32-280-002	A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-0005	A32-280-0005
Note													
CHEMICAL PROPERTIES													
pH		3.82	2.32	2.25	2.48	2.8	3.32	3.8	6.2	3.9	4	4.1	3.5
Conductivity	uS/cm	1210	11200	13100	12200		2670						
Filter Residue TDS	mg/L					1040		9300	900	490	350	370	2500
FILTERED CONSTITUENTS													
Arsenic As	mg/L	<0.01	27.8	15	17	0.05	0.01	0.5	<0.02	<0.02	<0.02	<0.02	<0.02
Cadmium Cd	mg/L	0.015	0.52	0.55	0.47	0.024	0.06	0.18	0.00022	0.0051	7.6	0.0062	0.049
Calcium Ca	mg/L					13.1		78	34	23	21	25	110
Copper Cu	mg/L	1.3	61.2	71	59	2.06	2.65	22	<0.05	0.31	0.13	0.25	2.1
Iron Fe	mg/L	1.9	2890	1770	1850	23	0.7	197	<0.05	0.6	<0.05	0.12	1.3
Lead Pb	mg/L	0.01	<0.1	<0.1	<0.1	<0.005	<0.01	<0.1	<0.005	<0.005	<0.005	<0.001	0.001
Magnesium Mg	mg/L					27	121	224	14	19	11	13	21
Manganese Mn	mg/L	6.15	80.1	90.6	69.1		23.1		1.7	3.1	2	2.6	74
Nickel Ni	mg/L					0.66		7.2	0.07	0.27	0.14	0.16	1.3
Sodium Na	mg/L												
Sulphur as SO4	mg/L					950	1730	9600	620	340	220	290	1900
Zinc Zn	mg/L	2.61	49.4	50.5	47.2	2.2	5.75	19	<0.05	0.7	0.44	0.76	8.9

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	Site	
	Date	25-Mar-97
	Lab Tested At	AEL
	Contained In Report	
	Note	
CHEMICAL PROPERTIES		
pH		4
Conductivity	uS/cm	1000
Filter Residue TDS	mg/L	690
FILTERED CONSTITUENTS		
Arsenic As	mg/L	<0.01
Cadmium Cd	mg/L	0.01
Calcium Ca	mg/L	33
Copper Cu	mg/L	0.45
Iron Fe	mg/L	0.12
Lead Pb	mg/L	0.002
Magnesium Mg	mg/L	29
Manganese Mn	mg/L	4.8
Nickel Ni	mg/L	0.29
Sodium Na	mg/L	78
Sulphur as SO4	mg/L	570
Zinc Zn	mg/L	1.3

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Site		SW3A												
Date		02-Feb-94	09-Mar-94	25-Mar-94	24-Nov-95	30-Jan-96	05-Mar-96	03-Apr-96	13-May-96	31-May-96	08-Dec-96	19-Jan-97	28-Mar-97
Lab Tested At		not recorded	not recorded	not recorded	ALS	ANALABS	ANALABS	ANALABS	ANALABS	ANALABS	AEL	AEL	AEL
Contained in Report		A32-280-002	A32-280-002	A32-280-002	A32-280-002	A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-0005	
Note													
CHEMICAL PROPERTIES													
pH		4.93	4.39	3.98	1.59	2.5	2.8	2	1.9	1.7	4	3.9	4.2
Conductivity	uS/cm	146	190	430	26000								1400
Filter Residue TDS	mg/L					1570	11300	26000	55600	120000	560	2100	1100
FILTERED CONSTITUENTS													
Arsenic As	mg/L	<0.01	<0.01	<0.01	<0.01	0.4	5.4	12.5	25	80	<0.02	<0.02	<0.01
Cadmium Cd	mg/L	<0.005	<0.005	<0.005	4	0.037	0.18	0.295	0.7	4.4	0.0063	0.049	0.017
Calcium Ca	mg/L				690	11	41	45	95	4250	29	94	45
Copper Cu	mg/L	0.05	0.01	0.02	565	3.66	26	56	135	340	0.23	1.3	0.49
Iron Fe	mg/L	0.29	<0.1	<0.1	2310	90	630	1100	2720	4850	0.52	14	<0.05
Lead Pb	mg/L	<0.01	<0.01	<0.01	1	<0.005	<0.1	<0.05	<0.05	<0.05	0.005	0.069	0.004
Magnesium Mg	mg/L				4250	25	184	350	780	3400	27	110	60
Manganese Mn	mg/L	0.5	0.54	1.23	821					380	3.6	16	8.1
Nickel Ni	mg/L				151	0.91	6.3	13	33	80	0.29	1.2	0.4
Sodium Na	mg/L												120
Sulphur as SO4	mg/L				118000	1450	10600	18200	12000	24000	420	1700	880
Zinc Zn	mg/L	0.25	0.18	0.28	468	2.7	18	42	90	235	0.58	2.5	0.96

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Site		SW3								
Date		30-Jan-96	05-Mar-96	05-Mar-96	13-May-96	05-Dec-96	31-Dec-96	19-Jan-97	06-Feb-97	26-Mar-97
Lab Tested At		ANALABS	ANALABS	ANALABS	ANALABS	AEL	AEL	AEL	AEL	AEL
Contained In Report		A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-0005	A32-280-0005	
Note										
CHEMICAL PROPERTIES										
pH		6.6	6.5	7.3	7.3	6	6.5	6	5.6	6.4
Conductivity	uS/cm									120
Filter Residue TDS	mg/L	130	140	190	180	130	150	130	170	80
FILTERED CONSTITUENTS										
Arsenic As	mg/L	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.01
Cadmium Cd	mg/L	0.0006	<0.0005	<0.0005	<0.0005	<0.0005	0.0008	<0.0005	<0.0005	<0.005
Calcium Ca	mg/L	2.5	4.3	7.3	6.7	2.4	3.7	4.4	5.5	2.4
Copper Cu	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron Fe	mg/L	0.84	1.53	0.54	0.8	6.5	1.5	3	<0.05	0.2
Lead Pb	mg/L	<0.005	<0.1	<0.05	<0.05	0.006	0.006	0.004	0.01	<0.002
Magnesium Mg	mg/L	1.9	1.9	2.6	3.5	1.5	1.7	2.2	2.3	1.9
Manganese Mn	mg/L			<0.05		<0.05	0.09	<0.05	<0.05	<0.05
Nickel Ni	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sodium Na	mg/L									16
Sulphur as SO4	mg/L	35	53	74	58	20	36	27	71	39
Zinc Zn	mg/L	<0.05	<0.05	<0.05	0.14	<0.05	<0.05	<0.05	<0.05	<0.05

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Site		SW4								
Date		05-Jul-96	07-Aug-96	05-Sep-96	09-Oct-96	30-Oct-96	30-Nov-96	31-Dec-96	28-Mar-97	31-Mar-97
Lab Tested At		ANALABS	ANALABS	ANALABS	ANALABS	AEL	AEL	AEL	AEL	AEL
Contained In Report		A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005		
Note										
CHEMICAL PROPERTIES										
pH		7.8	7.6	8.3	7.9	7.5	7	6.8	6.6	6.8
Conductivity	uS/cm								150	160
Filter Residue TDS	mg/L	210	270	410	470	530	300	290	170	190
FILTERED CONSTITUENTS										
Arsenic As	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02		0.05	<0.01	<0.01
Cadmium Cd	mg/L	<0.0005	<0.0005	0.0008	<0.0005	<0.0005	0.0002	0.003	<0.0005	<0.0005
Calcium Ca	mg/L	9.5	10	15	20	22	12	7.9	4.3	4.3
Copper Cu	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron Fe	mg/L	0.67	0.15	0.5	0.33	1.3	0.76	2.7	0.38	0.5
Lead Pb	mg/L	<0.05	<0.05	<0.05	<0.05	<0.005	<0.05	0.006	0.002	0.003
Magnesium Mg	mg/L	4.3	5	6.8	8.4	8.6	5	3.4	3.1	22
Manganese Mn	mg/L	<0.05	<0.05	<0.05	<0.05	0.13	0.18	0.12	<0.05	<0.05
Nickel Ni	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sodium Na	mg/L								19	23
Sulphur as SO4	mg/L	76	72	78	120	170	140	68	66	73
Zinc Zn	mg/L	<0.05	0.08	<0.05	<0.05	0.16	<0.05	<0.05	<0.05	<0.05

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Site		SW5					
Date		06-Dec-96	31-Dec-96	19-Jan-97	06-Feb-97	28-Mar-97	31-Mar-97
Lab Tested At		AEL	AEL	AEL	AEL	AEL	AEL
Contained in Report		A32-280-005	A32-280-005	A32-280-0005	A32-280-0005		
Note							
CHEMICAL PROPERTIES							
pH		6	6	5.7	5.4	5.7	5.4
Conductivity	uS/cm					130	650
Filter Residue TDS	mg/L	160	160	180	410	120	440
FILTERED CONSTITUENTS							
Arsenic As	mg/L	<0.02	<0.02	<0.02	<0.02	<0.01	<0.01
Cadmium Cd	mg/L	<0.0005	0.0012	<0.0005	0.0005	<0.005	0.0046
Calcium Ca	mg/L	4	6.3	11	10	3.3	24
Copper Cu	mg/L	0.05	0.05	<0.05	<0.05	<0.05	<0.05
Iron Fe	mg/L	6.2	4	0.72	<0.05	0.3	<0.05
Lead Pb	mg/L	0.024	0.023	0.003	20	0.003	<0.001
Magnesium Mg	mg/L	2.8	2.5	3.2	4.5	2	20
Manganese Mn	mg/L	0.22	0.51	0.34	0.22	0.12	1.9
Nickel Ni	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sodium Na	mg/L					16	57
Sulphur as SO4	mg/L	24	42	75	150	50	420
Zinc Zn	mg/L	<0.05	0.05	0.07	<0.05	<0.05	0.2

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Site		Golden Butterfly Pit												
Date		08-Feb-91	20-Aug-91	05-Mar-92	16-Feb-93	11-Nov-93	02-Feb-94	21-Apr-94	19-Jan-95	24-Nov-95	05-Mar-98	03-Apr-98	15-May-96	31-May-96
Lab Tested At		ALSB	ALSB	ALSB	ALSB	ALSB	not recorded	not recorded	not recorded	ALS	ANALABS	ANALABS	ANALABS	ANALABS
Contained in Report					4971-7 Dec93	4971-7 Dec93	A32-280-002	A32-280-002	A32-280-002	A32-280-002	A32-280-005	A32-280-005	A32-280-005	A32-280-005
Note														
CHEMICAL PROPERTIES														
pH		2.6	2.45	2.24	2.33	2.53	2.53	2.32		1.79	3.4	2.1	2.2	2.1
Conductivity	uS/cm	2670	4910	5180	5340	6690	6320			6540				
Filter Residue TDS	mg/L							9400			8200	8500	9700	10000
FILTERED CONSTITUENTS														
Arsenic As	mg/L	1.05	1.36	2.05	2.31	4.2	3.5			2.3	1.75	2.1	2.9	5
Cadmium Cd	mg/L	0.1	0.297	0.3	0.26	0.31	0.275	0.3		0.4	0.19	0.21	0.275	0.37
Calcium Ca	mg/L							308		345	241	205	260	320
Copper Cu	mg/L	12.4	33.8	28.7	26.8	38.1	33.1	32.9		39.6	24.4	26	32	33
Iron Fe	mg/L	310	971		19.4	1010	968	748		957	640	680	640	830
Lead Pb	mg/L	0.03	0.05	0.06	48.9	<0.01	<0.01	<0.1		<0.1	<0.1	<0.05	<0.05	<0.05
Magnesium Mg	mg/L							145		185	136	140	165	190
Manganese Mn	mg/L	24.2	51	47.9	651	69.6	6.16	65.6		92.1				140
Nickel Ni	mg/L									9	5.6	5.8	6.8	7.5
Sodium Na	mg/L													
Sulphur as SO4	mg/L							6720		8060	8000	690	6600	2000
Zinc Zn	mg/L	8.66	20.9	19.2	0.06	27.2	27.3	24.4		35.5	21	22.4	27.8	27.5

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Rele

Site		Golden Butterfly Pit (continued)							
Date		05-Jul-96	07-Aug-96	05-Sep-96	09-Oct-96	30-Oct-96	30-Nov-96	31-Dec-96	31-Mar-97
Lab Tested At		ANALABS	ANALABS	ANALABS	ANALABS	AEL	AEL	AEL	AEL
Contained in Report		A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	
Note									
CHEMICAL PROPERTIES									
pH		2.3	2.2	2.1	2.3	2.1	2.2	2.3	2.3
Conductivity	uS/cm								6700
Filter Residue TDS	mg/L	9900	9700	8700	12000	11000	11000	10000	9400
FILTERED CONSTITUENTS									
Arsenic As	mg/L	4.5	48	3.5	<0.2	4.4	3.4	3.1	3.2
Cadmium Cd	mg/L	0.6	0.3	0.32	0.00033	0.00032	0.00033	0.16	0.27
Calcium Ca	mg/L	250	250	300	290	250	250	280	180
Copper Cu	mg/L	33.8	34	34	33	34	35	31	26
Iron Fe	mg/L	1100	1000	860	930	940	890	760	67
Lead Pb	mg/L	<0.05	<0.05	<0.05	<0.05	<0.025	<0.05	<0.005	<0.01
Magnesium Mg	mg/L	175	165	180	200	190	200	190	180
Manganese Mn	mg/L	82	7.8	69	79	88	89	79	67
Nickel Ni	mg/L	7.7	7.8	7.2	7.4	8.7	8.5	8.1	4.4
Sodium Na	mg/L								160
Sulphur as SO4	mg/L	5500	7600	7400	9500	7900	8400	7900	7400
Zinc Zn	mg/L	27	28	30	32	30	29	28	22

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Site		Golden Butterfly North Pit												
Date		08-Feb-91	20-Aug-91	05-Mar-92	16-Jul-92	16-Feb-93	11-Nov-93	02-Feb-94	19-Jan-95	24-Nov-95	05-Mar-96	03-Apr-96	13-May-96	31-May-96
Lab Tested At		ALSB	ALSB	ALSB	ALSB	ALSB	ALSB	not recorded	not recorded	ALS	ANALABS	ANALABS	ANALABS	ANALABS
Contained in Report						4371-7 Dec93	4371-7 Dec93	A32-280-002	A32-280-002	A32-280-002	A32-280-005	A32-280-005	A32-280-005	A32-280-005
Note														
CHEMICAL PROPERTIES														
pH		6.35	6.79	6.1	7.17	6.69	5.88	6	7.38	7.21	8.2	7.7	7.2	7.8
Conductivity	uS/cm	185	226	259	303	281	351	212	259	381				
Filter Residue TDS	mg/L										190	185	200	220
FILTERED CONSTITUENTS														
Arsenic As	mg/L	0.01	0.02	<0.01	0.01	<0.01	0.04	0.01	0.02	0.02	0.04	0.02	0.02	0.03
Cadmium Cd	mg/L	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0005	<0.0005	<0.0005	<0.0005
Calcium Ca	mg/L									47	21.3	21	15	21.8
Copper Cu	mg/L	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.03	0.01	0.02	<0.05	0.11	<0.05	<0.05
Iron Fe	mg/L	0.33	0.9		<0.1	0.04	0.61	0.18	<0.1	<0.1	0.13	0.12	0.14	0.06
Lead Pb	mg/L	0.01	<0.01	<0.01	<0.01	0.23	0.02	<0.01	<0.01	<0.01	<0.1	<0.05	<0.05	<0.05
Magnesium Mg	mg/L									3	24	3.4	3.6	3.1
Manganese Mn	mg/L	0.01	0.01	0.15	0.02	<0.1	0.53	0.38	0.04	0.04				<0.05
Nickel Ni	mg/L									<0.01	0.07	<0.05	<0.05	<0.05
Sodium Na	mg/L													
Sulphur as SO4	mg/L									69	650	72	59	57
Zinc Zn	mg/L	<0.01	<0.01	0.02	0.01	<0.01	0.02	0.08	0.04	0.05	<0.05	<0.05	0.1	<0.05

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Site		Golden Butterfly North Pit							
Date		05-Jul-96	07-Aug-96	05-Sep-96	09-Oct-96	30-Oct-96	30-Nov-96	31-Dec-96	31-Mar-97
Lab Tested At		ANALABS	ANALABS	ANALABS	ANALABS	AEL	AEL	AEL	AEL
Contained in Report		A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	
Note									
CHEMICAL PROPERTIES									
pH		7.6	8	7.9	8.1	7.6	7.7	7.2	7.3
Conductivity	uS/cm								270
Filter Residue TDS	mg/L	210	220	280	220	250	240	250	170
FILTERED CONSTITUENTS									
Arsenic As	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.01
Cadmium Cd	mg/L	<0.0005	<0.0005	<0.0005	0.0008	<0.0005	<0.0005	0.0087	<0.0005
Calcium Ca	mg/L	22.5	22	20	23	25	23	20	12
Copper Cu	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	
Iron Fe	mg/L	0.13	0.05	<0.05	<0.05	<0.05	0.1	0.52	<0.05
Lead Pb	mg/L	<0.05	<0.05	<0.05	<0.05	<0.005	<0.05	<0.005	<0.001
Magnesium Mg	mg/L	4.5	3.9	4.4	4.7	4.6	4.2	4.4	3.7
Manganese Mn	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.29	<0.05
Nickel Ni	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sodium Na	mg/L								34
Sulphur as SO4	mg/L	64	60	67	64	72	72	59	68
Zinc Zn	mg/L	<0.05	0.07	<0.05	<0.05	0.07	0.22	<0.05	<0.05

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Site		Lady Isabella Pit												
Date		20-Feb-90	20-Aug-91	05-Mar-92	06-Mar-92	16-Feb-93	11-Nov-93	02-Feb-94	21-Apr-94	19-Jan-95	24-Nov-95	05-Mar-96	03-Apr-96	13-May-96
Lab Tested At		ALSB	ALSB	ALSB	SMTRS	ALSB	ALSB	not recorded	not recorded	not recorded	ALS	ANALABS	ANALABS	ANALABS
Contained in Report						4571-7 Dec93	4571-7 Dec93	A32-280-002	A32-280-002	A32-280-002	A32-280-002	A32-280-005	A32-280-005	A32-280-005
Note														
CHEMICAL PROPERTIES														
pH		4.15	3.36	3.17	3.5	3.24	3.18	3.47	2.97	3.39	3.74	4.3	3.4	3.4
Conductivity	uS/cm	570	608	781	830	970	1110	1090		1280	1045			
Filter Residue TDS	mg/L	460							870			930	930	940
FILTERED CONSTITUENTS														
Arsenic As	mg/L	0.26	<0.01	0.01	15	<0.01	<0.01	<0.01	n/r	<0.01	<0.01	<0.02	<0.02	0.03
Cadmium Cd	mg/L	<0.0005	0.135	0.15	0.1	0.16	0.23	0.205	0.2	0.265	0.21	0.155	0.185	0.22
Calcium Ca	mg/L	20						n/r	70	n/r	81	59	55	57
Copper Cu	mg/L	0.42	1.34	1.44	1.5	1.68	2.05	1.92	1.73	2.12	1.75	1.36	1.38	1.45
Iron Fe	mg/L	11	1.89	?	0.6	4.07	0.22	0.34	0.5	0.5	0.4	0.76	0.62	0.32
Lead Pb	mg/L	0.01	<0.01	<0.01	0.1	3.71	0.04	<0.01	<0.01	<0.01	<0.01	<0.1	<0.05	<0.05
Magnesium Mg	mg/L	9							33	37	38	28.2	40.5	28
Manganese Mn	mg/L	1.4	2.62	3.01	3.2	0.5	5	4.97	4.58	6.03	6.11			
Nickel Ni	mg/L										0.73	0.6	0.59	0.57
Sodium Na	mg/L	59												
Sulphur as SO4	mg/L	220			310				482	555	679	680	660	670
Zinc Zn	mg/L	0.55	2.81	3.09	3.2	<0.01	5.31	6.04	4.88	6.37	5.7	4.5	4.6	4.99

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Site		Lady Isabella Pit (continued)								
Date		31-May-96	05-Jul-96	07-Aug-96	05-Sep-96	09-Oct-96	31-Oct-96	30-Nov-96	31-Dec-96	31-Mar-97
Lab Tested At		ANALABS	ANALABS	ANALABS	ANALABS	ANALABS	AEL	AEL	AEL	AEL
Contained in Report		A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	A32-280-005	
Note										
CHEMICAL PROPERTIES										
pH		3.3	3.5	3.3	3.4	3.4	3.2	3.3	3.4	3.5
Conductivity	uS/cm									990
Filter Residue TDS	mg/L	980	930	960	940	1000	1000	970	910	850
FILTERED CONSTITUENTS										
Arsenic As	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.01
Cadmium Cd	mg/L	0.365	0.19	0.15	0.09	0.2	0.00022	0.03	0.02	0.16
Calcium Ca	mg/L	65	61	62	69	65	70	57	60	43
Copper Cu	mg/L	1.48	1.53	1.58	1.6	1.6	1.7	1.5	1.4	1
Iron Fe	mg/L	0.36	0.31	0.3	0.23	0.21	0.92	0.91	1.3	0.46
Lead Pb	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.005	<0.05	<0.005	0.005
Magnesium Mg	mg/L	32	33	33	36	35	36	32	31	26
Manganese Mn	mg/L	5.5	6.4	5.6	7.1	5.8	6.7	6.1	5.5	4.2
Nickel Ni	mg/L	0.63	0.64	0.6	0.64	0.64	0.74	0.73	0.67	0.43
Sodium Na	mg/L									60
Sulphur as SO4	mg/L	620	550	490	480	610	660	600	520	580
Zinc Zn	mg/L	4.9	4.7	4.85	5.9	5.4	6.9	6.6	4.8	3.5

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Site		Content Pit											
Date		20-Feb-90	20-Aug-91	20-Aug-91	05-Mar-92	16-Feb-93	11-Nov-93	02-Feb-94	21-Apr-94	19-Jan-95	24-Nov-95	05-Mar-96	03-Apr-96
Lab Tested At		ALSB	ALSB	not recorded	ALSB	ALSB	ALSB	not recorded	not recorded	not recorded	ALS	ANALABS	ANALABS
Contained in Report						4571-7 Dec93	4571-7 Dec93	A52-280-002	A32-280-002	A32-280-002	A32-280-002	A32-280-005	A32-280-005
Note													
CHEMICAL PROPERTIES													
pH		2.85	2.87	2.07	2.75	2.84	3.07	3.11	2.81	3.03	3.15	4.2	3
Conductivity	uS/cm	1560	1420	1420	1420	1580	1640	1670	n/r	1780	1845		
Filter Residue TDS	mg/L	1260							1270			1200	1200
FILTERED CONSTITUENTS													
Arsenic As	mg/L	0.27	0.08	0.08	0.02	<0.01	0.04	<0.01	n/r	0.06	0.05	0.03	<0.02
Cadmium Cd	mg/L	0.035	0.027	0.027	0.028	0.025	0.035	0.015	0.02	<0.005	0.01	0.019	0.044
Calcium Ca	mg/L	80							n/r	n/r	92	73	69
Copper Cu	mg/L	9.3	2.56	2.56	2.43	2.34	2.11	1.85	1.4	1.5	1.02	0.86	0.83
Iron Fe	mg/L	27	8.21	8.21	?	1.94	3.82	3.65	7.3	3.9	3.7	2.04	1.83
Lead Pb	mg/L	<0.01	<0.01	<0.01	<0.01	4	0.04	<0.01	<0.01	<0.01	<0.01	<0.1	<0.05
Magnesium Mg	mg/L	25							n/r	41	44	38.7	41
Manganese Mn	mg/L	3.3	3.13	3.13	3.4	2.5	4.9	4.86	4.36	5.56	5.36		
Nickel Ni	mg/L								n/r	n/r	n/r	0.51	0.48	0.48
Sodium Na	mg/L	110											
Sulphur as SO4	mg/L	680							676	783	923	870	850
Zinc Zn	mg/L	1.1	1.58	<0.01	1.62	<0.01	2.18	2.52	1.84	2.3	1.95	1.66	1.61

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Site		
Date		31-Mar-97
Lab Tested At		AEL
Contained In Report		
Note		
CHEMICAL PROPERTIES		
pH		3.3
Conductivity	uS/cm	1700
Filter Residue TDS	mg/L	1300
FILTERED CONSTITUENTS		
Arsenic As	mg/L	<0.01
Cadmium Cd	mg/L	0.018
Calcium Ca	mg/L	64
Copper Cu	mg/L	0.6
Iron Fe	mg/L	4.3
Lead Pb	mg/L	0.003
Magnesium Mg	mg/L	40
Manganese Mn	mg/L	6
Nickel Ni	mg/L	0.38
Sodium Na	mg/L	140
Sulphur as SO4	mg/L	1000
Zinc Zn	mg/L	1.5

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Site		GBMB1										
Date		29-May-89	13-Jul-89	30-Oct-89	02-Nov-89	14-Nov-89	05-Jan-90	08-Feb-90	20-Feb-90	09-Mar-94	05-Mar-95	31-May-96
Lab Tested At		ALSB	not recorded	not recorded	not recorded	not recorded	not recorded	not recorded	not recorded	not recorded	ANALABS	ANALABS
Contained in Report		4101-1 Jun 89	4015/2	4015/2	4133	4133	4015/2	4015/2	4015/2	A32-280-002	A32-280-005	A32-280-005
Note												
CHEMICAL PROPERTIES												
pH		5.8	6.15	3.9	3.9	5.5	3.6	3.85	3.9	7.68	7.8	7.4
Conductivity	µS/cm	605	610	600	600		590	600	560	3070	805	1045
Filter Residue TDS	mg/L	390	510	510			520	420			570	560
FILTERED CONSTITUENTS												
Arsenic As	mg/L	0.02	0.06	0.02	0.02	0.03	0.01	<0.01		<0.01	<0.02	0.03
Cadmium Cd	mg/L	<0.01	<0.01	<0.01			<0.01	0.03	0.022	<0.005	0.0005	0.0013
Calcium Ca	mg/L	12	11	10	10	12	10	11				
Chloride												
Copper Cu	mg/L	<0.01	<0.01	0.05			0.01	0.04	0.03	0.05	<0.05	0.08
Iron Fe	mg/L	6.2		3.7	3.7		2.1	2.5	3.2	1.2	1.96	0.86
Lead Pb	mg/L	0.08	0.14	0.23	0.23	0.24	0.14	0.26	0.19	0.08	0.9	<0.05
Magnesium Mg	mg/L	4.6	5	4.3			8.5	8.3			8.5	8.5
Manganese Mn	mg/L	0.55	0.5	0.53			0.45	0.56	0.52	0.21		
Nickel Ni	mg/L											
Potassium K	mg/L	20	20	82			21	19				
Sodium Na		89	91	17	82		62	67			130	119
Sulphur as SO4	mg/L	240	210	230	230	250	170	200			200	180
Zinc Zn	mg/L	0.34	0.04	0.2	0.2	0.3	0.26	0.35	0.31	0.17	0.15	0.05

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Woodward-Clyde

Releas

Site		GBMB1 (continued)		
Date		25-Sep-96	02-Jan-97	31-Mar-97
Lab Tested At		ANALABS	AEL	AEL
Contained In Report		A32-280-005	A32-280-006	
Note				
CHEMICAL PROPERTIES				
pH		6.6	6.5	6.9
Conductivity	µS/cm	800	760	810
Filter Residue TDS	mg/L	560	580	540
FILTERED CONSTITUENTS				
Arsenic As	mg/L	<0.02	<0.02	<0.01
Cadmium Cd	mg/L	0.0009	<0.0005	<0.0005
Calcium Ca	mg/L			11
Chloride				
Copper Cu	mg/L	<0.05	0.15	<0.05
Iron Fe	mg/L	11	3.9	1.6
Lead Pb	mg/L	1.4	130	0.018
Magnesium Mg	mg/L	8.4	8.5	8.8
Manganese Mn	mg/L			1
Nickel Ni	mg/L			
Potassium K	mg/L			
Sodium Na		220	120	120
Sulphur as SO4	mg/L	240	220	200
Zinc Zn	mg/L	0.24	0.09	<0.05

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Site		GBMB 2										
Date		29-May-89	13-Jul-89	30-Oct-89	02-Nov-89	05-Jan-90	06-Feb-90	20-Feb-90	09-Mar-94	24-Nov-95	05-Mar-96	31-May-96
Lab Tested At		not recorded	not recorded	not recorded	not recorded	not recorded	not recorded	not recorded	not recorded	ALS	ANALABS	ANALABS
Contained in Report		4015/2	4015/2	4015/2	4193	4015/2	4015/2	4015/2	A32-280-002	A32-280-002	A32-280-006	A32-280-005
Note												
CHEMICAL PROPERTIES												
pH		8.15	7.3	7.6	7.6	7.6	7.8	7.65	7.92	6.48	8.3	7.5
Conductivity	µS/cm	1970	2040	2120	2120	2070	2130	2010	947	1948	1620	2220
Filter Residue TDS	mg/L	1290	1400	1450		1480	1360				1400	1400
FILTERED CONSTITUENTS												
Arsenic As	mg/L	0.04	0.07	0.05	0.05	0.03	0.02		0.02	<0.01	<0.02	<0.02
Cadmium Cd	mg/L	<0.01	<0.01	<0.01		<0.01	<0.005	0.036	<0.005	<0.005	<0.0005	0.0082
Calcium Ca	mg/L	57	61	65	65	65	65			70		
Chloride												
Copper Cu	mg/L	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	0.03	0.01	<0.05	<0.05
Iron Fe	mg/L	1.7		1.8	1.8	1	0.87	1	0.5	<0.1	1.53	0.06
Lead Pb	mg/L	0.7	0.28	0.12	0.12	0.19	<0.01	0.01	0.03	<0.01	0.3	<0.05
Magnesium Mg	mg/L	16	17	18		16	15			17	15.2	13.6
Manganese Mn	mg/L	0.44	0.44	0.68		0.45	0.53	0.52	0.09	0.68		
Nickel Ni	mg/L									<0.01		
Potassium K	mg/L	28	28	27		26	23					
Sodium Na		390	400	350	350	350	360				370	370
Sulphur as SO4	mg/L	580	500	580	580	500	590			605	730	680
Zinc Zn	mg/L	0.15	0.06	0.03	0.03	0.02	0.02	0.09	0.08	0.12	0.11	<0.05

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Woodward-Clyde

Rele

Site		GBMB 2 (continued)		
Date		25-Sep-96	02-Jan-97	31-Mar-97
Lab Tested At		ANALABS	AEL	AEL
Contained in Report		A32-280-005	A32-280-005	
Note				
CHEMICAL PROPERTIES				
pH		7.3	7.2	7.2
Conductivity	µS/cm	2000	1900	2100
Filter Residue TDS	mg/L	1400	1500	1400
FILTERED CONSTITUENTS				
Arsenic As	mg/L	<0.02	<0.02	<0.01
Cadmium Cd	mg/L	0.0012	0.0005	<0.005
Calcium Ca	mg/L			63
Chloride				
Copper Cu	mg/L	<0.05	<0.05	<0.05
Iron Fe	mg/L	0.19	0.53	0.2
Lead Pb	mg/L	<0.05	0.022	0.014
Magnesium Mg	mg/L	17	18	19
Manganese Mn	mg/L			0.07
Nickel Ni	mg/L			
Potassium K	mg/L			
Sodium Na		370	350	370
Sulphur as SO4	mg/L	640	660	800
Zinc Zn	mg/L	0.07	<0.05	<0.05

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Woodward-Clyde

Rele

Site		GBMB3									
Date		29-May-89	19-Jul-89	30-Oct-89	02-Nov-89	05-Jan-90	06-Feb-90	20-Feb-90	09-Mar-94	05-Mar-96	31-May-96
Lab Tested At		ALSB	not recorded	not recorded	not recorded	not recorded	not recorded	not recorded	not recorded	ANALABS	ANALABS
Contained in Report		4101-1 Jun 89	4015/2	4015/2	4133	4015/2	4015/2	4015/2	A32-280-002	A32-280-005	A32-280-005
Note											
CHEMICAL PROPERTIES											
pH		7.1	6.65	7.25	7.25	7.2	7.3	7.05	6.18	6.3	5.8
Conductivity	µS/cm	445	420	410	410	440	460	425	5460	58	78
Filter Residue TDS	mg/L	315	280	300		500	310			77	74
FILTERED CONSTITUENTS											
Arsenic As	mg/L	0.04	0.03	0.01	0.01	0.02	<0.01		<0.01	<0.02	<0.02
Cadmium Cd	mg/L	<0.01	<0.01	<0.01		<0.01	<0.005	0.008	<0.005	<0.0005	0.0016
Calcium Ca	mg/L	12	9	9.3	9.3	9.8	9				
Chloride											
Copper Cu	mg/L	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	0.03	<0.05	<0.05
Iron Fe	mg/L	2.8		1.8	1.8	3.7	0.01	2.4	0.5	8	0.13
Lead Pb	mg/L	0.54	0.04	0.02	0.03	0.37	0.01	0.01	0.03	0.1	<0.05
Magnesium Mg	mg/L	4.6	5	4.9		4.6	4			<0.5	<0.5
Manganese Mn	mg/L	0.09	1.3	0.09		0.15	0.18	0.15	0.09		
Nickel Ni	mg/L										
Potassium K	mg/L	8.1	7	6.5		6.2	5				
Sodium Na		76	75	72	72	75	68			12.8	11.3
Sulphur as SO4	mg/L	35	110	11	11	17	8			<5	<5
Zinc Zn	mg/L	0.24	0.08	<0.01	<0.01	0.05	<0.01	0.02	0.08	<0.05	<0.05

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Woodward-Clyde

Release

Site		GBMB3 (continued)		
Date		25-Sep-96	02-Jan-97	31-Mar-97
Lab Tested At		ANALABS	AEL	AEL
Contained In Report		A32-280-005	A32-280-005	
Note				
CHEMICAL PROPERTIES				
pH		5.3	5.6	6
Conductivity	µS/cm	70	88	89
Filter Residue TDS	mg/L	76	250	250
FILTERED CONSTITUENTS				
Arsenic As	mg/L	<0.02	<0.02	<0.01
Cadmium Cd	mg/L	<0.0005		<0.0005
Calcium Ca	mg/L			2.6
Chloride				
Copper Cu	mg/L	<0.05	<0.05	<0.05
Iron Fe	mg/L	2.4	5.8	3.3
Lead Pb	mg/L	<0.05	0.07	0.041
Magnesium Mg	mg/L	<0.5	1.4	15
Manganese Mn	mg/L			<0.05
Nickel Ni	mg/L			
Potassium K	mg/L			
Sodium Na		10	15	14
Sulphur as SO4	mg/L	<5	<5	27
Zinc Zn	mg/L	<0.05	0.15	<0.05

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Woodward-Clyde

Rele

Site		GBMB4										
Date		29-May-89	13-Jul-89	30-Oct-89	02-Nov-89	05-Jan-90	08-Feb-90	20-Feb-90	09-Mar-94	24-Nov-95	05-Mar-96	31-May-96
Lab Tested At		not recorded	not recorded	not recorded	not recorded	not recorded	not recorded	not recorded	not recorded	ALS	ANALABS	ANALABS
Contained in Report		4015/2	4015/2	4015/2	4133	4015/2	4015/2	4015/2	A32-280-002	A32-280-002	A32-280-005	A32-280-005
Note												
CHEMICAL PROPERTIES												
pH		6.5	5.95	6.5	6.5	6.3	6.35	5.95	8.25	5.35	7.1	5.9
Conductivity	µS/cm	225	190	190	190	220	220	200	4280	234	185	251
Filter Residue TDS	mg/L	150	240	220		210	190				210	200
FILTERED CONSTITUENTS												
Arsenic As	mg/L	0.02	0.02	0.02	0.02	0.02	0.01		<0.01	<0.01	0.02	<0.02
Cadmium Cd	mg/L	<0.01	<0.01	<0.0.1		<0.0.1	<0.005	0.025	<0.005	<0.005	0.0005	0.0042
Calcium Ca	mg/L	2.5	1	1.2	1.2	1.7	1.4			2		
Chloride												
Copper Cu	mg/L	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	0.03	0.01	<0.05	<0.05
Iron Fe	mg/L	2.3		2.2	2.2	2.6	2.5	2.5	0.5	<0.1	2.15	<0.05
Lead Pb	mg/L	0.16	0.07	0.12	0.12	0.13	0.12	0.11	<0.01	0.04	0.3	<0.05
Magnesium Mg	mg/L	1.6	1	0.86		1.1	0.7			1	1	1
Manganese Mn	mg/L	0.1	0.02	<0.01		0.04	0.04	0.04	0.11	0.04		
Nickel Ni	mg/L									<0.01		
Potassium K	mg/L	14	12	11		11	11					
Sodium Na		37	28	28	28	31	26				33.3	23
Sulphur as SO4	mg/L	20	65	17	17	11	15			24	32	23
Zinc Zn	mg/L	0.45	0.09	0.02	0.02	<0.01	<0.01	0.06	0.04	0.1	0.06	0.06

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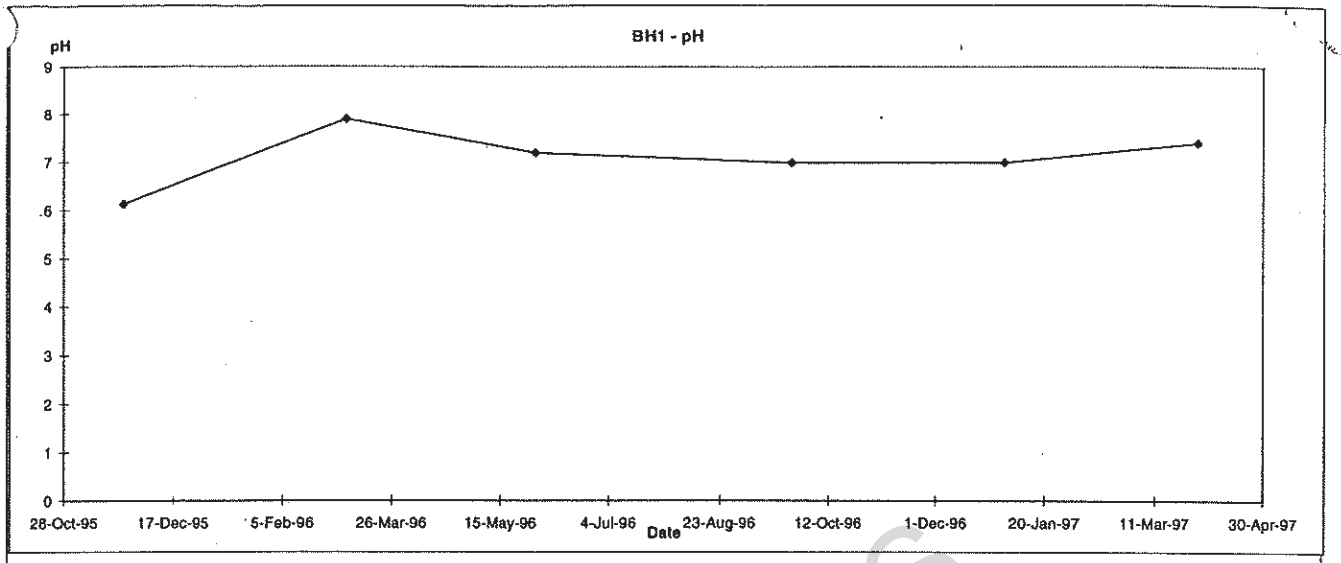

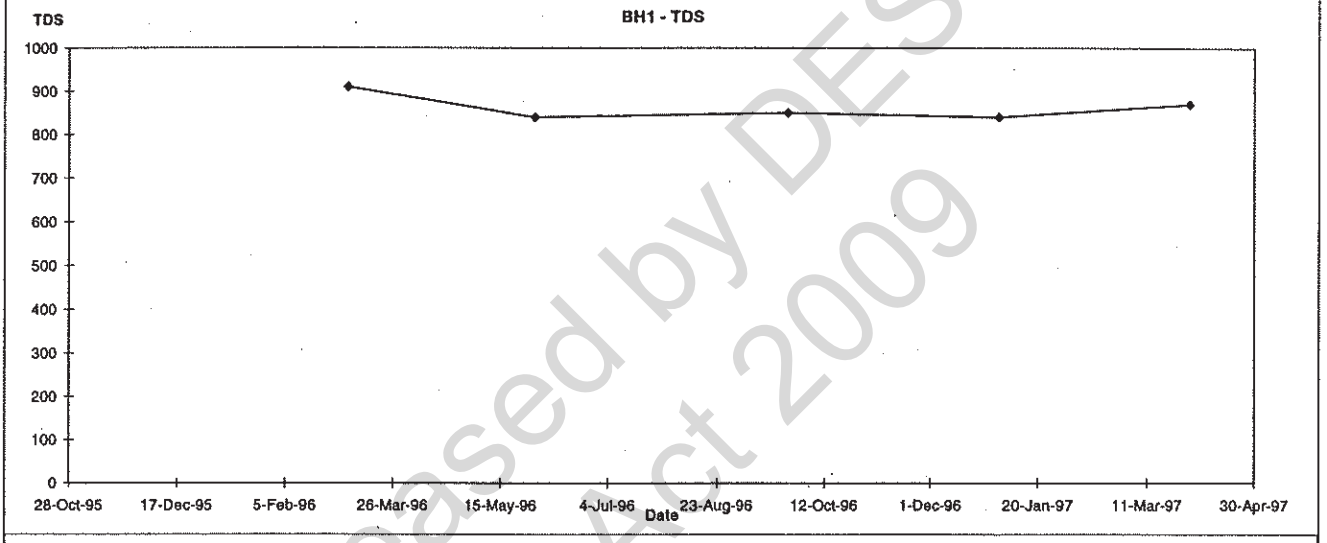

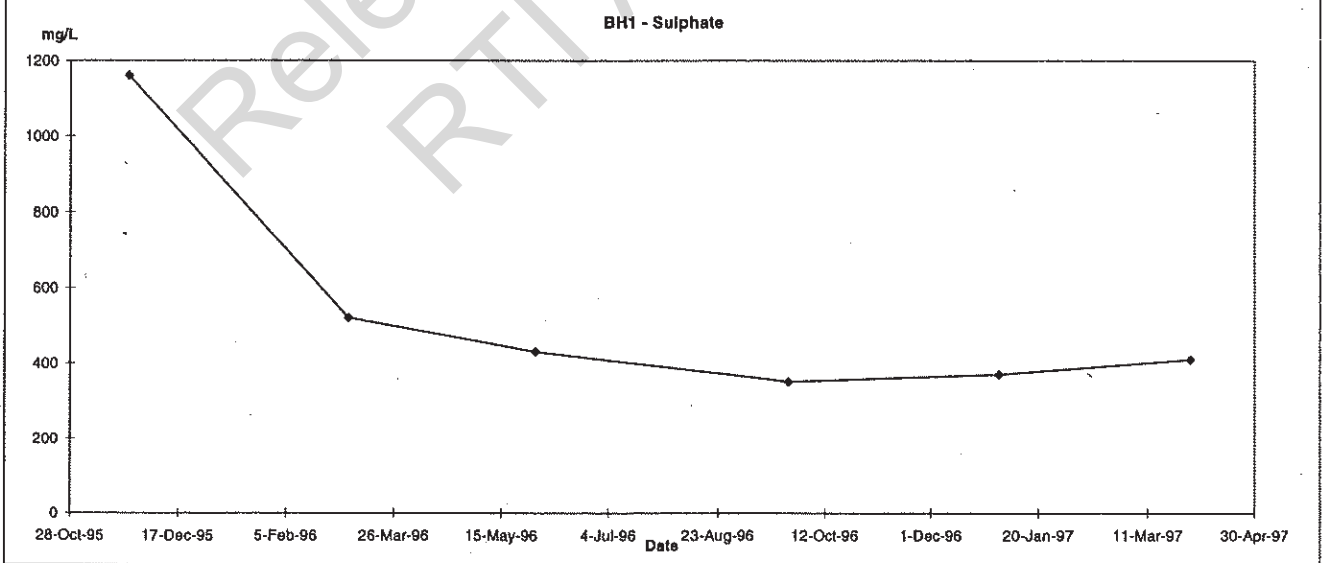

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Date	Rev.	Description	Dwn	Chk'd
10/30/96	A	A32/00280/0005/Graph2	MRK	

Woodward-Clyde

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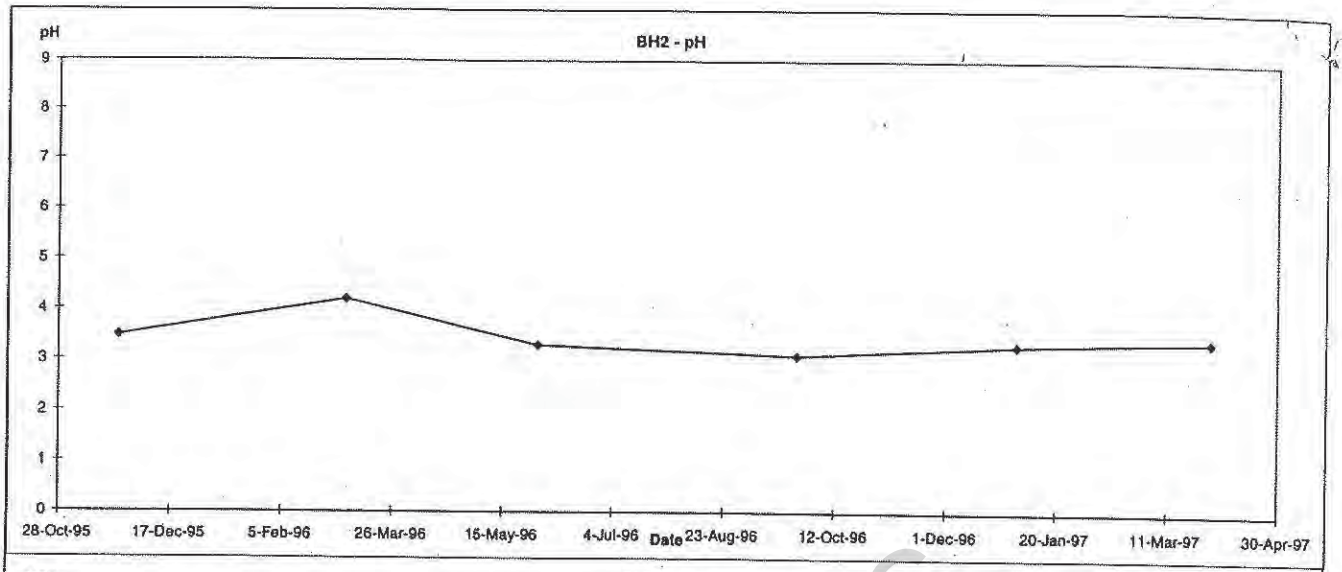
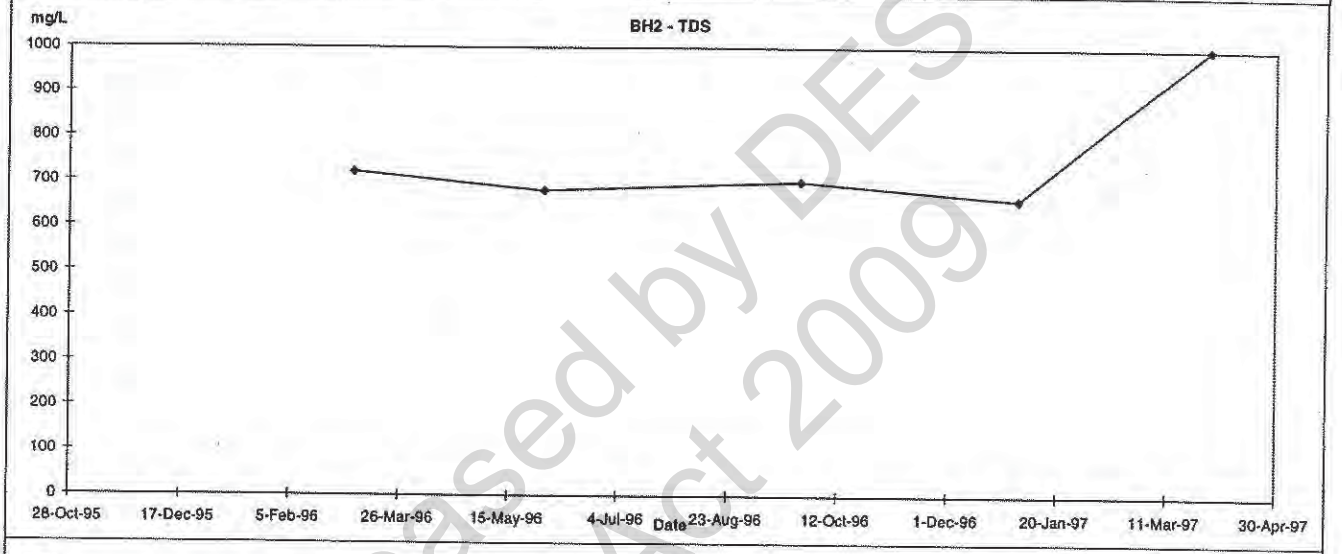
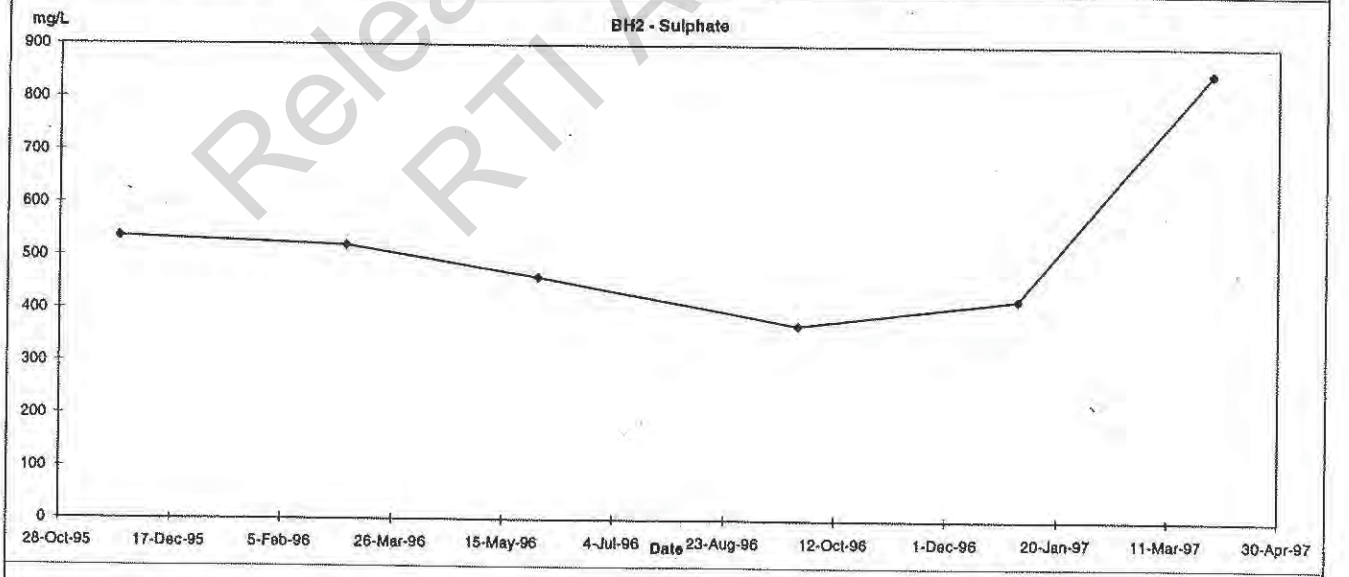
PANCONTINENTAL MINING LIMITED
CROYDON GOLD MINE
WATER QUALITY MONITORING
BH 1

Project:	Drawing:	Figure:
a32/280/0005		10

Relea







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Date	Rev.	Description	Dwn	Chk'd
10/30/96	A	A32/00280/0005/Graph2	MRK	

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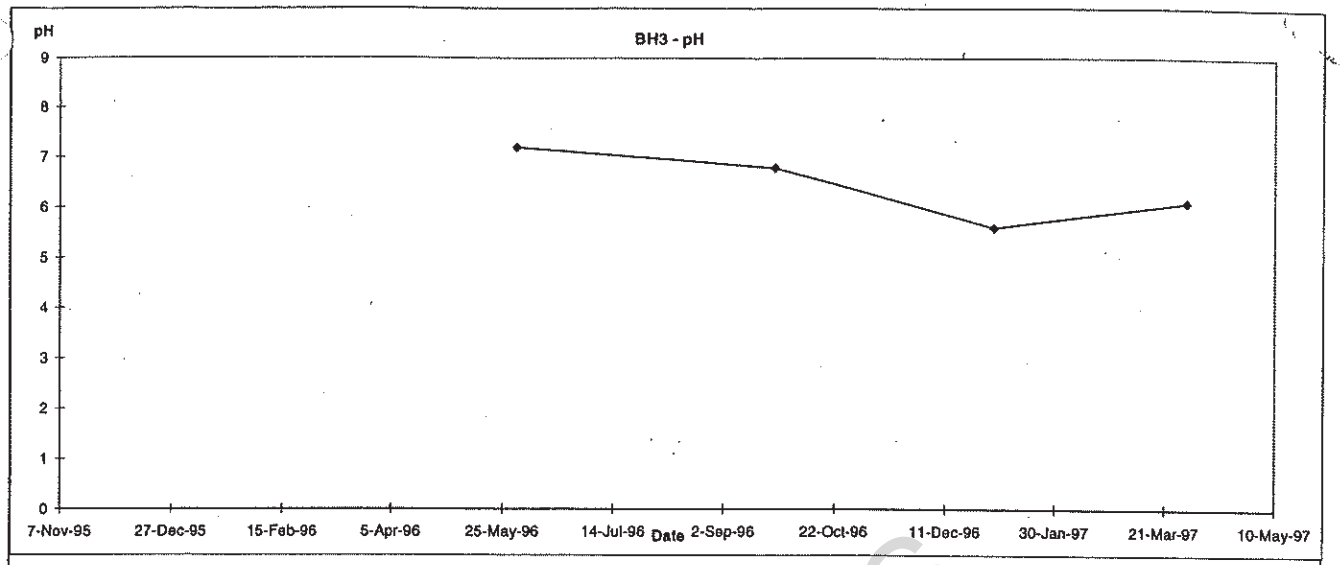
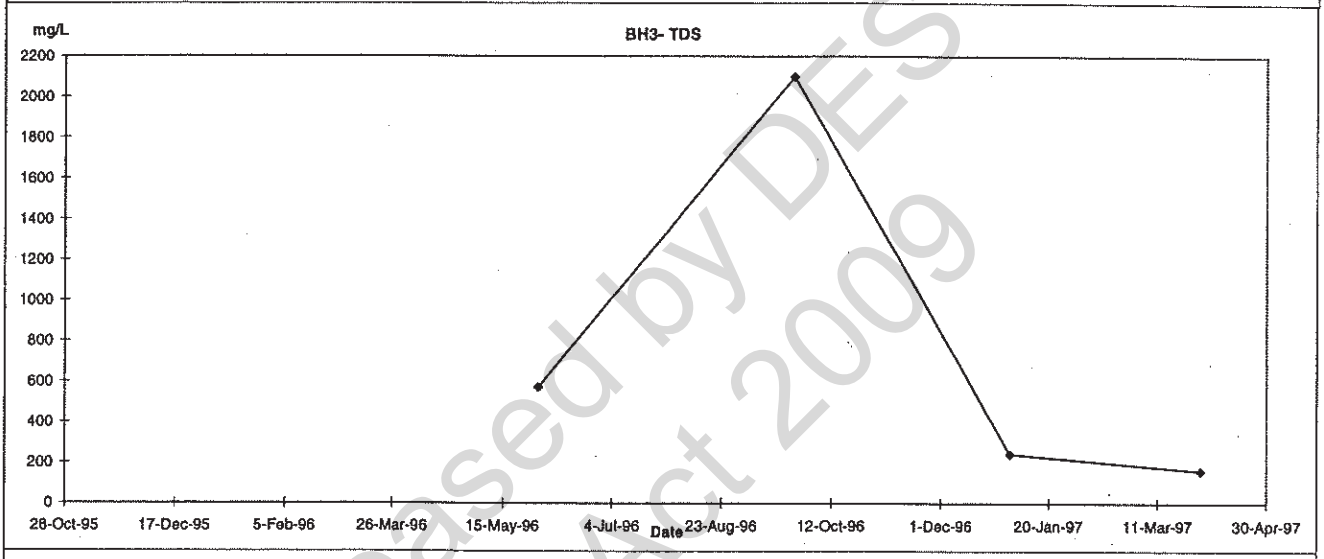
PANCONTINENTAL MINING LIMITED

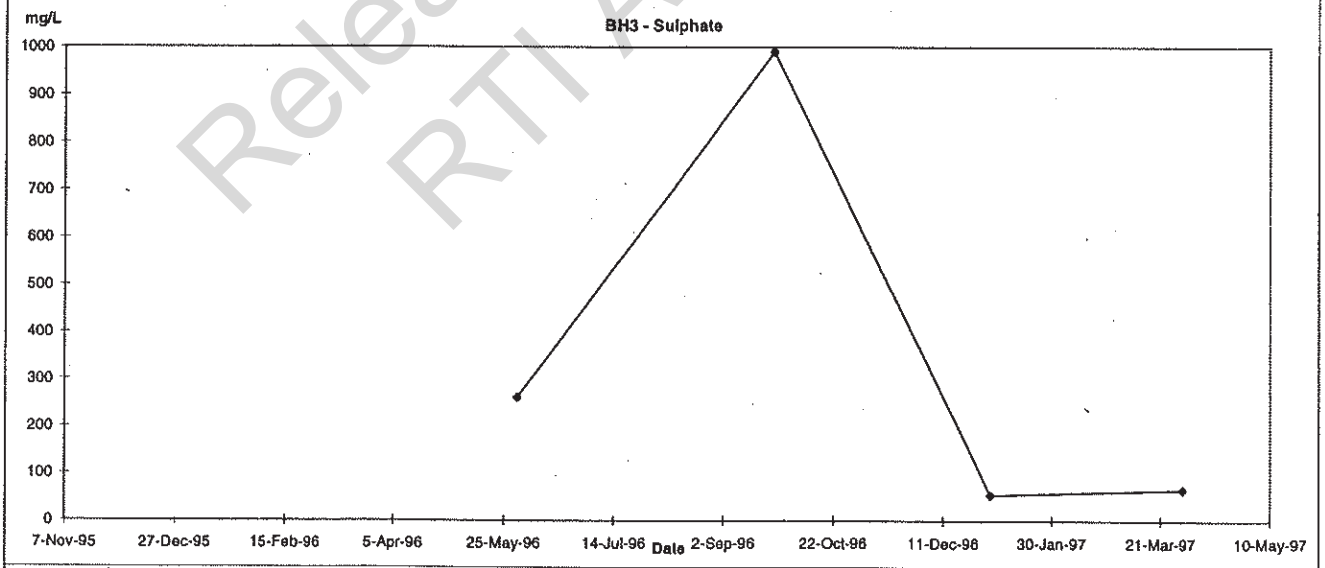
CROYDON GOLD MINE
WATER QUALITY MONITORING
BH2

Project:	Drawing:	Figure:
a32/280/0005		11

A32/00280/0005/GRAPHS3.XLS/BH2/5/22/97/MRK







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Date	Rev.	Description	Dwn	Chk'd
10/30/96	A	A32/00280/0005/Graph2	MRK	

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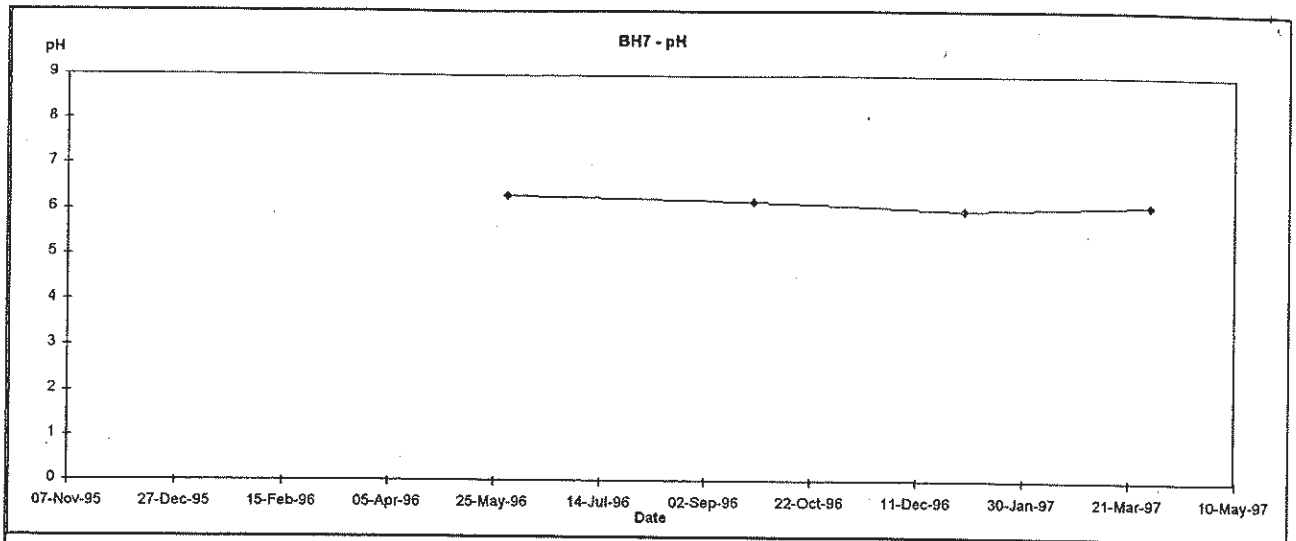
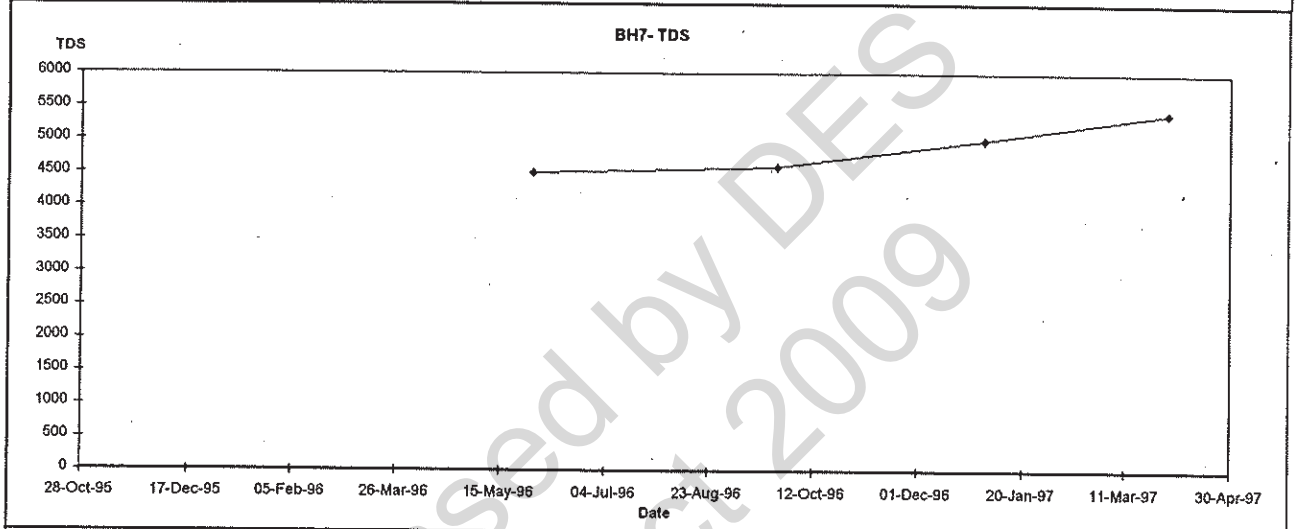
PANCONTINENTAL MINING LIMITED

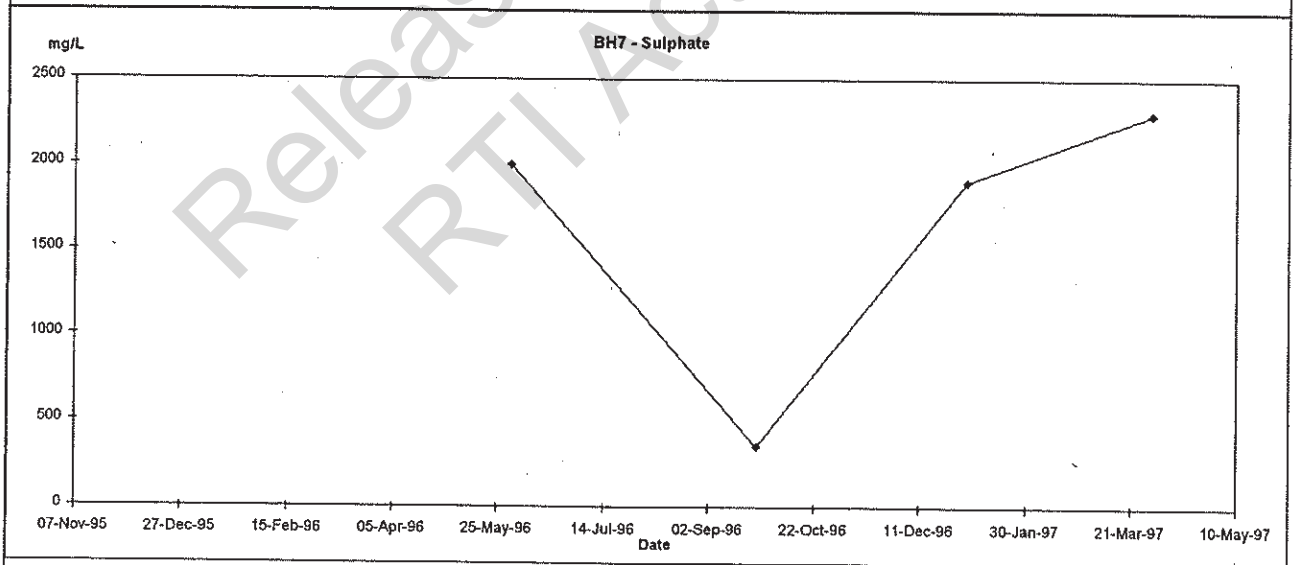
CROYDON GOLD MINE
WATER QUALITY MONITORING
BH3

Project:	Drawing:	Figure:
a32/280/0005		11

A32/00280/0005/GRAPHS3.XLS/BH3/5/22/97/MRK







Date	Rev.	Description	Dwn	Chk'd
#########	A	A32/00280/0005/Graph2	MRK	

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PANCONTINENTAL MINING LIMITED

CROYDON GOLD MINE
WATER QUALITY MONITORING
BH7

Project:	Drawing:	Figure:
a32/280/0005		11

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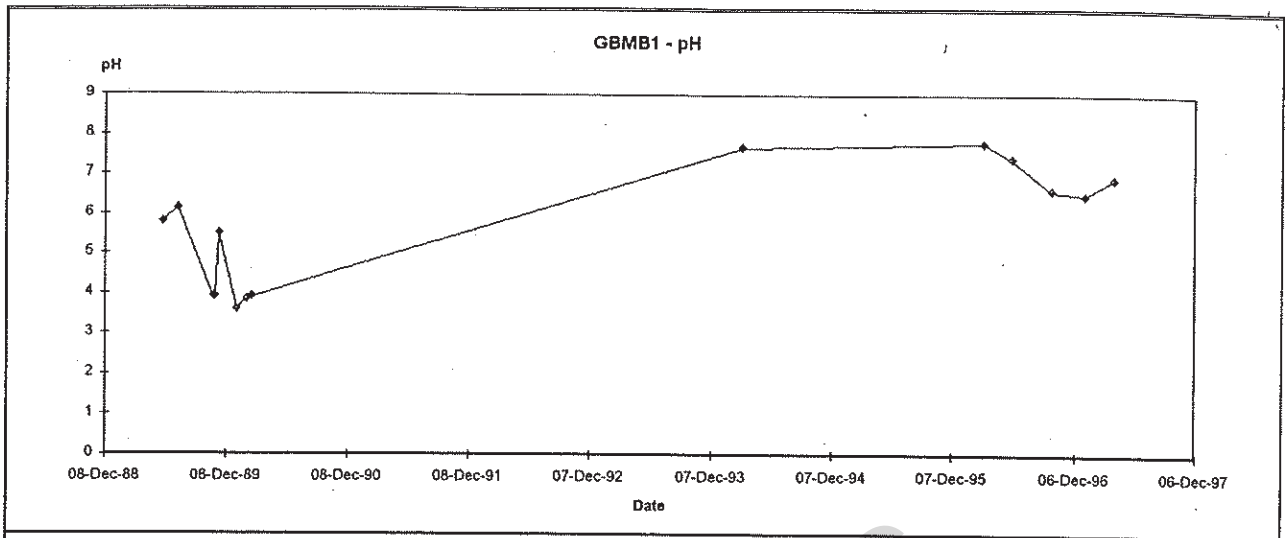

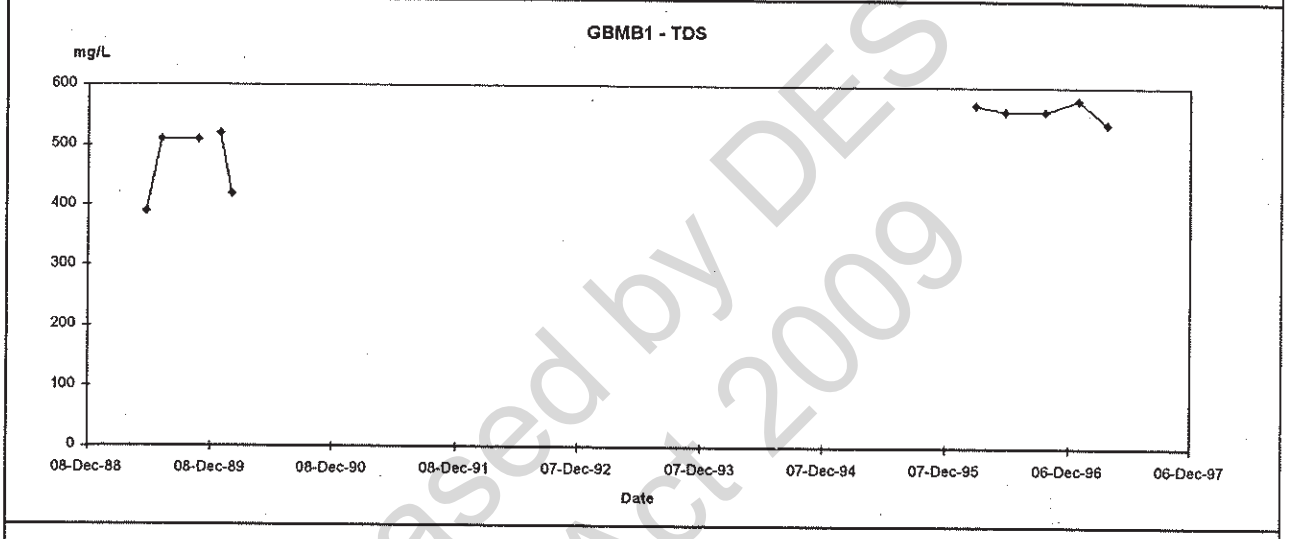

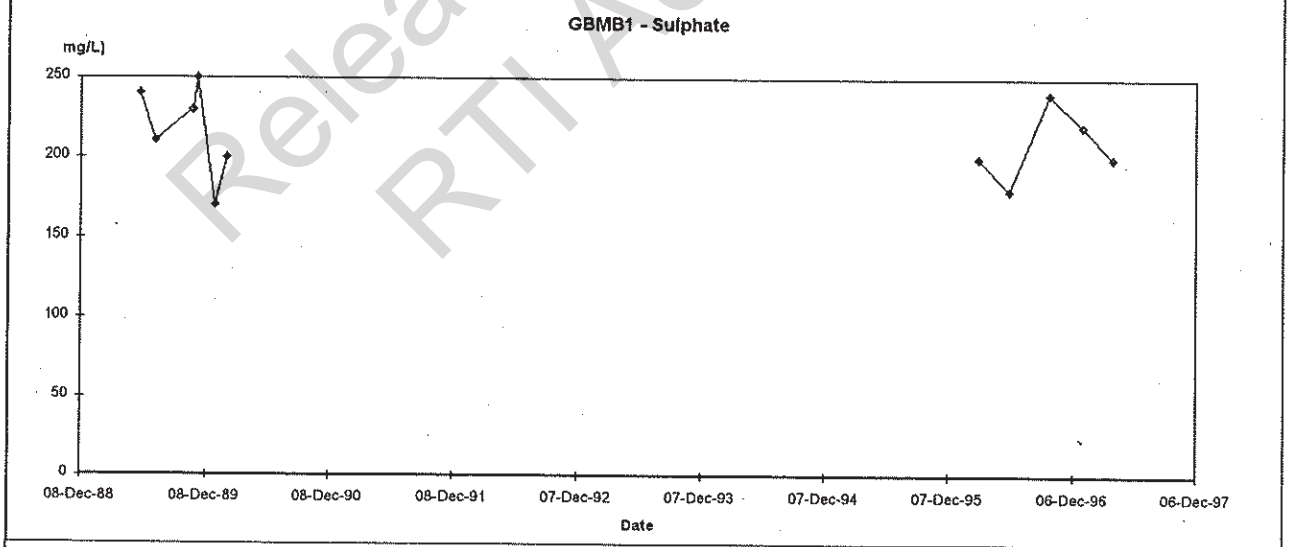

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########	A	A32/00280/0005/Graph2	MRK	

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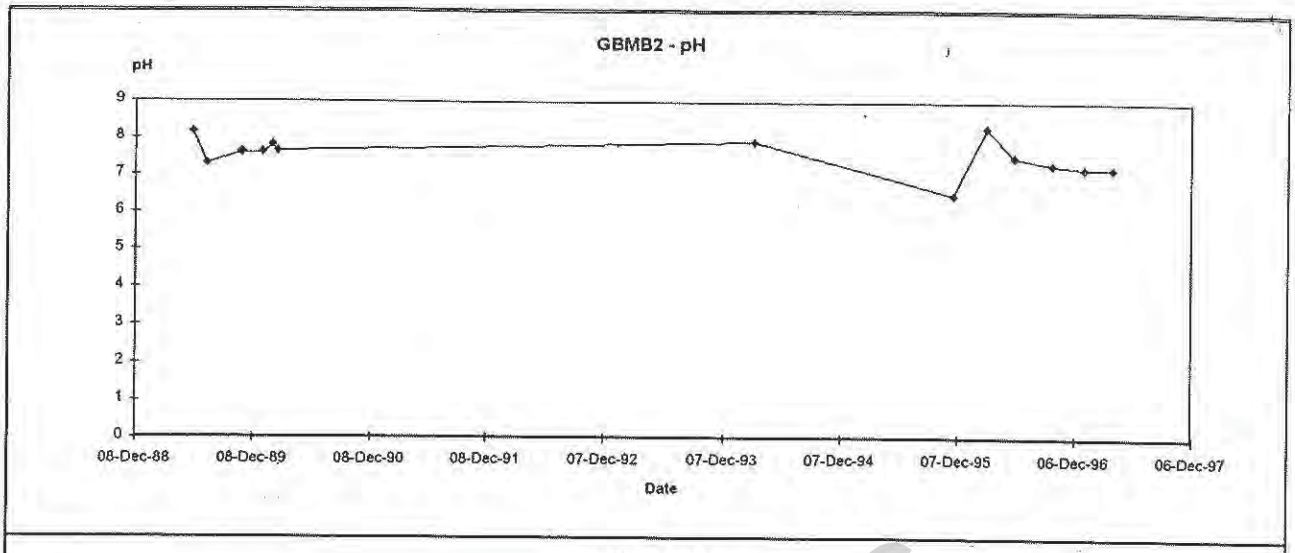
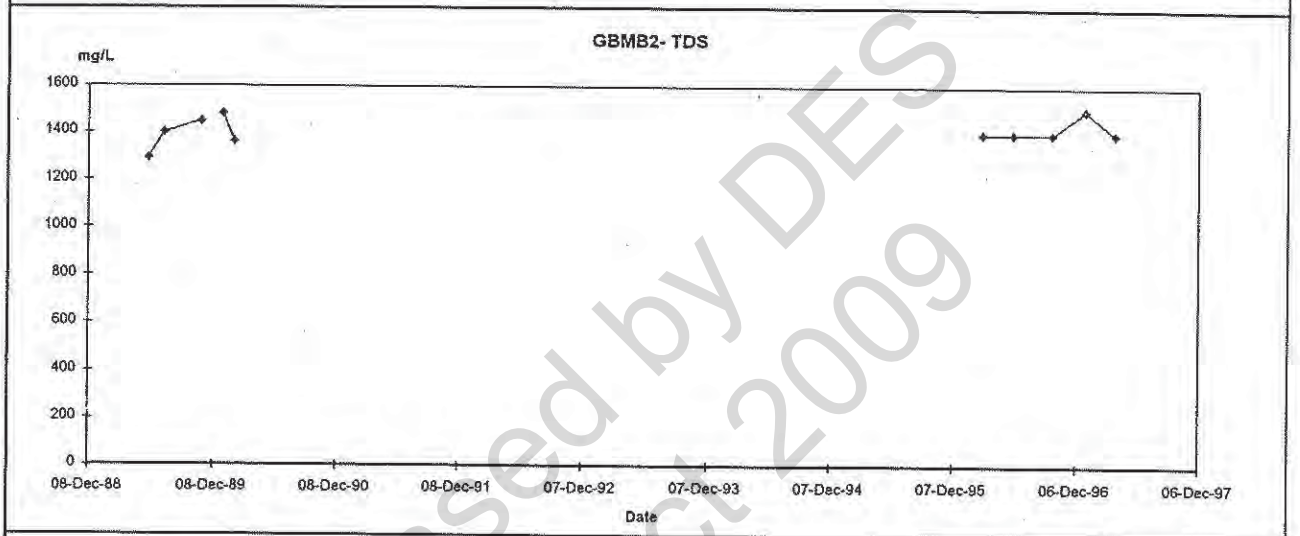
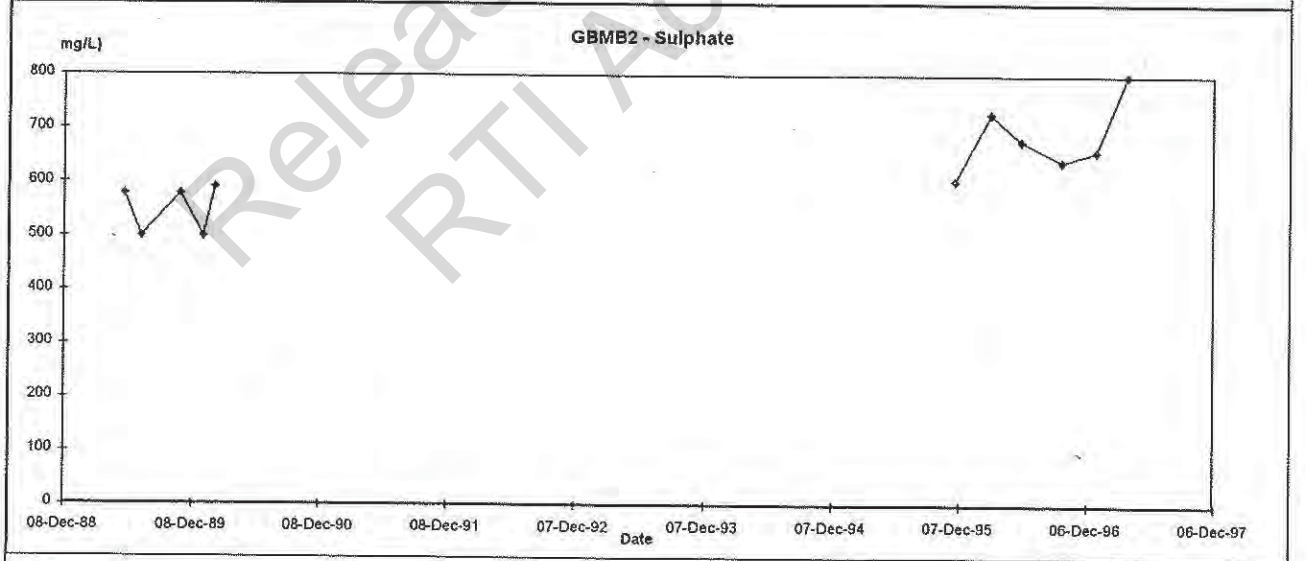
PANCONTINENTAL MINING LIMITED

CROYDON GOLD MINE
WATER QUALITY MONITORING
GBMB 1

Project:	Drawing:	Figure:
a32/280/0005		12







Date	Rev.	Description	Dwn	Chk'd
########	A	A32/00280/0005/Graph2	MRK	

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PANCONTINENTAL MINING LIMITED

CROYDON GOLD MINE
WATER QUALITY MONITORING
GBMB 2

Project:	Drawing:	Figure:
a32/280/0005		12

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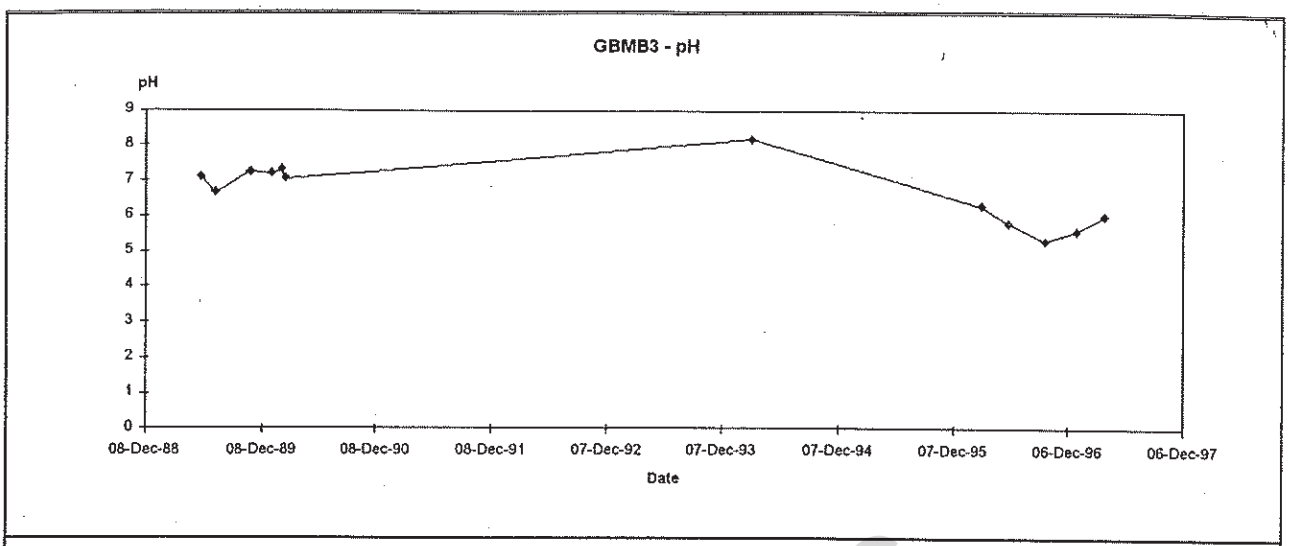

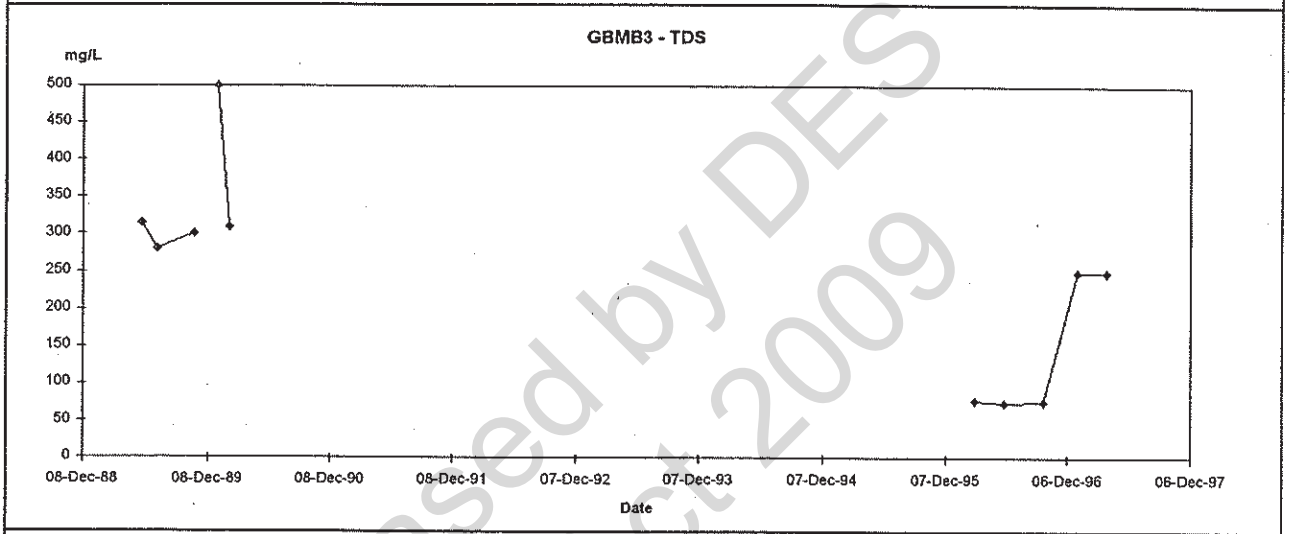

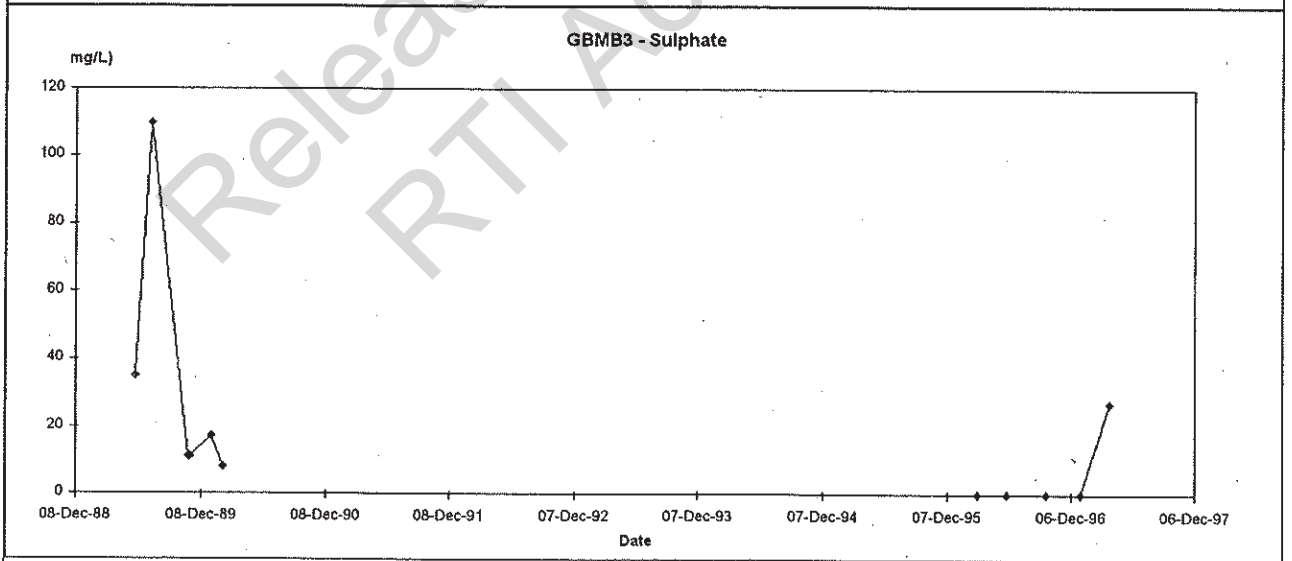

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Date	Rev.	Description	Dwn	Chk'd
########	A	A32/00280/0005/Graph2	MRK	

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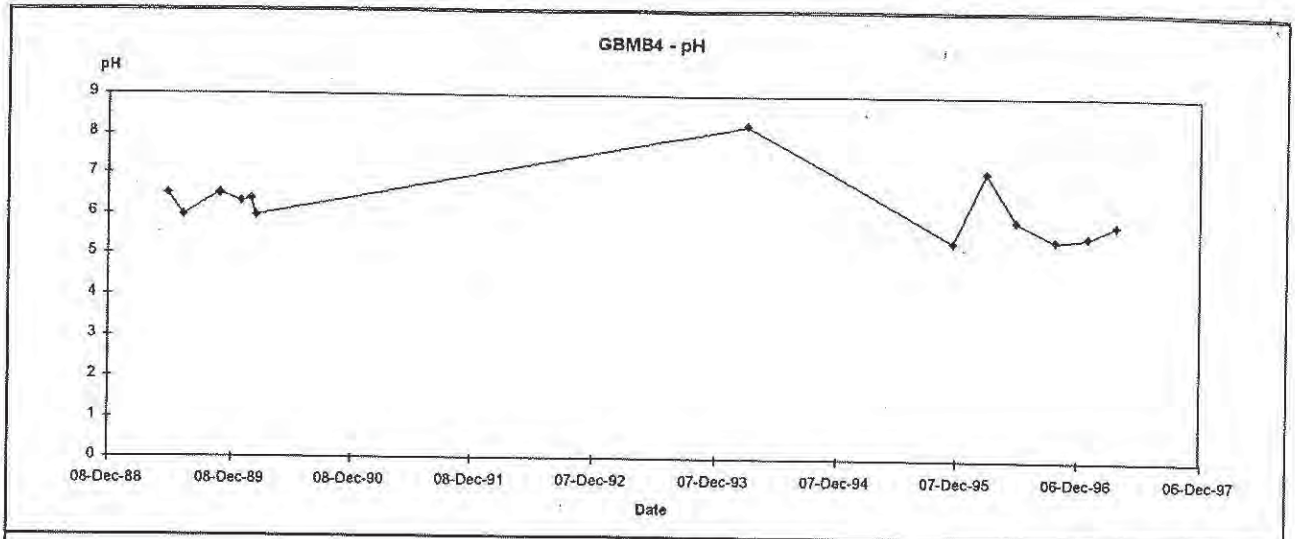
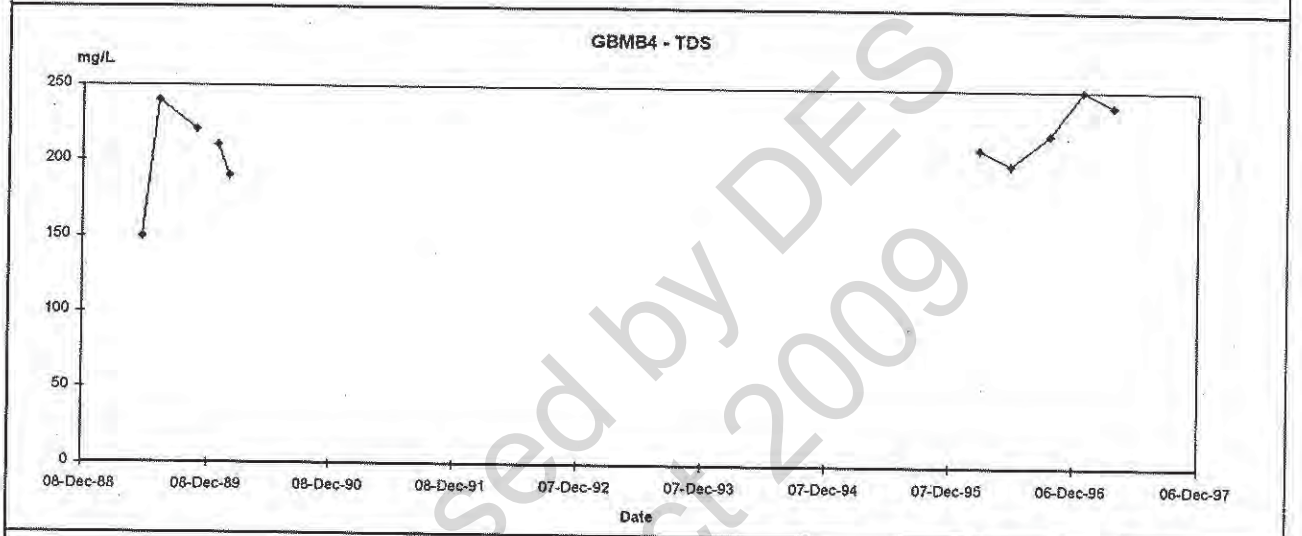
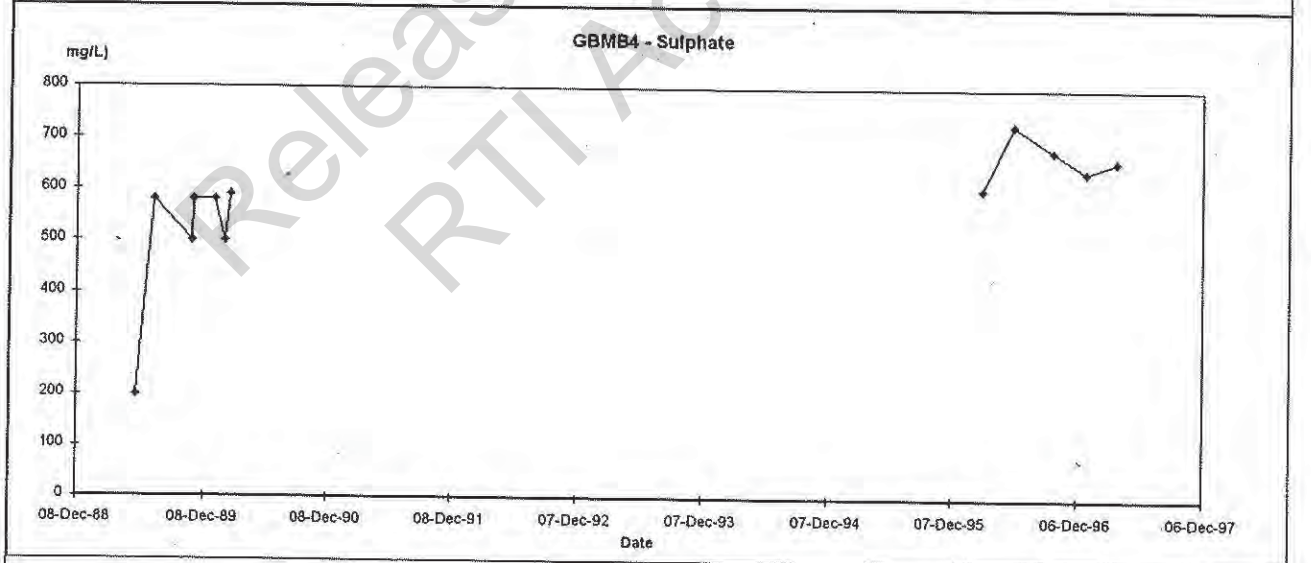
PANCONTINENTAL MINING LIMITED
CROYDON GOLD MINE
WATER QUALITY MONITORING
GBMB 3

Project:	Drawing:	Figure:
a32/280/0005		12

A32/00280/0005/GRAPHS3.XLS/GBMB3/22/05/1997/MRK







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Date	Rev.	Description	Dwn	Chk'd
########	A	A32/00280/0005/Graph2	MRK	

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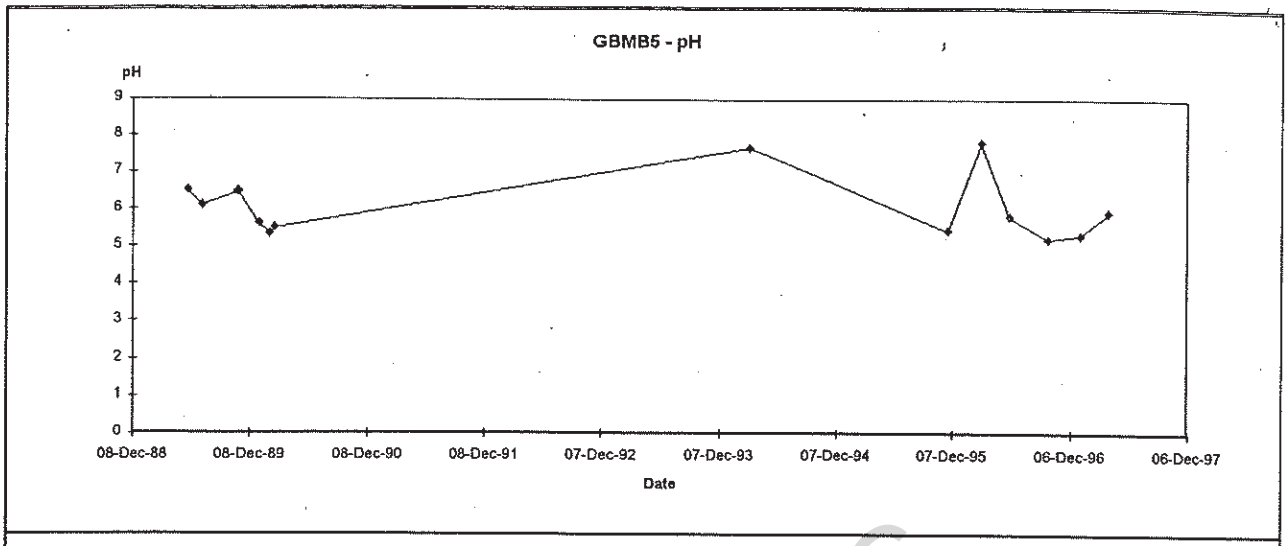
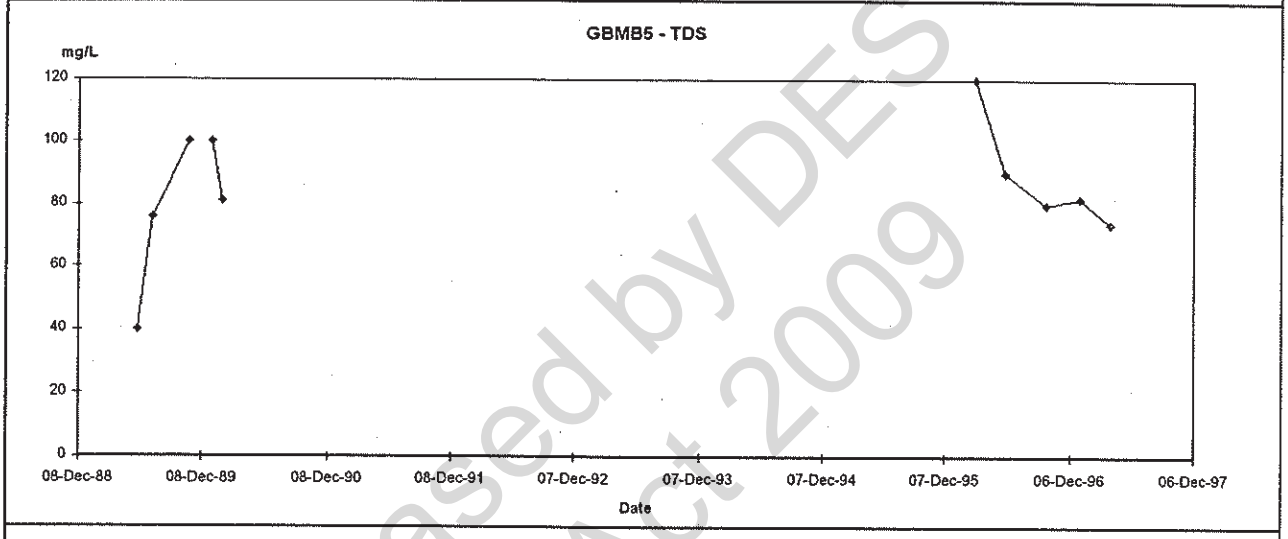
PANCONTINENTAL MINING LIMITED

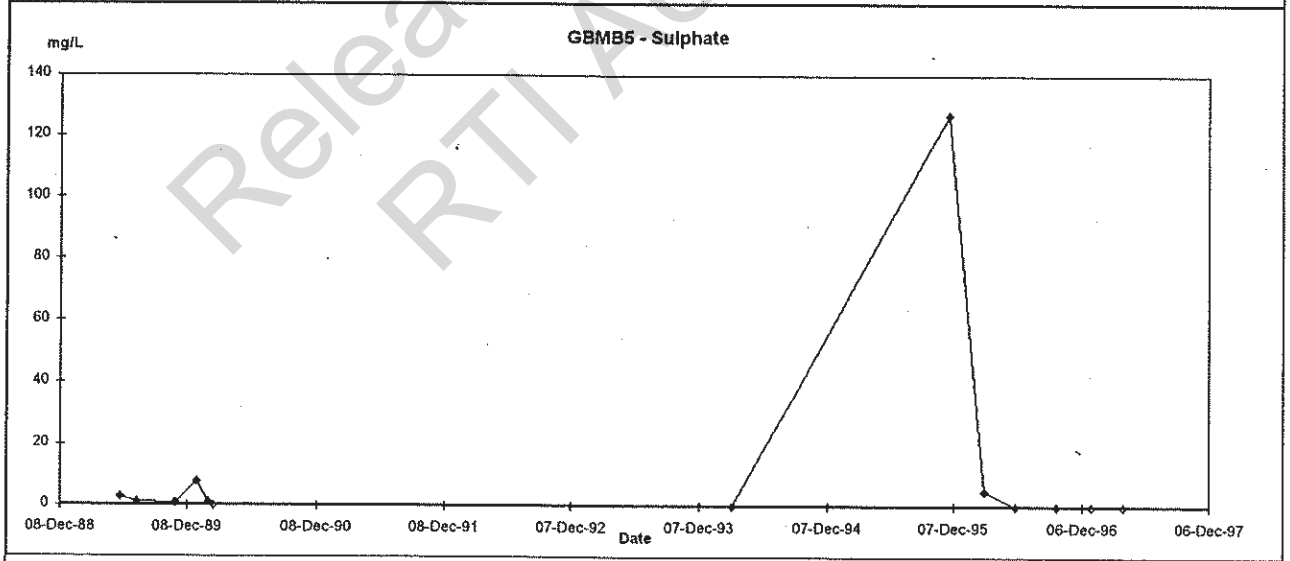
CROYDON GOLD MINE
WATER QUALITY MONITORING
GBMB 4

Project:	Drawing:	Figure:
a32/280/0005		12

A32/00280/0005/GRAPHS3.XLS/GBMB4/22/05/1997/MRK







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Date	Rev.	Description	Dwn	Chk'd
########	A	A32/00280/0005/Graph2	MRK	

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PANCONTINENTAL MINING LIMITED
CROYDON GOLD MINE
WATER QUALITY MONITORING
GBMB 5

Project:	Drawing:	Figure:
a32/280/0005		12

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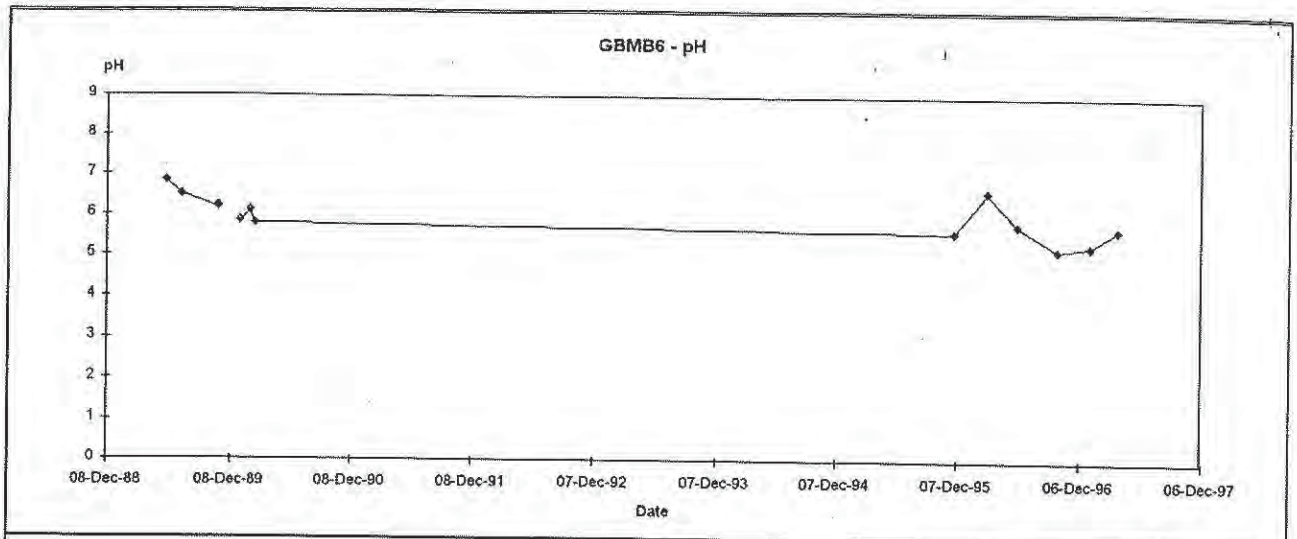

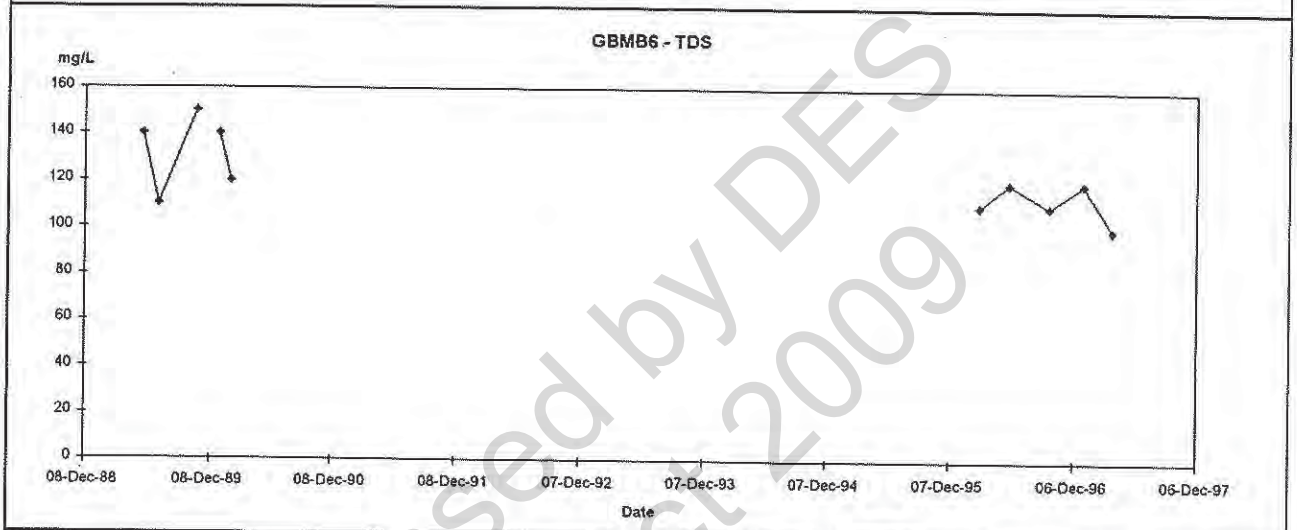

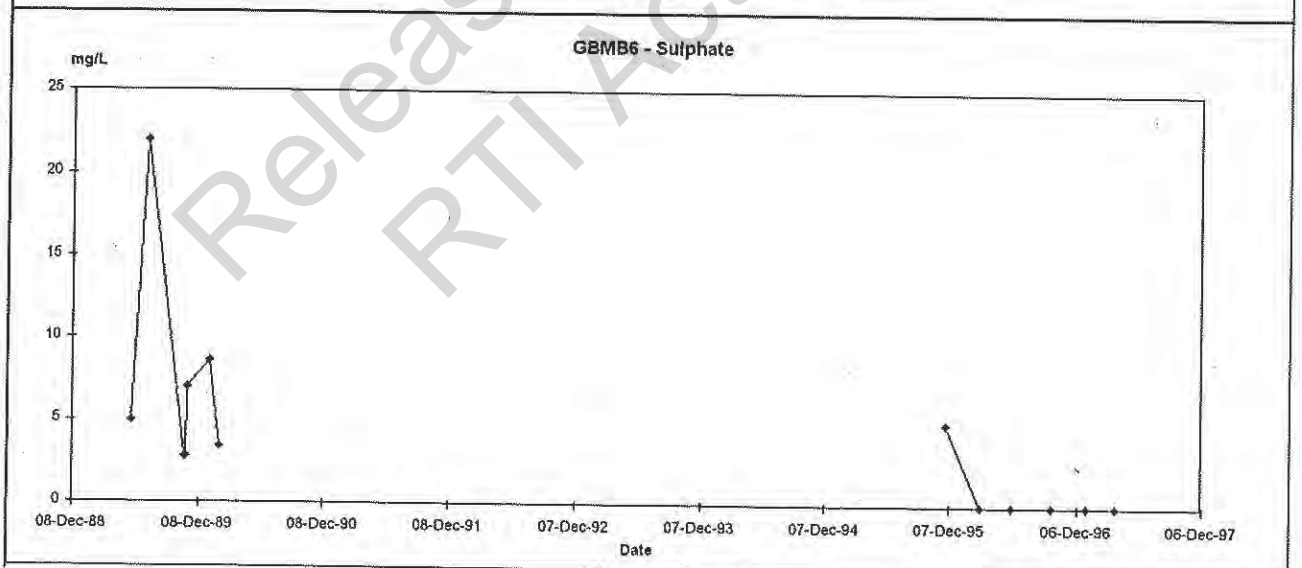

Date	Rev.	Description	Dwn	Chk'd
########	A	A32/00280/0005/Graph2	MRK	

Woodward-Clyde

A.C.N. 000 691 690

PANCONTINENTAL MINING LIMITED

CROYDON GOLD MINE
WATER QUALITY MONITORING
GBMB 6

Project:	Drawing:	Figure:
a32/280/0005		12

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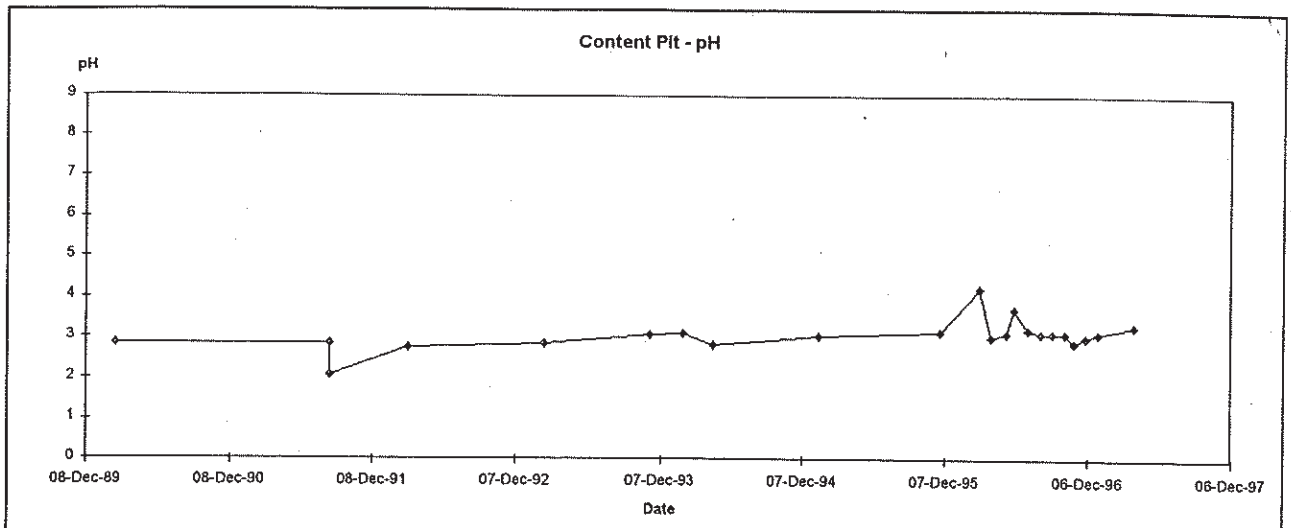

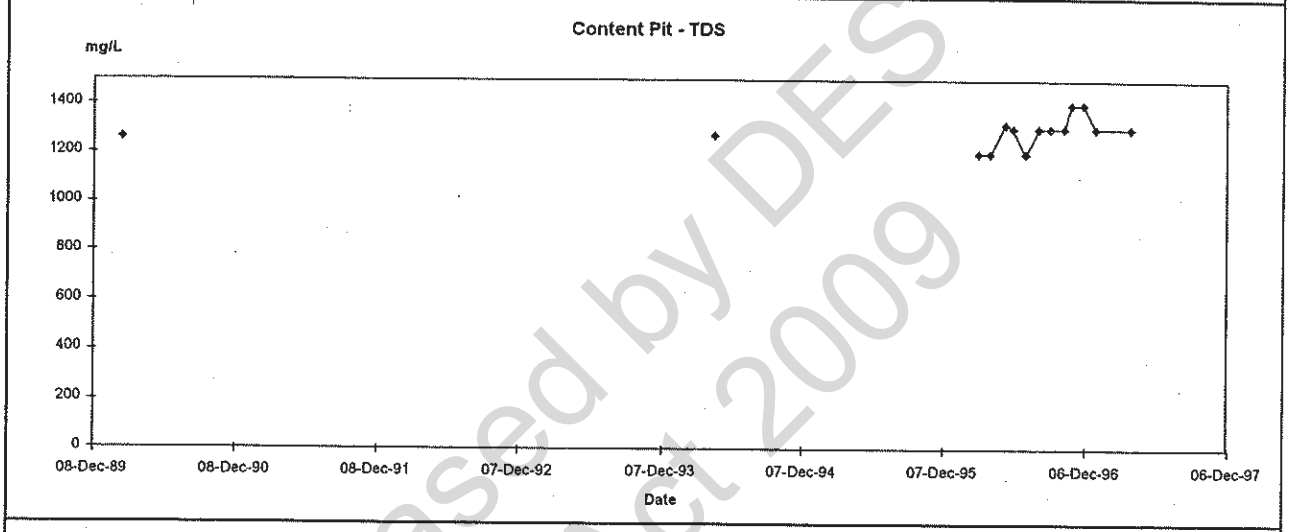

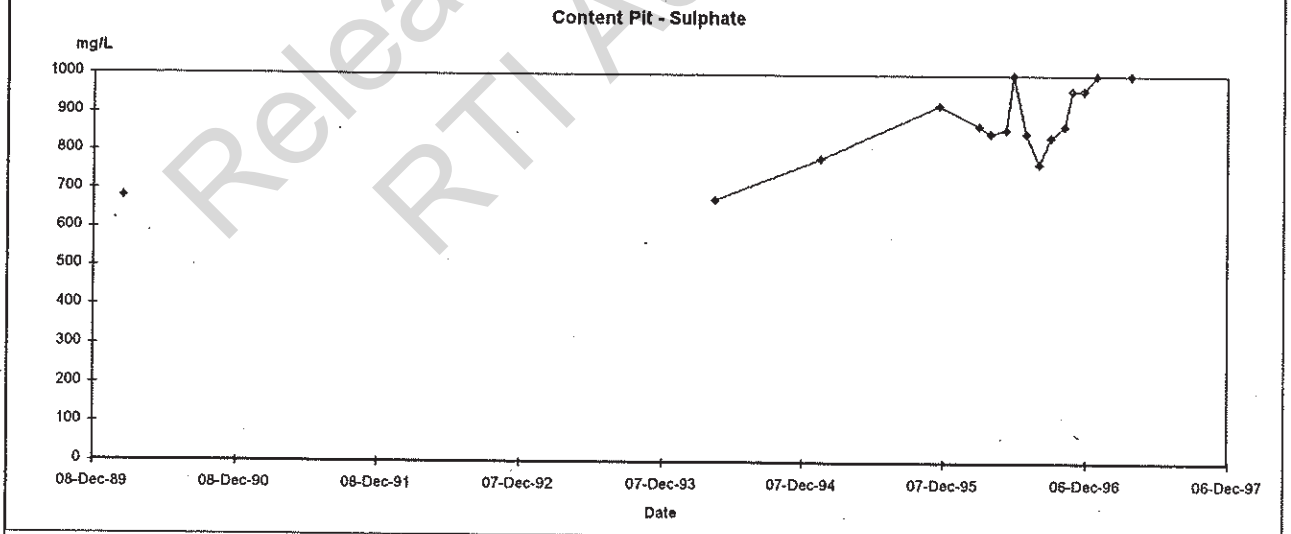

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RTI Act 2009

Date	Rev.	Description	Dwn	Chk'd
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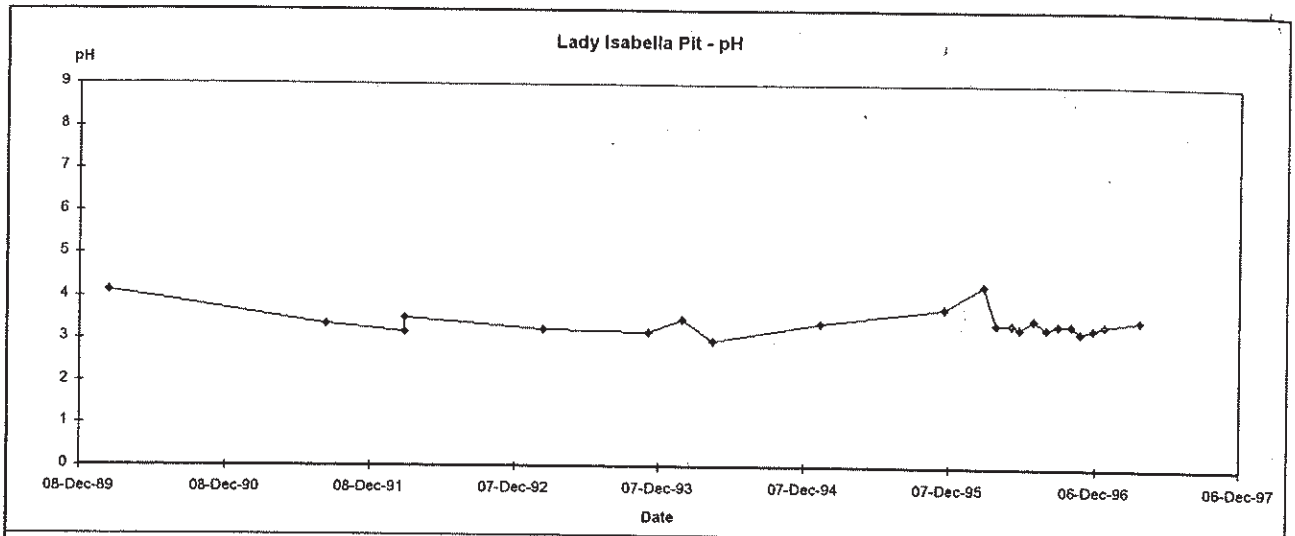
Woodward-Clyde

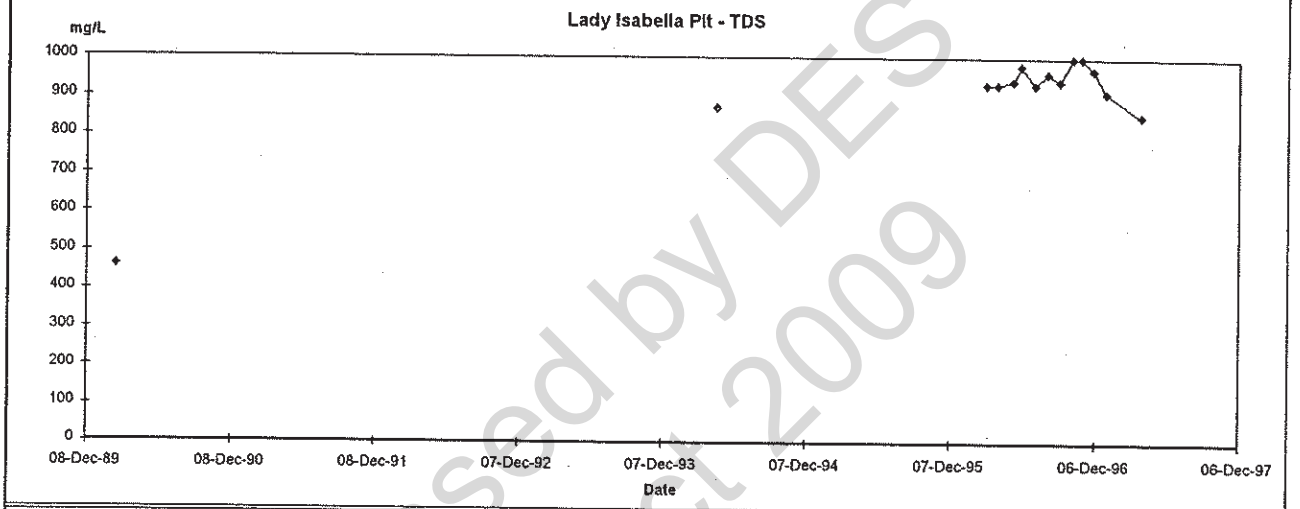
A.C.N. 000 691 690

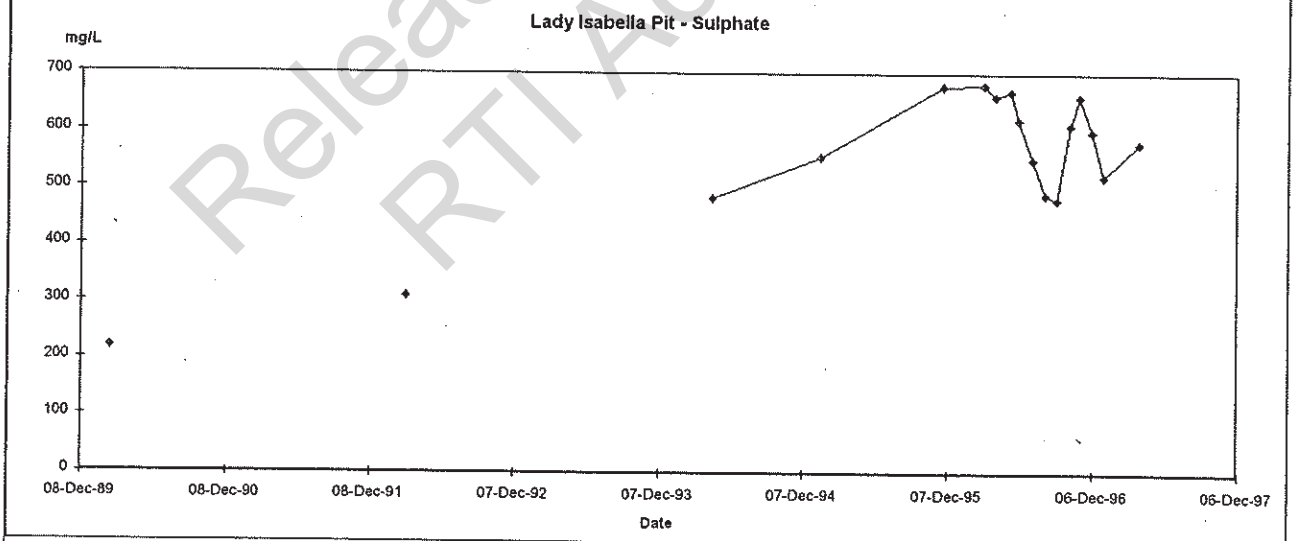
PANCONTINENTAL MINING LIMITED
CROYDON GOLD MINE
WATER QUALITY MONITORING
Content pit

Project:	Drawing:	Figure:
a32/280/0005		9

Rele







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A.C.N. 000 691 690

PANCONTINENTAL MINING LIMITED

CROYDON GOLD MINE
WATER QUALITY MONITORING
Lady Isabella Pit

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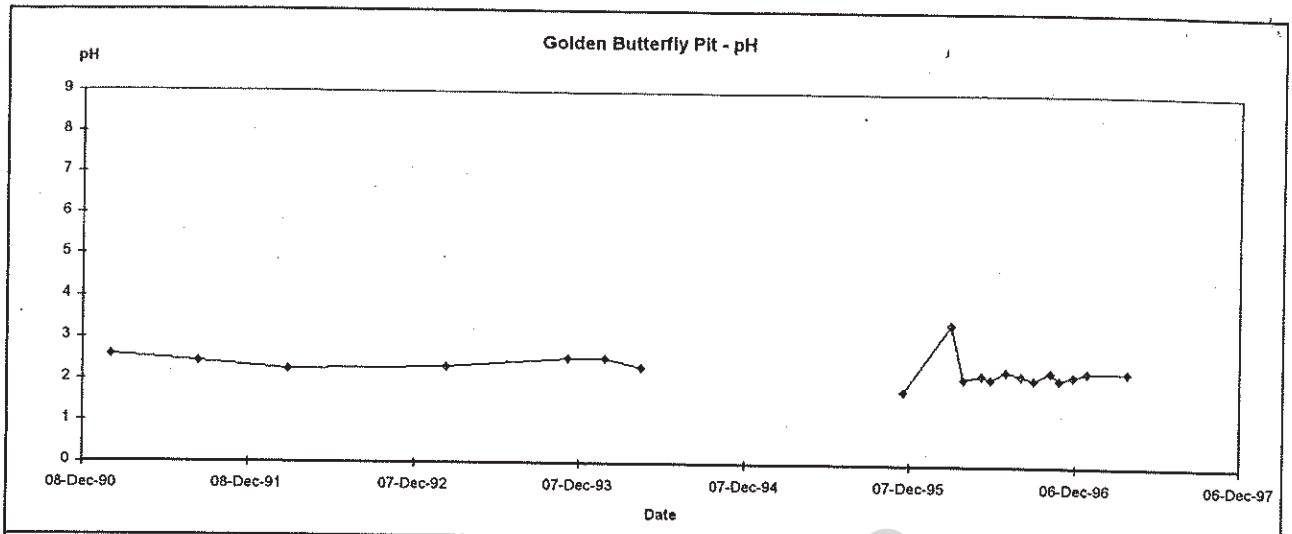

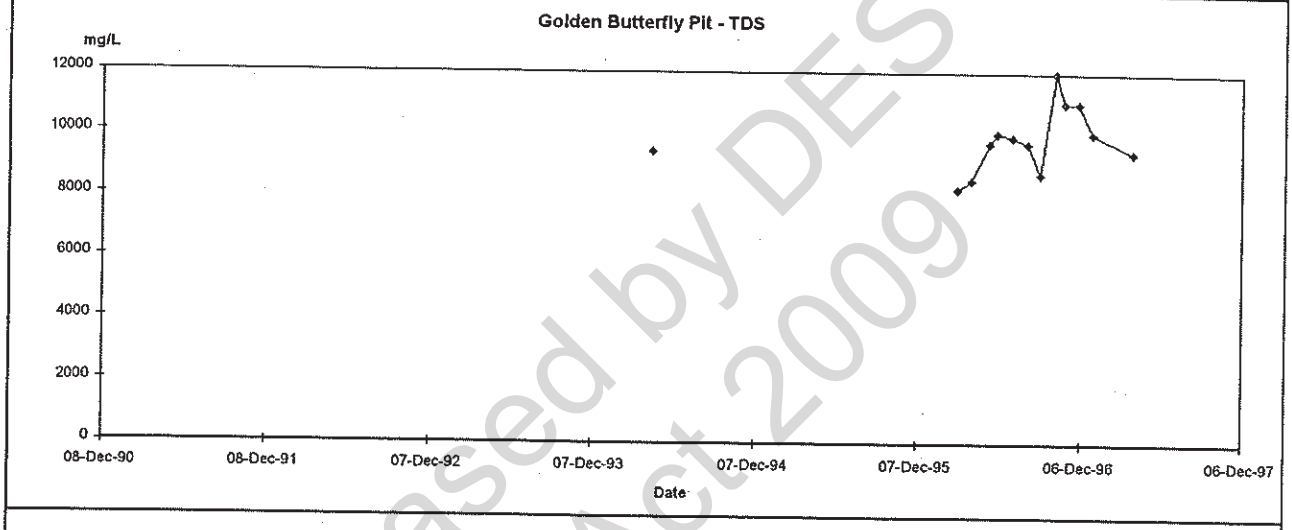

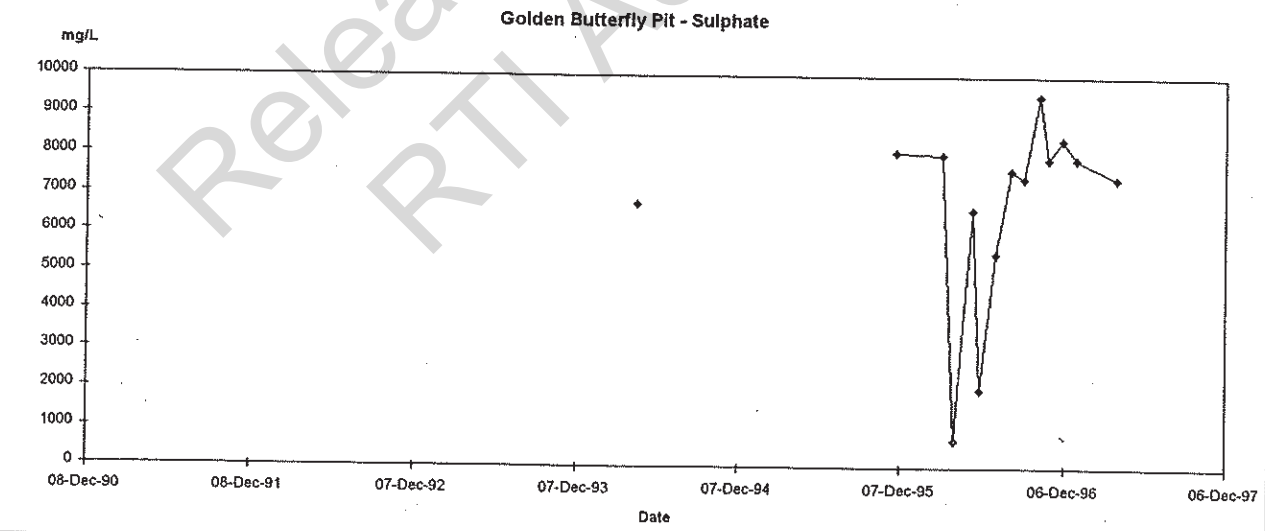

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Woodward-Clyde

A.C.N. 000 691 690

PANCONTINENTAL MINING LIMITED

CROYDON GOLD MINE
WATER QUALITY MONITORING
Golden Butterfly Pit

Project:	Drawing:	Figure:
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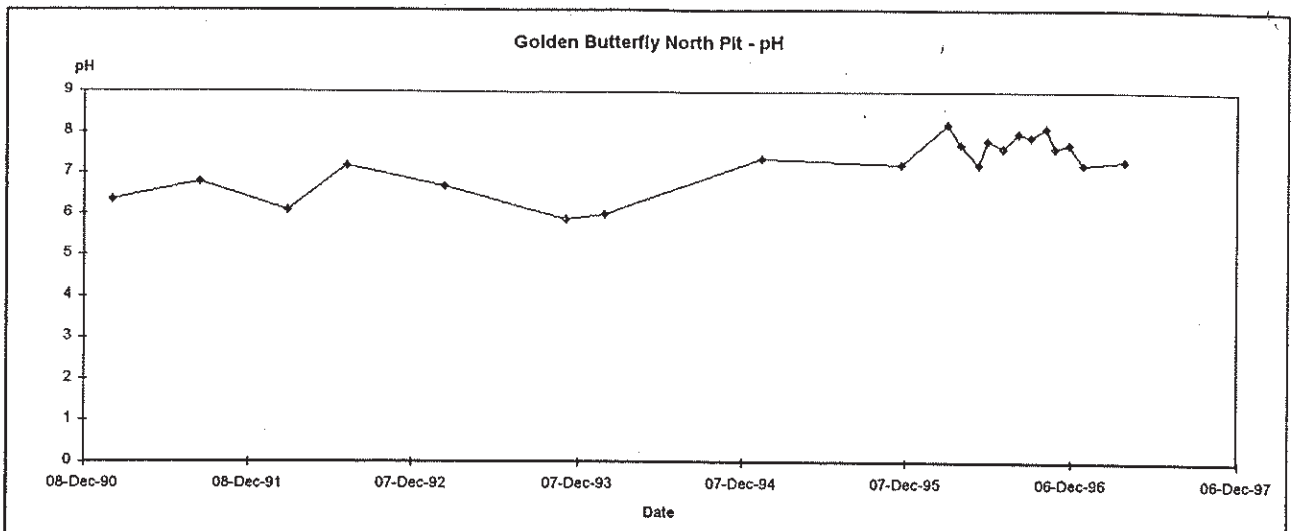

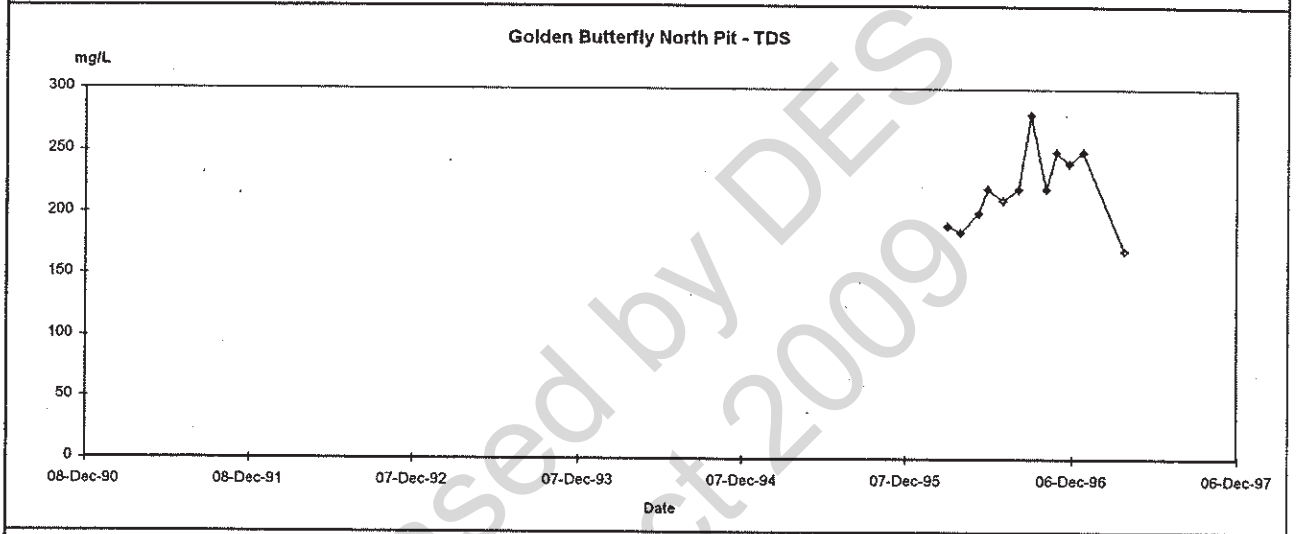

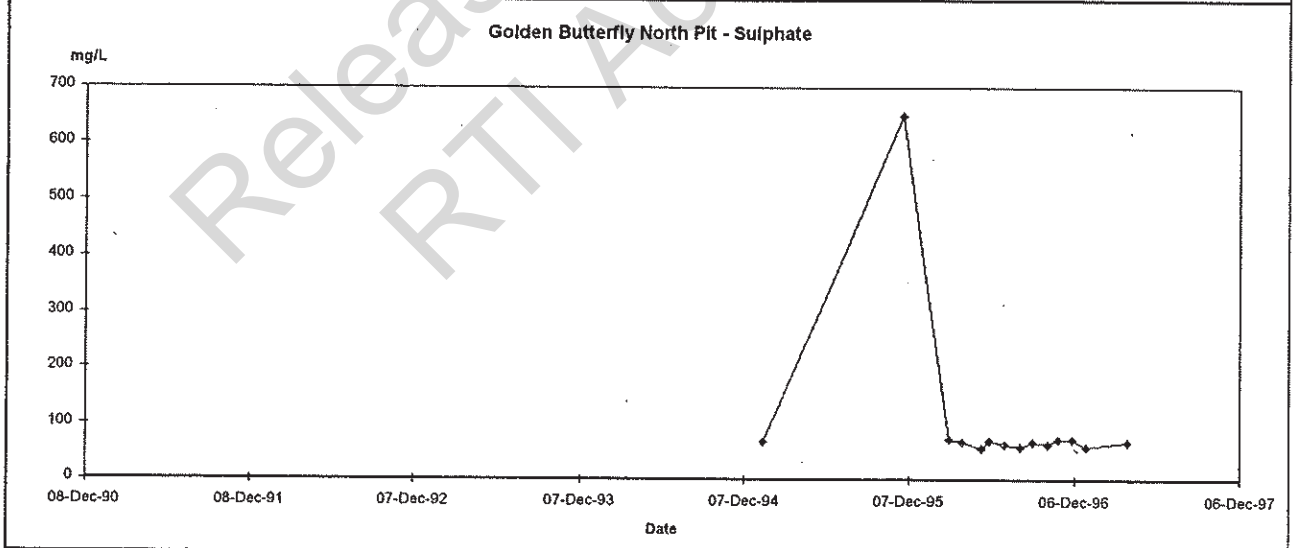

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Date	Rev.	Description	Dwn	Chk'd
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A.C.N. 000 691 690

PANCONTINENTAL MINING LIMITED

CROYDON GOLD MINE
WATER QUALITY MONITORING
Golden Butterfly North Pit

Project:	Drawing:	Figure:
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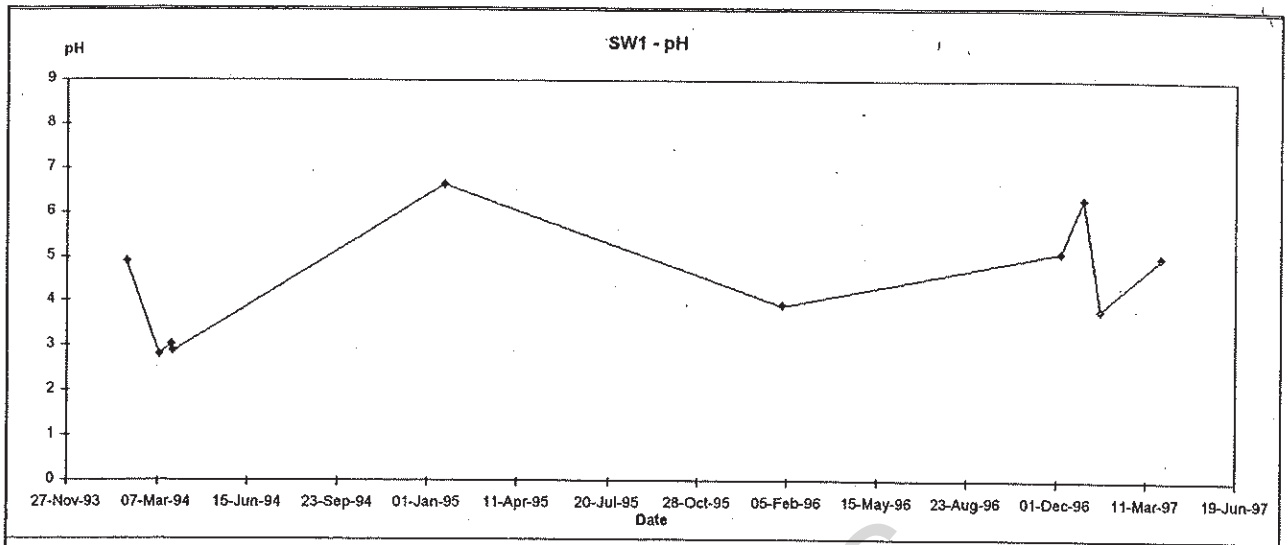

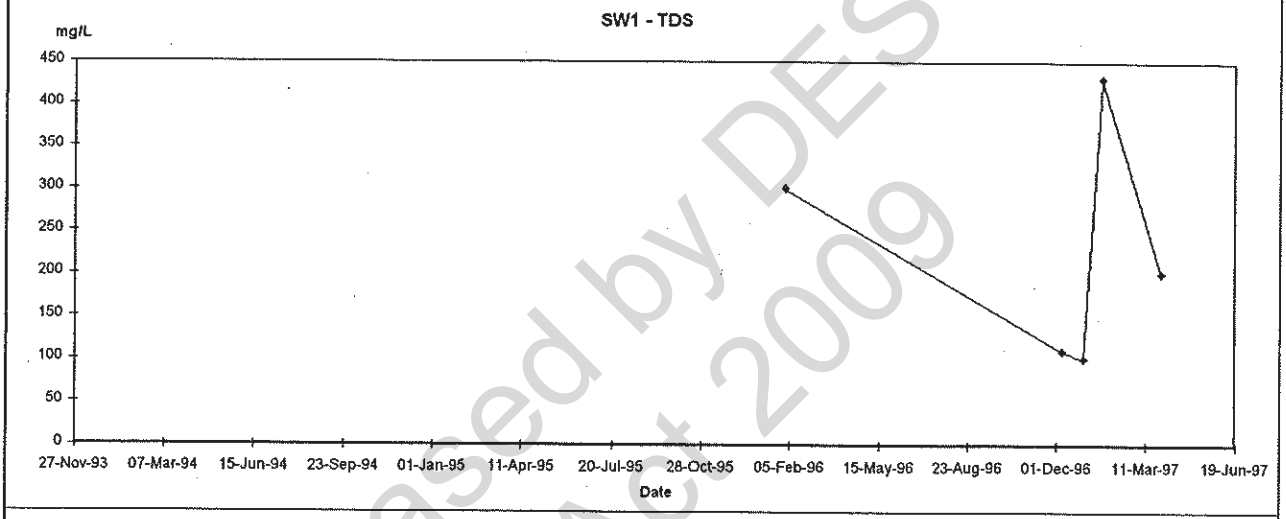

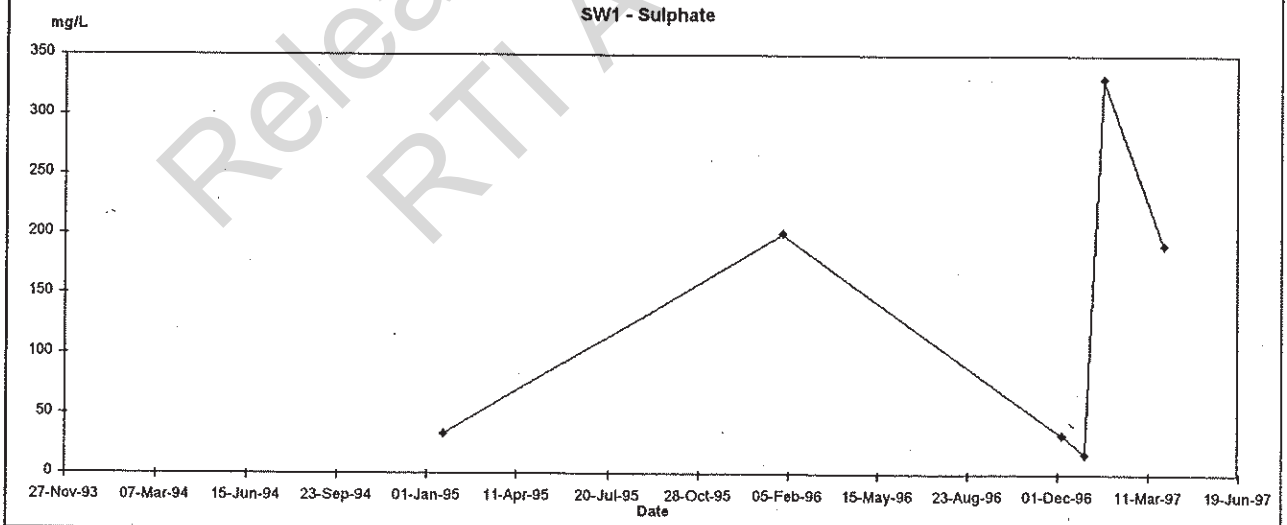

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A.C.N. 000 691 690

PANCONTINENTAL MINING LIMITED

CROYDON GOLD MINE
WATER QUALITY MONITORING
SW1

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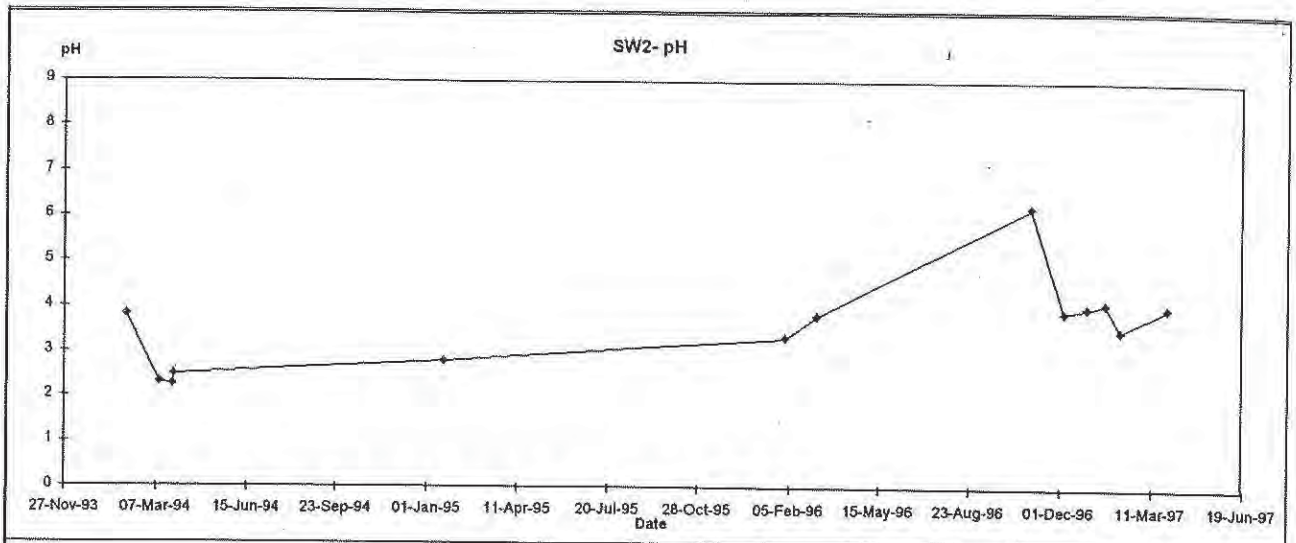

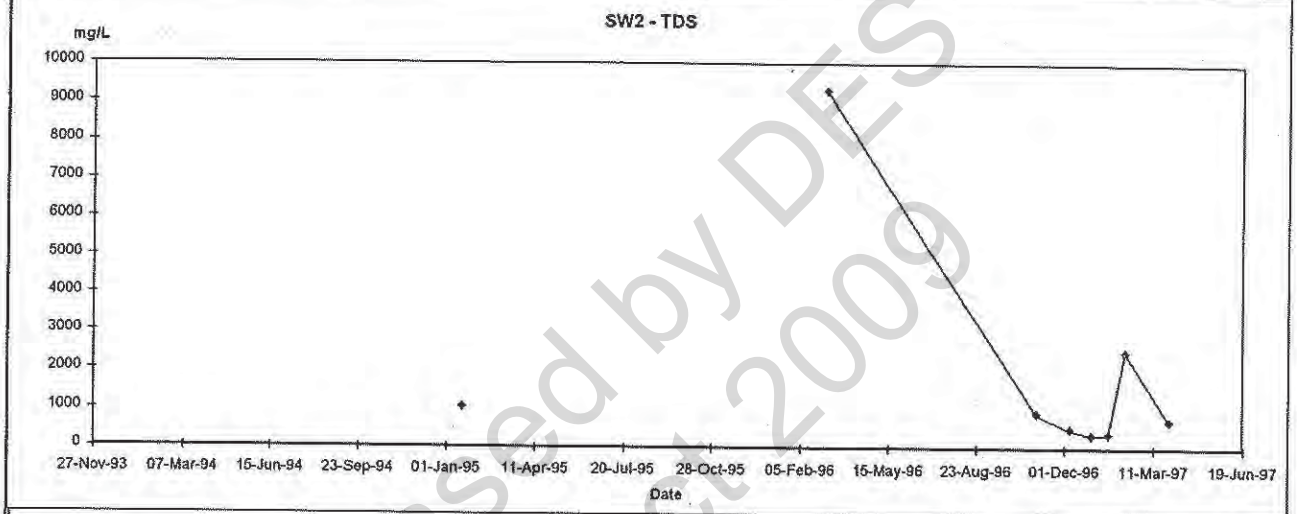

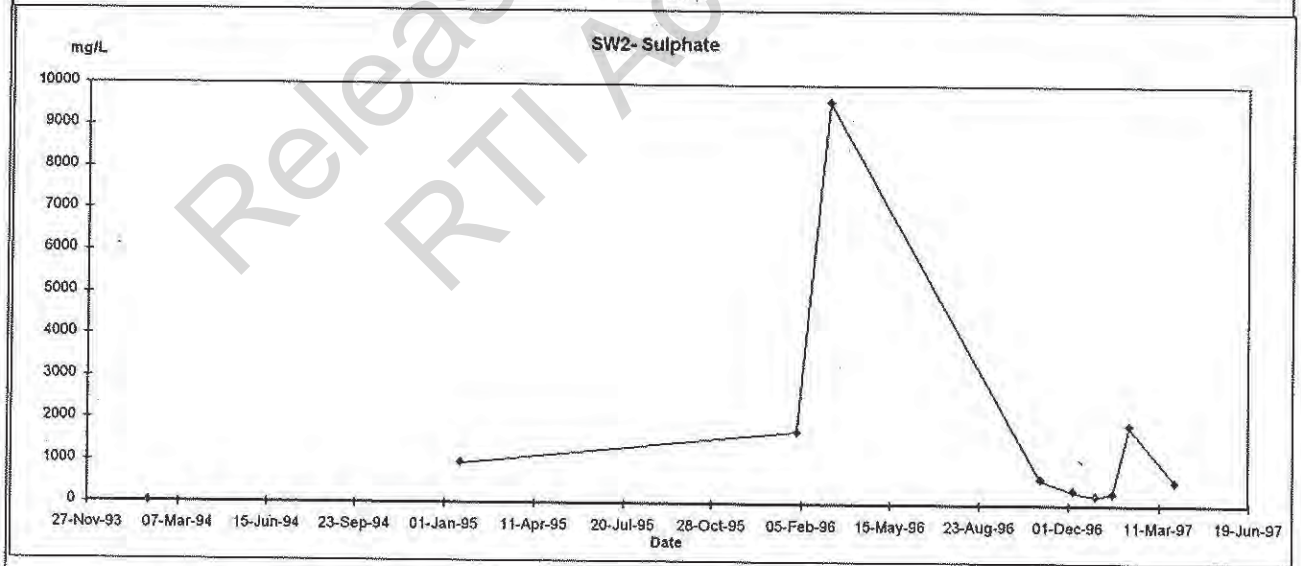

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Woodward-Clyde

A.C.N. 000 691 690

PANCONTINENTAL MINING LIMITED

CROYDON GOLD MINE
WATER QUALITY MONITORING
SW2

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RTI Act 2009

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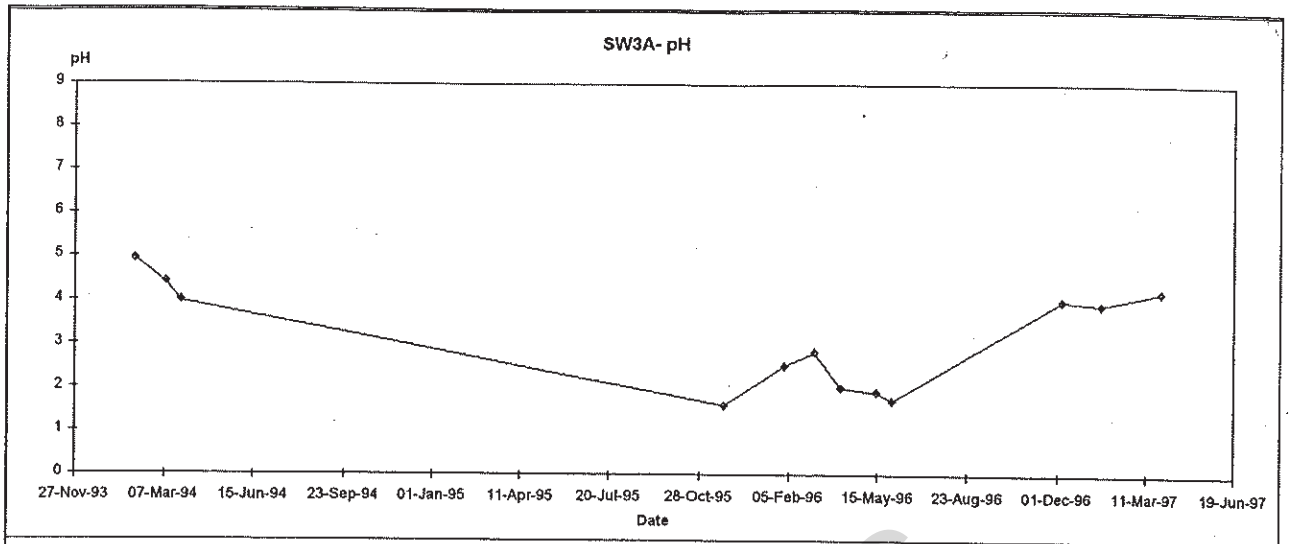

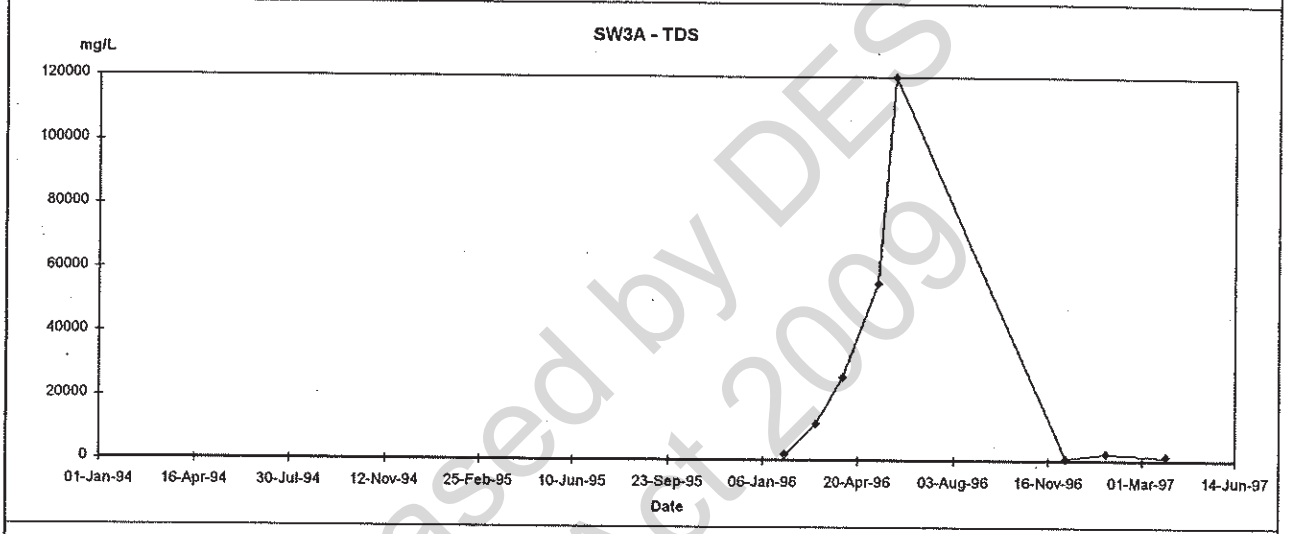

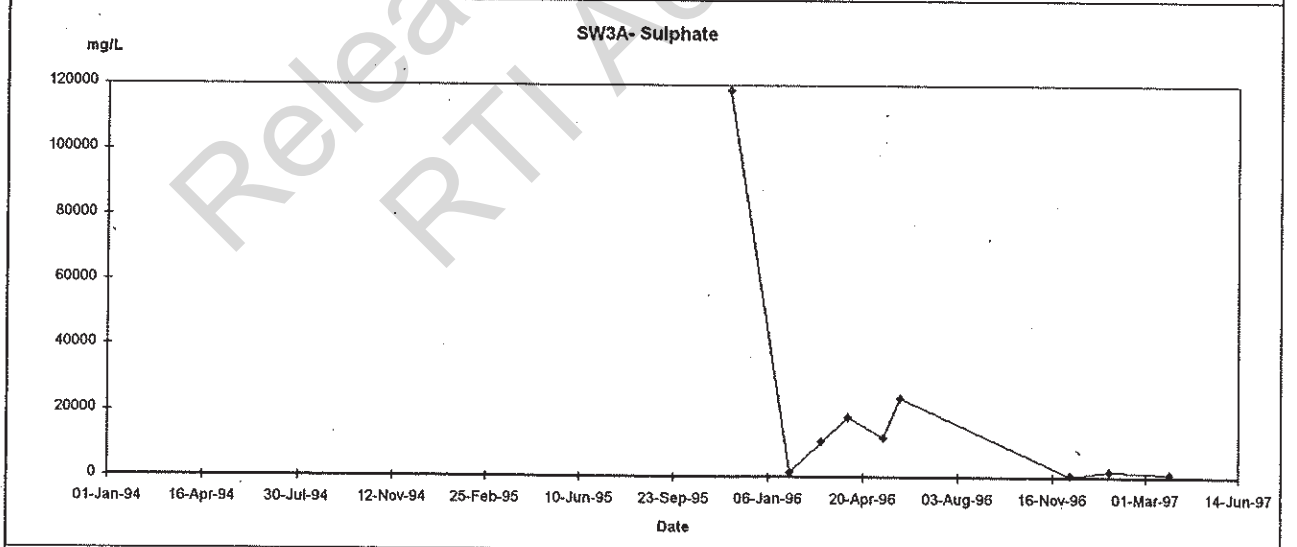

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Woodward-Clyde

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PANCONTINENTAL MINING LIMITED

CROYDON GOLD MINE
WATER QUALITY MONITORING
SW3A

Project:	Drawing:	Figure:
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RTI Act 2009

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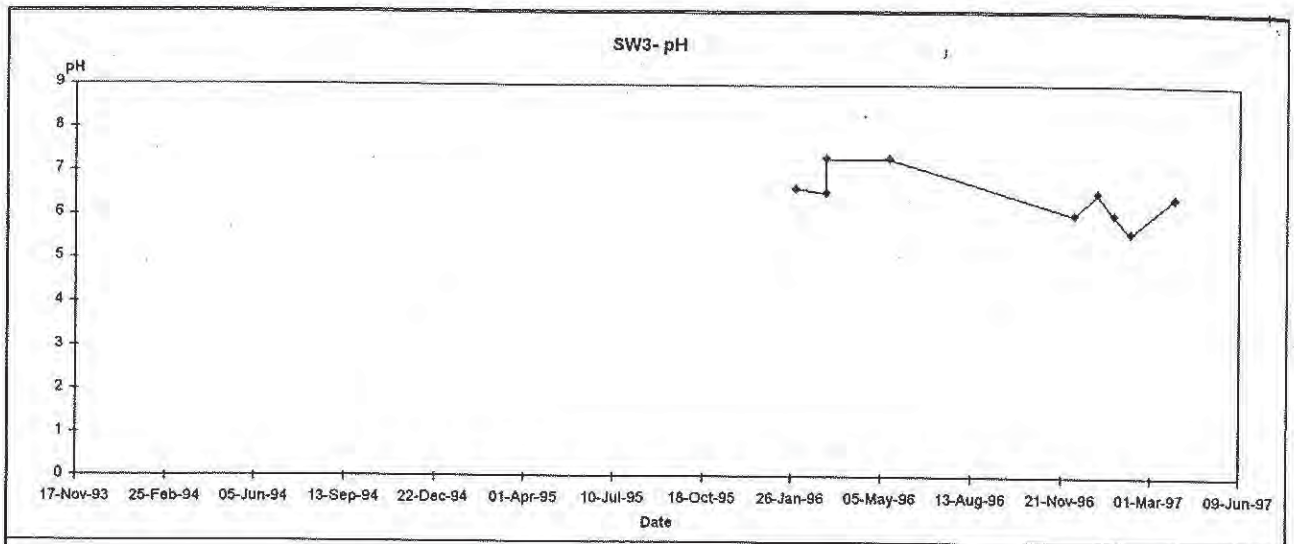

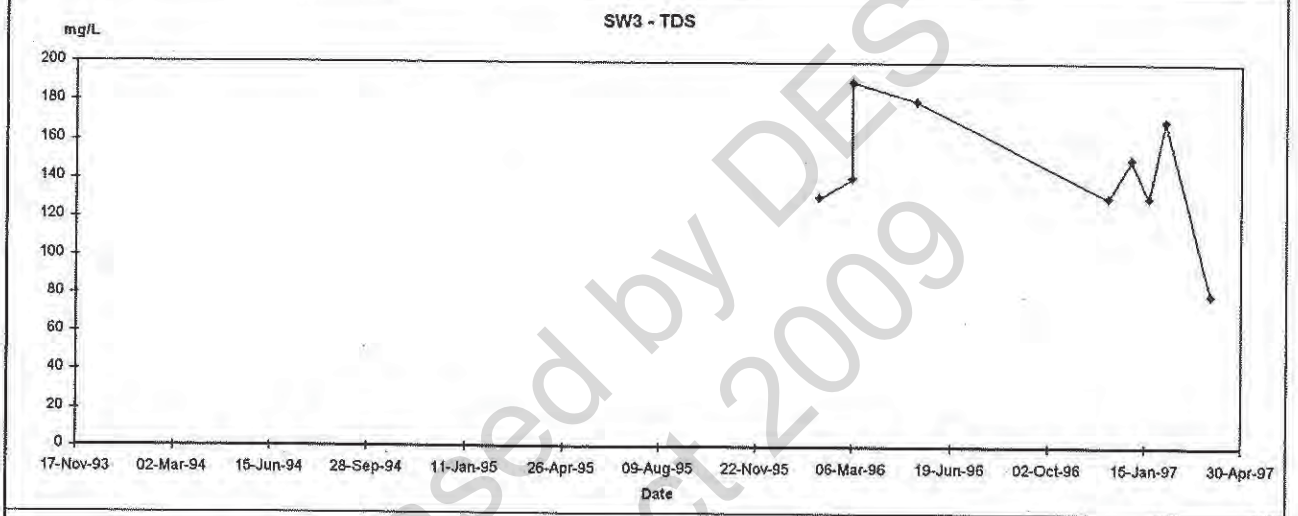

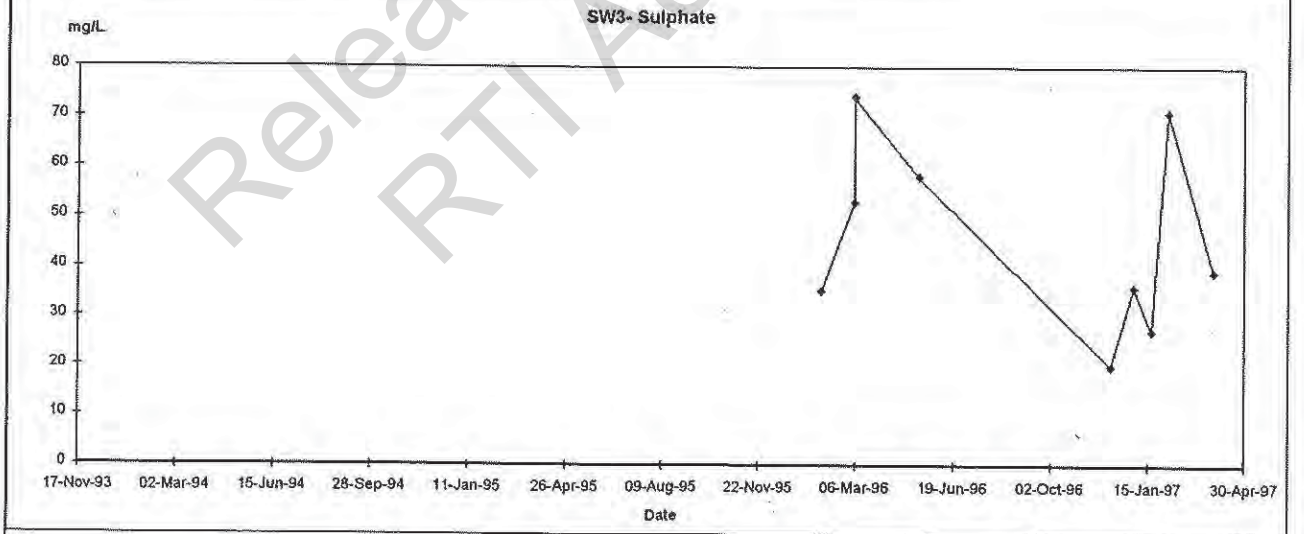

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PANCONTINENTAL MINING LIMITED

CROYDON GOLD MINE
WATER QUALITY MONITORING
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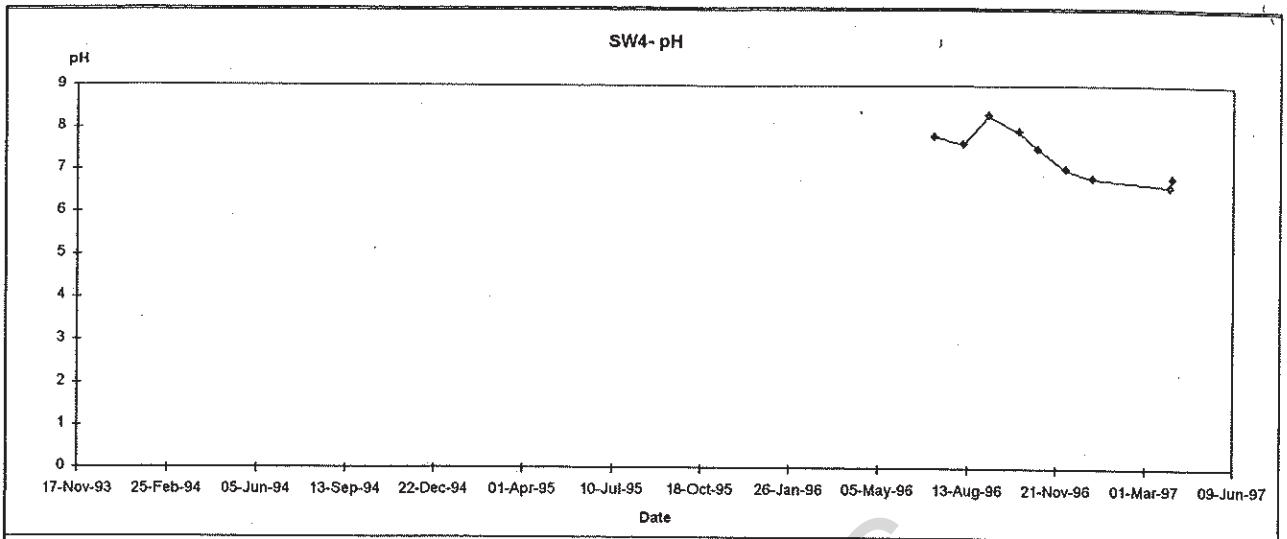

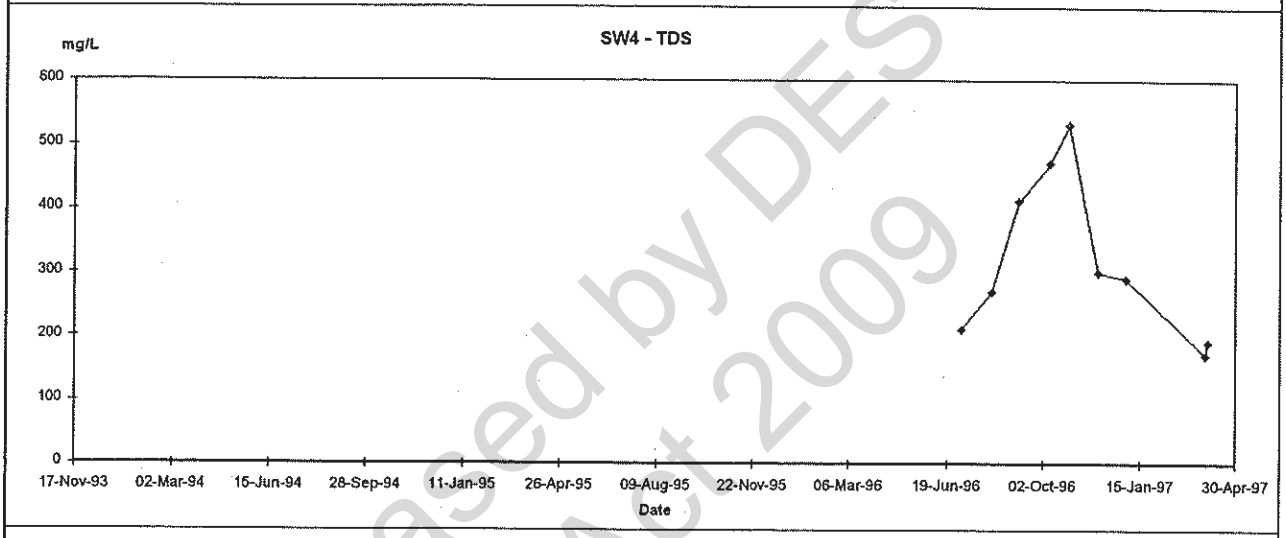

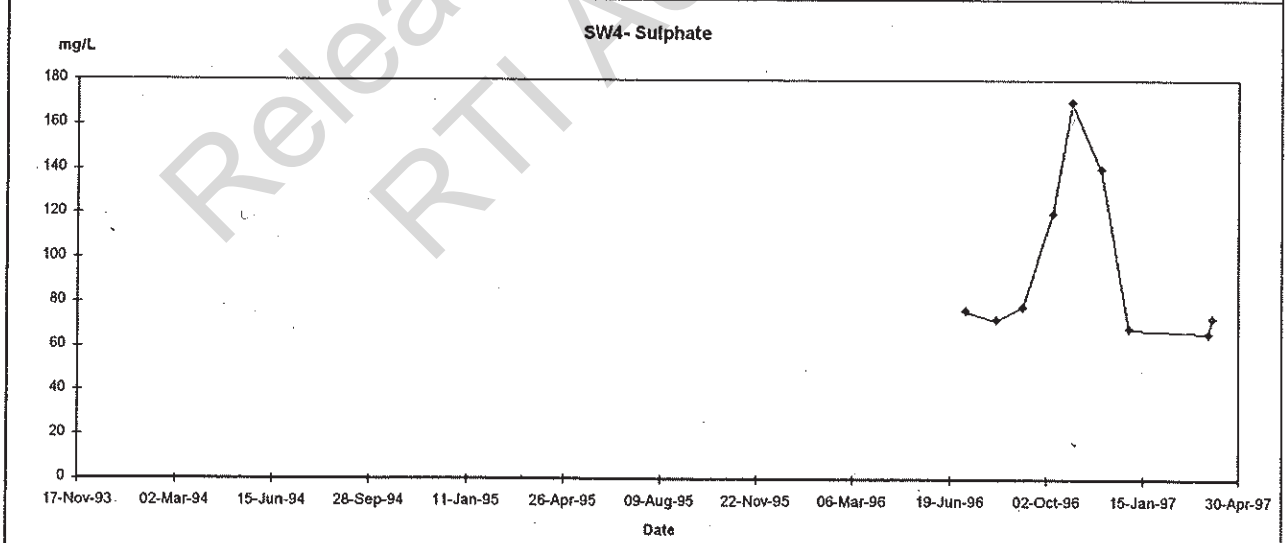

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PANCONTINENTAL MINING LIMITED

CROYDON GOLD MINE
WATER QUALITY MONITORING
SW4

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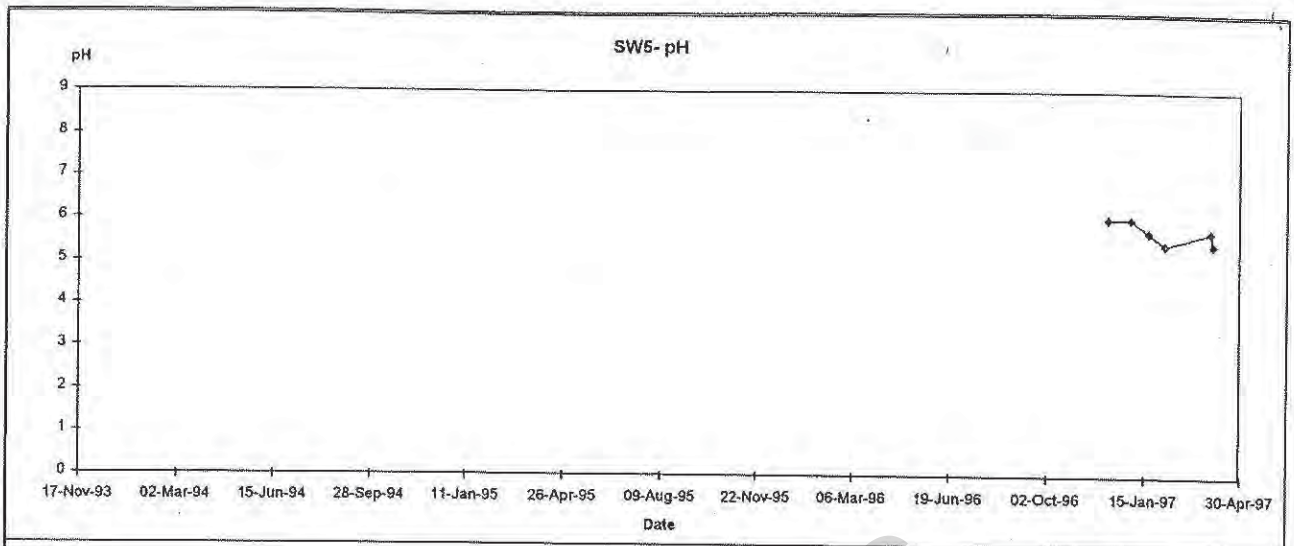

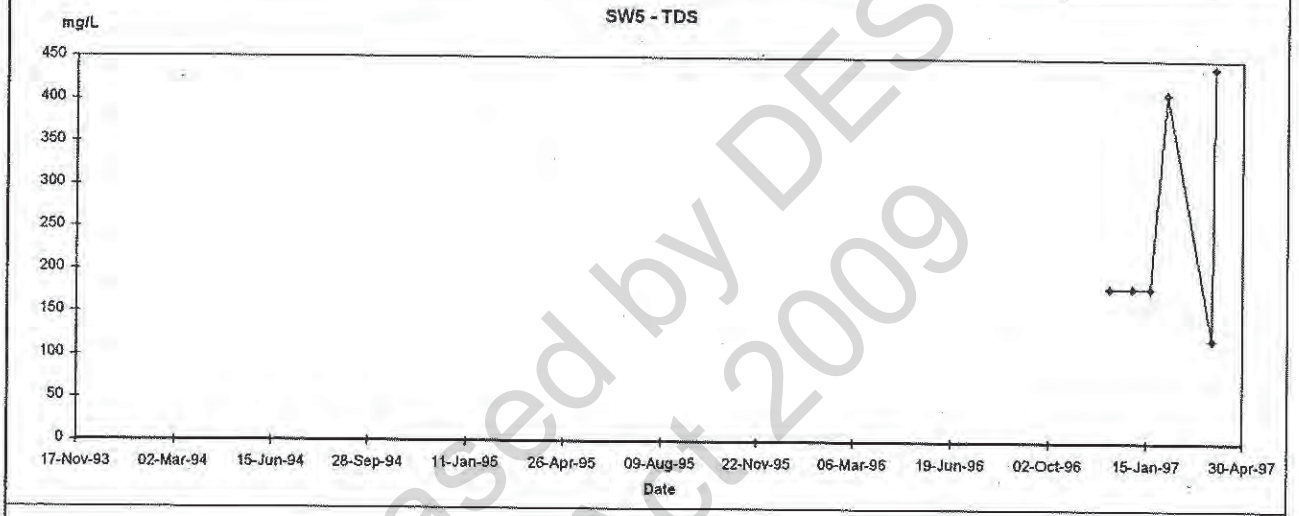

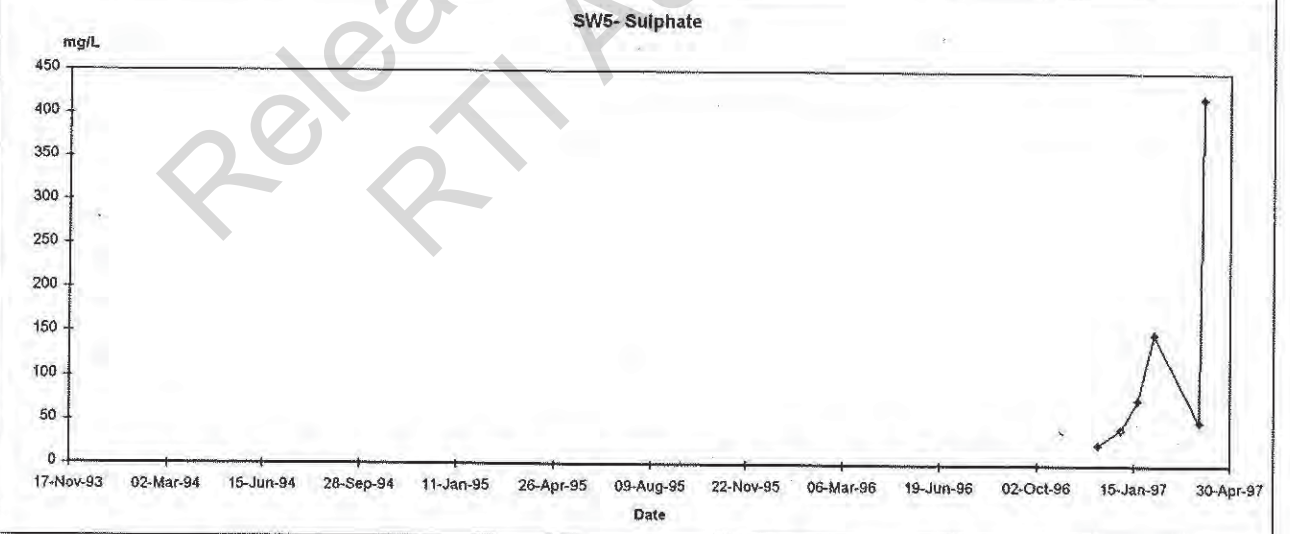

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PANCONTINENTAL MINING LIMITED

CROYDON GOLD MINE
WATER QUALITY MONITORING
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APPENDIX G

EXTENT OF 1996 REHABILITATION WORKS

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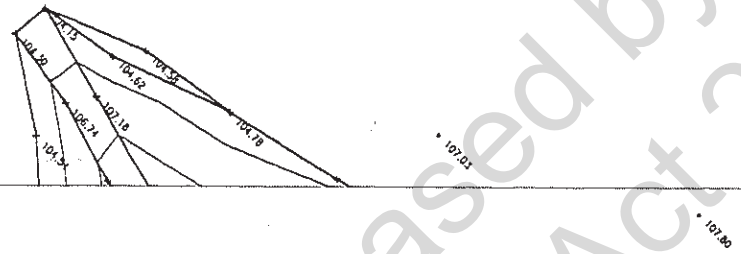

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APPROXIMATE MAGNETIC NORTH

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LEVEL ORIGIN :- STATION 58 = R.L. 103.123 (AHDD)

File d 399924.PLT Scale 1:1000 Point of interest 629028.322E 7989751.035N Created on 25/11/1996 at 11:13:55 using GEOCOMP

C&B CONSULTING GROUP
C & B CONSULTANTS PTY LTD
CONSULTING SURVEYORS DEVELOPMENT CONSULTANTS
TOWN PLANNERS
P.O.Box 59 PH: (070) 61 2211
Innisfail Fax: (070) 61 4631
ACN 010 921 000

DESIGNED		SURVEYED AWL	21.11.96
DRAWN AWL	25.11.96	CHECKED AWL	25.11.96

CTPI 49-Sch4

TITLE
CONTENT WASTE DUMP
POST WORKING
21.11.96

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	LEVEL DATUM AHDD
	FIELD BK 856
SHEET 1 OF SHEETS 1	SHEET SIZE A1
DRAWING No. 399924	AMENDED ISSUE

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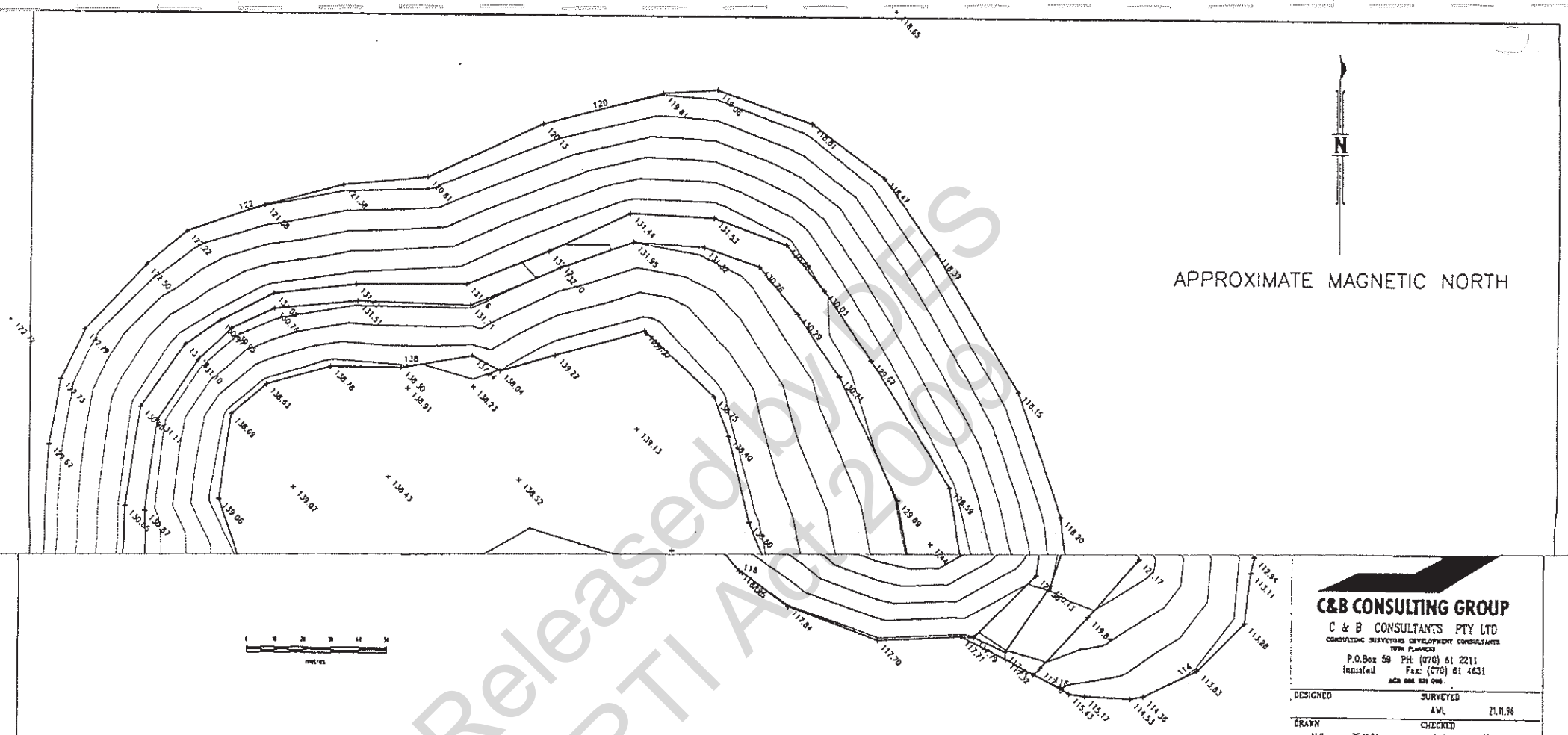

Released by DES
RTI Act 2009

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C & B CONSULTANTS PTY LTD
CONSULTING SURVEYORS DEVELOPMENT CONSULTANTS
TOWN PLANNERS
P.O.Box 59 PH: (070) 61 2211
Innisfail Fax: (070) 61 4631
ACN 066 931 096

DESIGNED		SURVEYED AWL	21.11.96
DRAWN AWL	25.11.96	CHECKED AWL	25.11.96

CTPI 49-Sch4

TITLE
GOLDEN BUTTERFLY
WASTEDUMP
POST WORK
21.11.96

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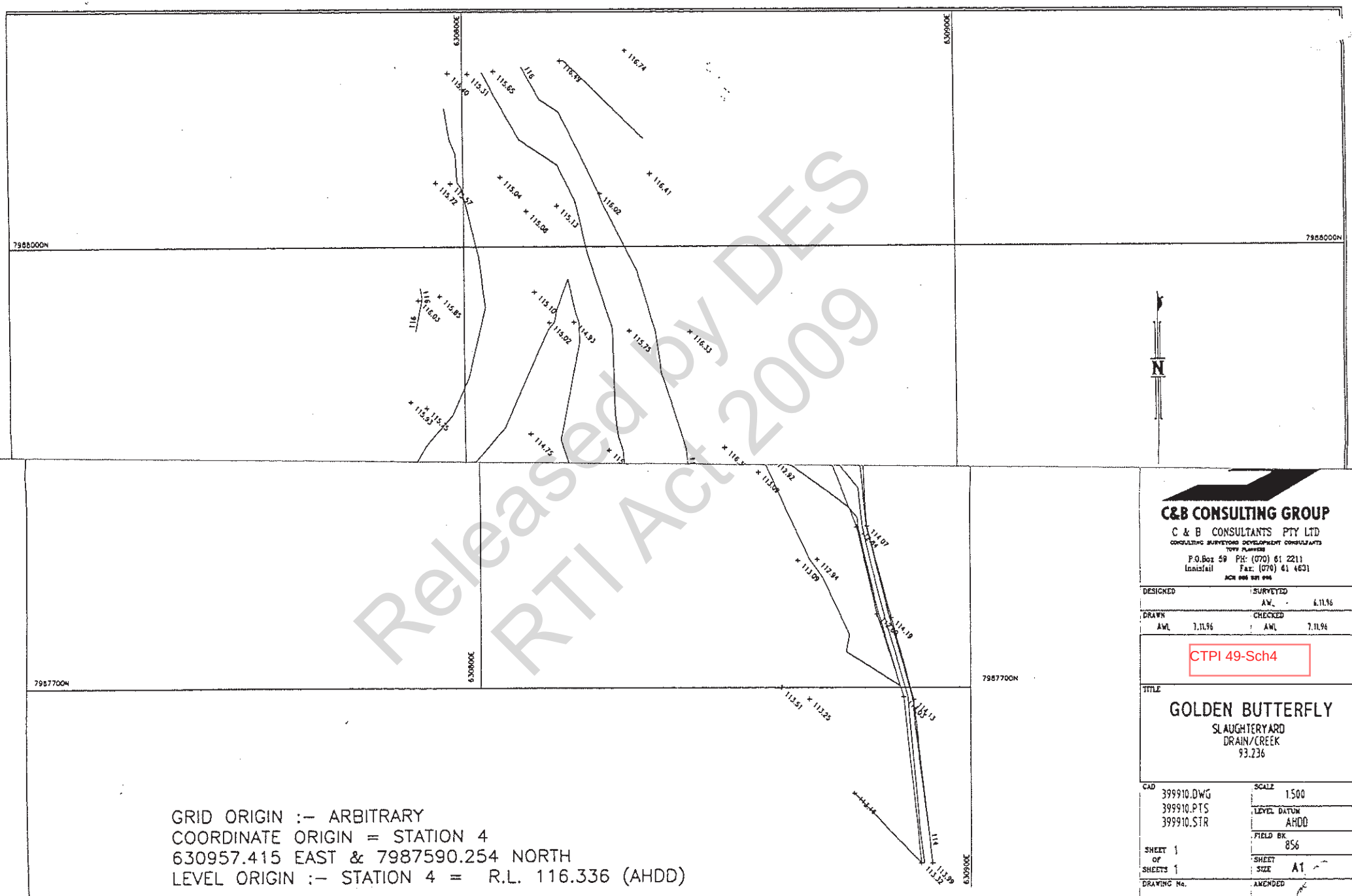
	FIELD BK. 856
SHEET 1 OF SHEETS 1	SHEET SIZE A1
DRAWING No. 399922	AMENDED ISSUE



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C&B CONSULTING GROUP

C & B CONSULTANTS PTY LTD
CONSULTING SURVEYORS DEVELOPMENT CONSULTANTS
TOWN PLANNERS
P.O.Box 59 PH: (070) 61 2211
Innisfail Fax: (070) 61 4631
ACN 066 881 096

DESIGNED		SURVEYED AWL	6.11.96
DRAWN AWL	7.11.96	CHECKED AWL	7.11.96

CTPI 49-Sch4

TITLE

GOLDEN BUTTERFLY

SLAUGHTERYARD
DRAIN/CREEK
93.236

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SHEET 1 of SHEETS 1	SHEET SIZE A1
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APPENDIX H
REVEGETATION WORKS PROGRAM

A survey was undertaken to identify the main components of these vegetation units, and from this a species list to be used in the revegetation program was designed. Wherever possible, seed supplies with local provenance were sourced.

All Acacia seeds were treated in boiling water prior to sowing, with the exception of *Acacia shirleyi* which was supplied coated. Seed was weighed out and mixed into "1 hectare lots" to which small quantities of damp sand were mixed immediately prior to broadcasting.

Seed was sown between the 20 and 23 of January 1997 by representatives of RGC. A total area of approximately 40 hectares was sown at the rate of 2.045 kilograms of native tree seed per hectare (in the proportions as outlined below).

SPECIES	SOWING RATE kg/ha
Acacia decora	0.100
Acacia julifera	0.100
Acacia platycarpa	0.200
Acacia shirleyi	0.250
Acacia torulosa	0.200
Acacia tropica	0.005
Erythrophleum chlorostachys	0.100
Eucalyptus confertiflora	0.080
Eucalyptus leptophelba	0.140
Eucalyptus melanophloia	0.300
Eucalyptus miniata	0.340
Eucalyptus polycarpa	0.180
Melaleuca nervosa	0.050
TOTAL	**2.045 kg/ha**

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Sowing was carried out by hand with the assistance of the Australian Trust for Conservation Volunteers (ATCV).

All surfaces were scarified immediately prior to sowing. The majority of the scarification was carried out using a Caterpillar D6H dozer, however, some of the flat areas adjacent to the Content Waste dump were scarified using a Mitsubishi MG400 grader. Scarifying was generally to a depth of approximately 300 mm, and on waste dump slopes significant effort was made to ensure that it was completed exactly along contour.

Fertiliser was applied in a one-off application by aerial topdressing. A custom blend of fertiliser with an N:P:K ratio of 16.3 : 7.6 : 7.6 was spread at a rate of 500 kilograms per hectare.

It is expected, from RGC experience elsewhere in northern Australia, that native grasses will colonise the site naturally.

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APPENDIX J CROYDON ML5248 STATUS REPORT

AURIONGOLD

Croydon ML 5248 Status Report

December 2002

Author: Gareth Thomas, Group Sustainability Manager

Distributed to:
Dean Ellwood, EPA, PO Box 2316, Mount Isa Q 4825
Alex Reid, EPA, PO Box 2316, Mount Isa Q 4825
Peter Wilson, Mining Registrar, DNRM, PO Box 28, Georgetown Q 4871
Nick Currey, Manager Sustainable Development, Placer Dome Asia Pacific
Pat Sankey, Managing Director, AurionGold Limited

AURIONGOLD

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Appendix 5 -	Photographs showing vegetative cover on Content waste dump and that white surface salts have not affected surrounding vegetation, 5 – 9 July 2002
Appendix 6 -	Analysis of white salts from Content hardstand area
Appendix 7 -	Analysis of soil from Content hardstand area
Appendix 8 -	Review of 2001/2002 water quality monitoring data
Appendix 9 -	Sketch of completed works at Content hardstand and waste dump area

Introduction

Mining lease ML 5248 is close to the township of Croydon in far north Queensland. Four open pits were mined during 1988 – 1990 under the ownership of Pancontinental Mining Pty Limited, and two waste dumps were generated. Ownership of the lease passed to Goldfields Limited during 1996, and this latter company became AurionGold Limited after merging with Delta Gold Limited in late 2001.

AurionGold is now majority owned by Placer Dome Incorporated of Canada and will be de-listed from the Australian Stock Exchange on completion of compulsory acquisition of remaining shares. Placer Dome Asia Pacific, through its Brisbane office, will continue the process towards relinquishment of this mining lease.

A draft Final Rehabilitation Report was submitted by HLA-Envirosciences to the EPA on behalf of Goldfields/AurionGold in late 2001. The EPA expressed concern in an e-mail from Dean Ellwood of EPA Mount Isa to Tom Farrell of HLA-Envirosciences on 14 February 2002 about a number of issues, in particular, geochemical issues and the lack of vegetation on the Content hardstand area. A new Plan of Operations was submitted in April 2002 to allow the EPA's concerns to be addressed.

Geochemical assessment work was started by HLA-Envirosciences in May as a preliminary site investigation in accordance with the *Draft Guideline for the Assessment and Management of Contaminated Land in Queensland*. A report was submitted to AurionGold in September 2002.

Remedial earthworks for the Content hardstand area were undertaken in July 2002.

This report summarises work carried out at Croydon during calendar year 2002 and is provided for information only.

History

Mining lease ML 5248 was originally held by Pancontinental Mining Limited (Pancon). The Golden Butterfly, Golden Butterfly North, Lady Isabelle and Content pits were developed and mined out between late 1988 and 1990. Mining and processing of ore was carried out by Barrick Mine Management for an unincorporated joint venture between Central Coast Exploration NL and Pancon. The processing plant was located several kilometres away. Part of the original lease held by Pancon was relinquished after mining stopped in 1990.

Pancon conducted rehabilitation works during 1990 - 1993, and Goldfields carried out further rehabilitation works during 1996 - 1997. Details of these works are contained in the Croydon Gold Mine 1996 (Amended) Decommissioning Plan that was submitted to the Department of Mines and Energy on 19 May 1997. More details including environmental monitoring results are included in the Draft Final Rehabilitation Report (FRR) prepared by HLA-Envirosciences and dated 6 November 2001, as submitted to the Environmental Protection Agency (EPA) Mount Isa office for comment.

Comments on the Draft FRR were received from the EPA on 14 February 2002. Two key issues requiring early action were identified. These were that:

1. A geochemical assessment was needed to identify or allay any concerns about metal/metalloid contamination at former hardstand areas or acid rock drainage (ARD) from waste dumps; and

2. Remedial works were needed at the Content hardstand area, which was largely devoid of vegetation.

As the term of the 1996 Decommissioning Plan effectively expired on 31 December 2001, the EPA advised that a new Plan of Operations (PoO) was required to allow the two key issues identified above to be addressed. This PoO was prepared and submitted through the Mining Registrar of the Department of Natural Resources and Mines on 10 April 2002. The term of the PoO is 2 years to 31 December 2003.

The April 2002 PoO was accepted by the EPA as meeting the requirements of Section 234 of the *Environmental Protection Act 1994* per its letter dated 17 June 2002.

HLA-Envirosciences conducted site investigation field work in May 2002 and finalised its report on 10 September 2002.

AurionGold organised and managed remedial works at the Content hardstand area in July 2002.

Geochemical Assessment

A site investigation was carried out for AurionGold by HLA-Envirosciences in May 2002. This was carried out in accordance with the *Draft Guideline for the Assessment and Management of Contaminated Land in Queensland*.

Full details of the site investigation and geochemical assessment are contained in the report by HLA-Envirosciences dated 10 September 2002. This report was submitted to the EPA's Contaminated Lands division in Brisbane for assessment, together with the prescribed $900.00 fee on 16 October 2002. At the time of preparation of this report, no comment has been received from the EPA. EPA file number BNE1050 refers.

The report concluded that "no visible sulphides, discoloured soil or stained soil were observed in any of the test pits excavated across the Golden Butterfly or Content hardstand areas". Also, "analysis results .... confirm that there is negligible sulphidic mineral and (negligible) metal/metalloid contamination present" in either the hardstand areas or in representative samples collected from the two waste dumps.

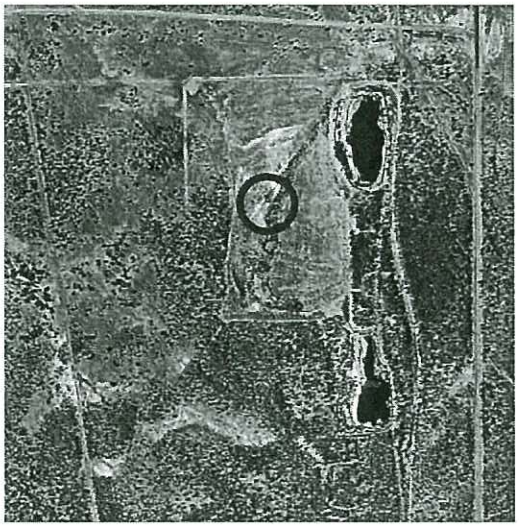
The report further concluded that in accordance with the Contaminated Land Guidelines, a Stage 2 Detailed Site Investigation is not required for the site and that, other than works proposed by AurionGold, no remediation plan was proposed.

Remedial Earthworks

In general, revegetation of disturbed areas on the lease has been excellent. Visitors to the area travelling on the Croydon to Normanton road would be most unlikely to recognise the waste dumps as anything other than natural landforms and the open pits are not visible until arriving at or close to the perimeter bunding. Aerial photographs showing the mining phase and early rehabilitation works are included in Appendix 1. Photographs taken in March 2002 are included in Appendix 2 for comparison purposes.

The only area of concern with respect to revegatation has been a former hardstand area adjacent to the Content waste dump. This area is only about 0.3 hectare in extent but has not been revegetated. Although verbal reports suggest that the area was seeded and possibly fertilised, this may not be the case. There is no evidence that vegetation had ever established.

The aerial photographs below show relevant areas of the lease in 1999 on the left and again in 2002 on the right.



Content and Lady Isabelle pits and Content waste dump with former hardstand area circled - 27 June 1999

Content and Lady Isabelle pits and Content waste dump with former hardstand area circled – 6 July 2002

Golden Butterfly and Golden Butterfly North pits and waste dump - 27 June 1999

Golden Butterfly and Golden Butterfly North pits and waste dump – 6 July 2002

Due to lack of vegetation, AurionGold acknowledged that remedial earthworks at the Content hardstand area were desirable and necessary. These works were described in the April 2002 Plan of Operations.

An efflorescence of white salts had been noticeable over most of the former Content hardstand area and amongst some adjacent vegetation. It had been assumed that acid drainage was seeping directly from the toe of the adjacent waste dump, however as described later, it has been established that this was not the case and was not the cause of the white salts.

Earthworks were planned to cut a toe drain along the side of the Content waste dump, and on the assumption that there would be indications of ARD, to seal this side of the waste dump with a cut-off trench and compacted seal.

As it was realised that groundwater was causing the white efflorescence in the Content hardstand area, part of the remedial works strategy was to cut drains from the opposite side of the waste dump into the Content pit. This was based on local advice that drainage used to run in this direction, and on the concept of using deep drains to lower the water table under the waste dump.

On 4 July 2002, people and equipment were mobilised to Croydon to undertake earthworks.

Work started in the Content area at 6.30am on 5 July 2002 with a 25 tonne Kobelco excavator and a 15 m^3 International tipper truck hired from Mario Puccini Excavations of Innisfail. A Hanomag D700D dozer was hired locally from Dave Fitzgerald. The International truck suffered a hydraulic pump failure in the first day and was sent away. It was replaced with a semi-trailer end-tipper truck, and later, a semi-trailer side-tipper truck was also hired through Dave Fitzgerald.

Work progressed generally as follows:

1. Temporarily remove sections of bund wall across top of Content pit access ramp, and elsewhere for trenches.

2. Cut trench about 52 m long and 1.5 m deep on the downslope side, along toe of Content waste dump next to hardstand area.

3. Cart and dump trench spoil in Content pit.

4. Cut about 150 mm of surface material off hardstand area.

5. Cart and dump hardstand spoil in Content pit.

6. Cut two trenches from nearest side of waste dump into Content pit, plus cut lateral trench parallel with toe of waste dump and linking first two trenches.

7. Place at least 1 m depth of screened river rock in base of trenches, cover and compact. (This rock was purchased from Wells Plant Hire which has an extractive operation on Belmore Creek, about 1 km northwest of the Content pit. The rock was brought to the site with equipment used on the remedial works.)

8. Replace all sections of Content pit bund wall.

9. Reprofile hardstand area where necessary to provide adequate fall and drainage.

10. Cart in clean sand and soil (sourced from a pit in red Tertiary sand off old haulroad back towards Golden Butterfly pits) to cover hardstand area and fill first toe trench, spread and level, with drainage fall to south-west.

Photographs of the works undertaken are shown in Appendices 3 and 4.

Relevant issues noted during the above works were:

1. When the trench was cut along the toe of the waste dump next to the hardstand area, a red clay seal was noted underneath the loose surface cover. This seal and covering was originated by Pancontinental Mining in 1990 - 1993 and had not been disturbed since.

2. The waste rock under the clay seal was uniformly grey with graphitic granite typical of the local area.

3. None of the waste rock showed any red or yellow iron oxidation nor was there any red or yellow iron oxide staining or any other discolouration present nor any other indication that there had ever been seepage present out of the waste dump in this area.

4. At the northern end of this trench, water was encountered at only about 1.5 m below surface. This water was quite clear but had a pH of 3 and extremely high TDS. Within a day of exposure, white salts were effloresceing from capillary action in the base of the trench around the ponded water.

5. When the first trench was cut on the opposite side of the Content waste dump running across from the toe of the waste dump to the pit crest, high TDS water was also encountered, about 1.8 m below surface.

6. Inside the Content pit perimeter bund wall on the side nearest to the waste dump, both dried up and active natural seepage can be observed flowing into the pit void. All of this seepage is accompanied by white salt efflorescence. Healthy vegetation including acacia and native passionfruit vine was observed growing in and around active seepage. (Refer to photographs in Appendix 5).

7. White salt efflorescence was observed in and around grasses and native trees at either end of the hardstand area with no apparent ill effect. Some of the salts were sampled and sent for analysis. Results are included in Appendix 6 and show the material to be a sodium/magnesium sulphate. Original soil from a section of the hardstand area was also sampled. The soil sample was taken from a dozer rip line parallel with and about 40 m away from the toe of the Content waste dump across the former hardstand area. A photograph of the rip line is shown at the end of appendix 3. Soil sample results are included in Appendix 7.

8. It was observed that the hardstand area had some low-lying areas that would pond water in the wet season as there had been a small "bar" on the downslope side that was removed during re-profiling.

From the above points, a number of conclusions can be drawn:

1. There is evidence of active seepage of groundwater with very high TDS for many years into the Content pit from quite close to natural surface.

2. Even in the dry season, the water table on either side of the Content waste dump is surprisingly close to the surface. This may indicate "mounding" under the waste dump that may be alleviated by the new rock-filled drains running into the Content pit.

3. There is no iron staining and there is no other similar evidence of acid rock drainage (ARD), corroborating general observations by HLA-Envirosciences in its September 2002 report.

4. Soil paste pH is about 3 to 3.5 in the Content hardstand area. Run-off from the Content hardstand area may have a pH of about 4 nearby at sample point SW5 in the wet season, but downstream water quality as measured at SW6 remains consistently good and appears to show no influence from the water at SW5.

5. Native vegetation will grow and is growing successfully in and around local groundwater.

6. There is acid sulphate soil in the Content waste dump and the adjacent former hardstand area. The source of the sulphate ions may be related to the Content waste dump but this could not be determined.

7. The hardstand area had a high groundwater table that almost certainly expressed itself at surface in the wet season and it had poor drainage.

8. It can reasonably be expected that addressing drainage issues and providing fresh soil and topsoil will allow vegetation to establish in the Content hardstand area and that this should now not be adversely affected by high TDS groundwater.

During earthworks, seed was collected from various native and other species around the immediate area. This seed was distributed over the fresh soil and subsoil on the Content hardstand area when the earthworks were finished.

Water Monitoring

After acceptance of the April 2002 Plan of Operations, water monitoring will be reduced. The only monitoring that is required to be carried out is twice per wet season at SW5 and SW6, downstream of the Content hardstand area, and at reference sites.

In September 2002, HLA-Envirosciences compiled a review of 2001/02 water monitoring results. This review is included in Appendix 8.

Bibliography

Croydon Gold Mine 1996 (Amended) Decommissioning Plant for ML 5248, Woodward Clyde, April 1997.

Draft Final Rehabilitation Report Croydon Gold Mine ML 5248, HLA-Envirosciences, 6 November 2001.

Plan of Operations for ML 5248, AurionGold Limited, 10 April 2002.

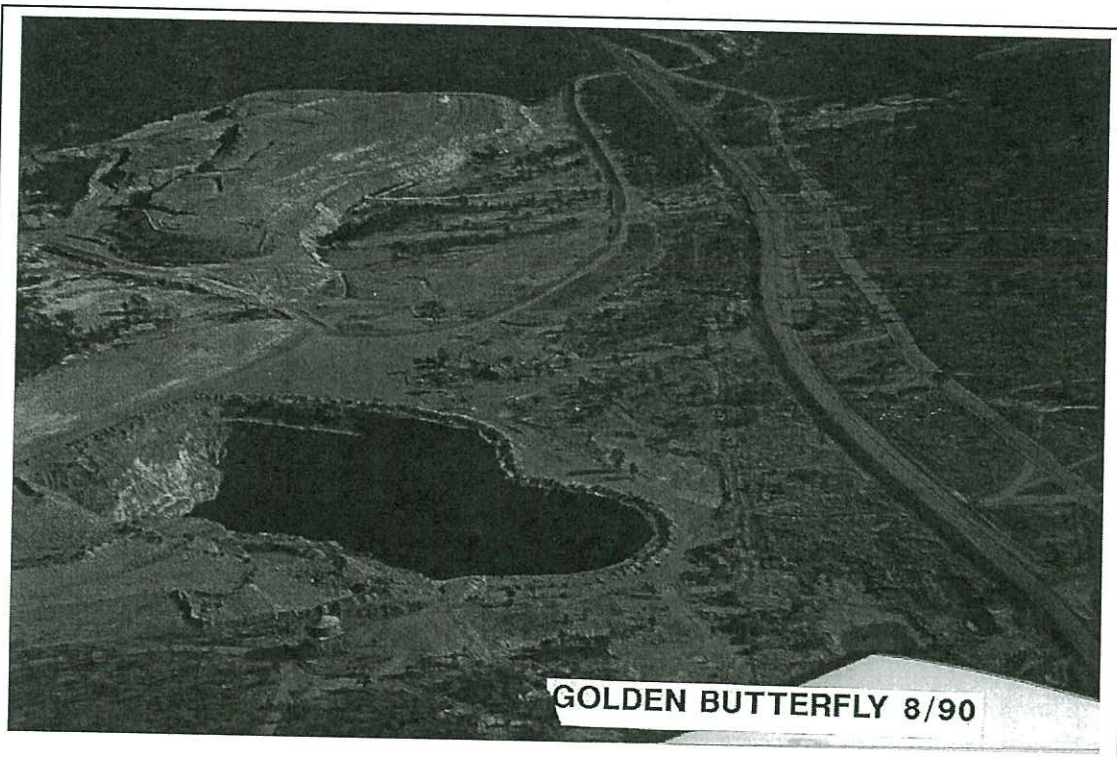
Contaminated Land Site Investigation Croydon Gold Mine, HLA-Envirosciences, 10 September 2002.

Appendix 1

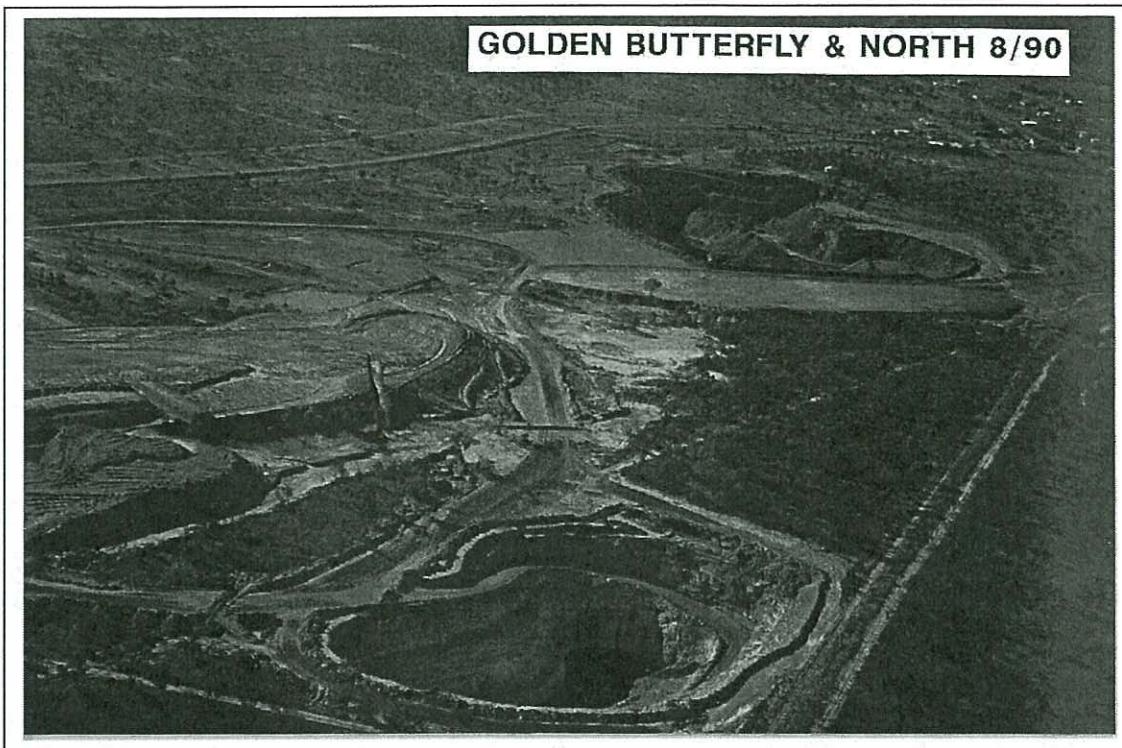
Photographs from 1989 - 1990

AURIONGOLD

Aerial view of Golden Butterfly pit with 10 metres depth to go. Note hardstand area on left with ore stockpiles. October 1989.



Aerial view of Golden Butterfly pit with hardstand area, roads and waste dump under rehabilitation. Croydon to Normanton road runs bottom right to top. August 1990.



Aerial view of Golden Butterfly North (foreground) and Golden Butterfly (distance) with waste dump (centre left) and Croydon township (far right). Note various areas under rehabilitation. August 1990.

Golden Butterfly North (left) and waste dump (centre) under rehabilitation. August 1990.

AURIONGOLD

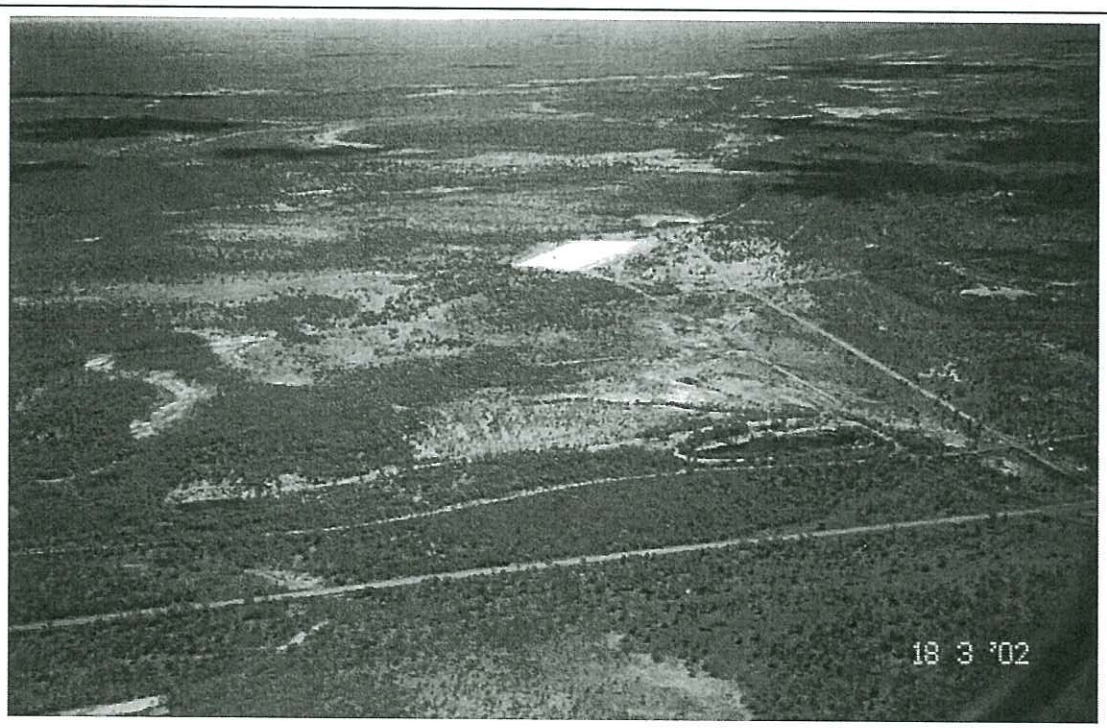
Lady Isabelle pit and Content waste dump. Probably 1990.

Appendix 2

Photographs from March 2002

AURIONGOLD

Aerial view of Golden Butterfly (left) and Golden Butterfly North (right) pits with waste dump to right and edge of Croydon township to left. Croydon to Normanton road runs left to right.

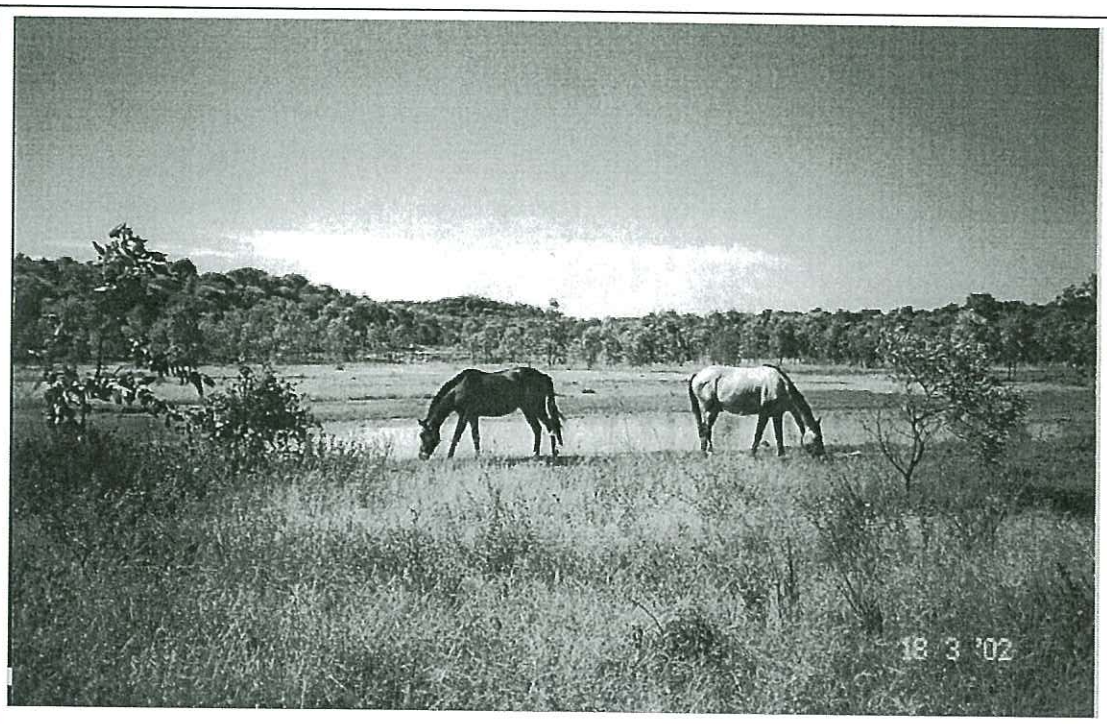


Aerial view of Lady Isabelle (left) and Content (right) pits with waste dump centre. Croydon to Normanton road runs left to right.

Aerial view of Content hardstand area (left foreground) with waste dump (centre) and Content pit. Croydon to Normanton road runs from right to left (distance).

Content hardstand area - 18 March 2002

AURIONGOLD



Horses grazing with Content hardstand area in middle distance between trees and waste dump covered with trees to left - 18 March 2002

Appendix 3

Photographs showing trench dug to check for ARD and remedial earthworks at Content hardstand area, 5 – 9 July 2002

AURIONGOLD

Former Content hardstand area with white efflorescence salts – 5 July 2002

First cut into waste dump next to Content hardstand area showing red clay capping and loose cover layer with no indication of any ARD – 5 July 2002

Preliminary cut along toe of waste dump to check for ARD seepage – note red clay layer under loose cover

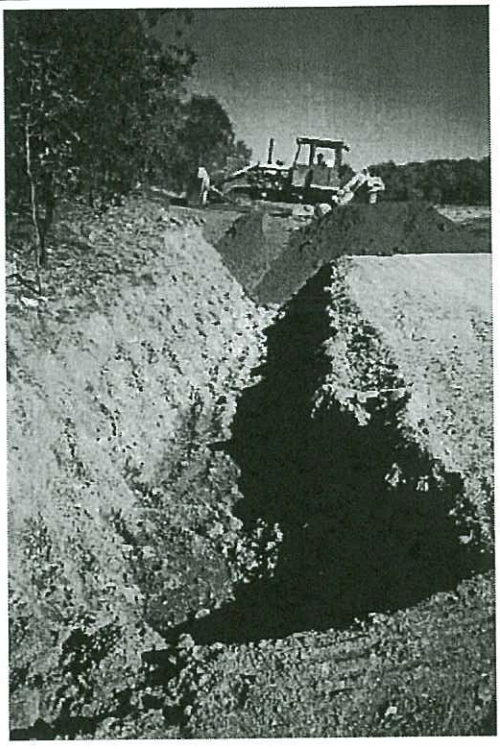
Trench about 52 m long opened up along toe of waste dump with no trace of ARD seepage

AURIONGOLD

High TDS groundwater with white efflorescence appearing through capillary action and evaporation in northern end of trench at about 1.5 m below ground level

Side of trench showing no trace of ARD, but white salts from evaporation of interstitial or capillary moisture after exposure for 2 days – 7 July 2002

Backfilling trench after finding no indication of ARD – note proximity of high TDS water to surface



Spreading and compacting trench backfill

AURIONGOLD

Excavation of sand for backfilling and coverage at Content hardstand area

Continuing backfilling of trench

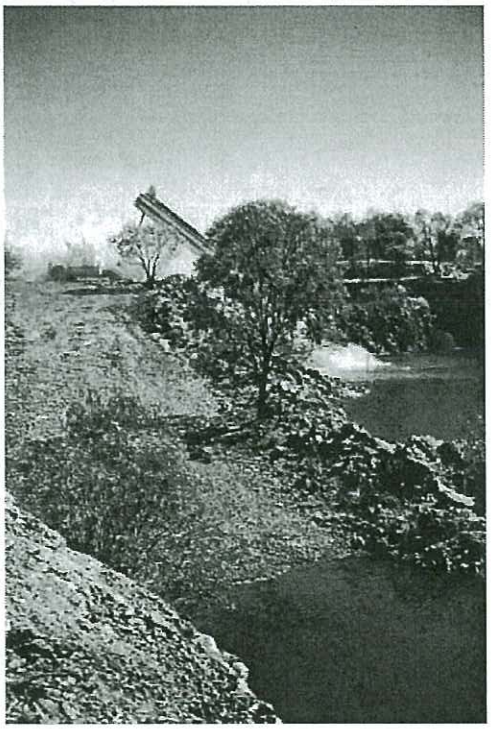
AURIONGOLD

Stripping of surface layer from Content hardstand area – 6 July 2002

Stripping of surface layer from hardstand area continues – 6 July 2002

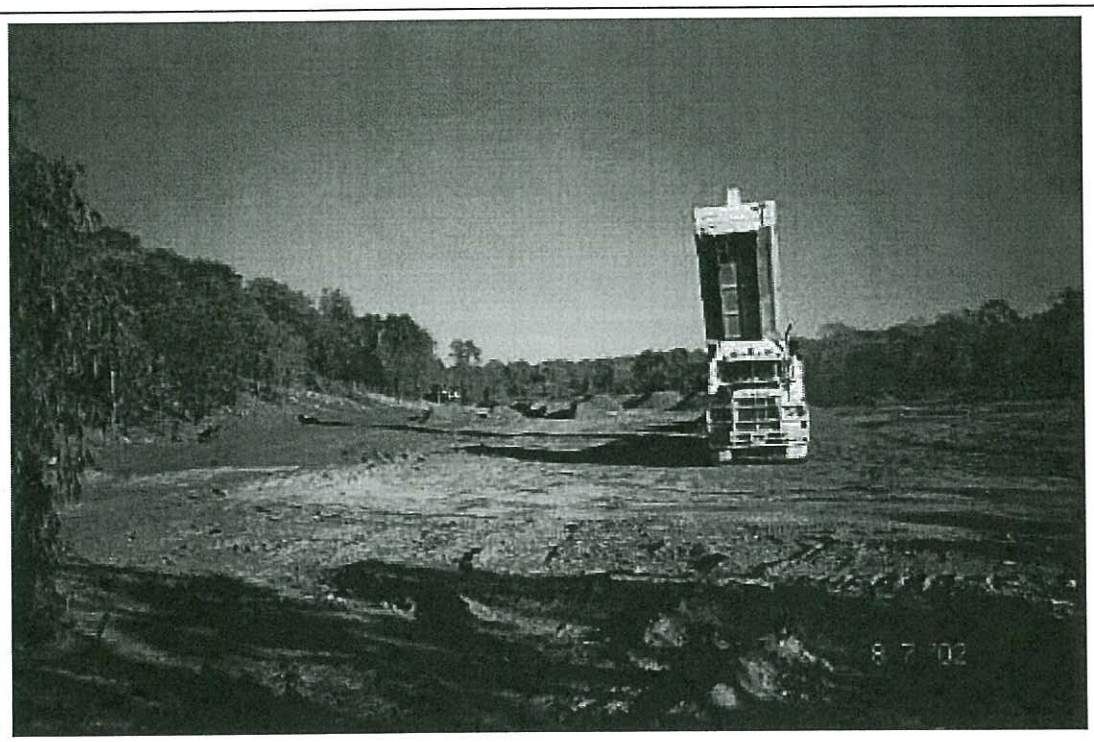
AURIONGOLD

Loading of surface layer material for disposal in Content pit



Dumping of material stripped from hardstand area into Content pit

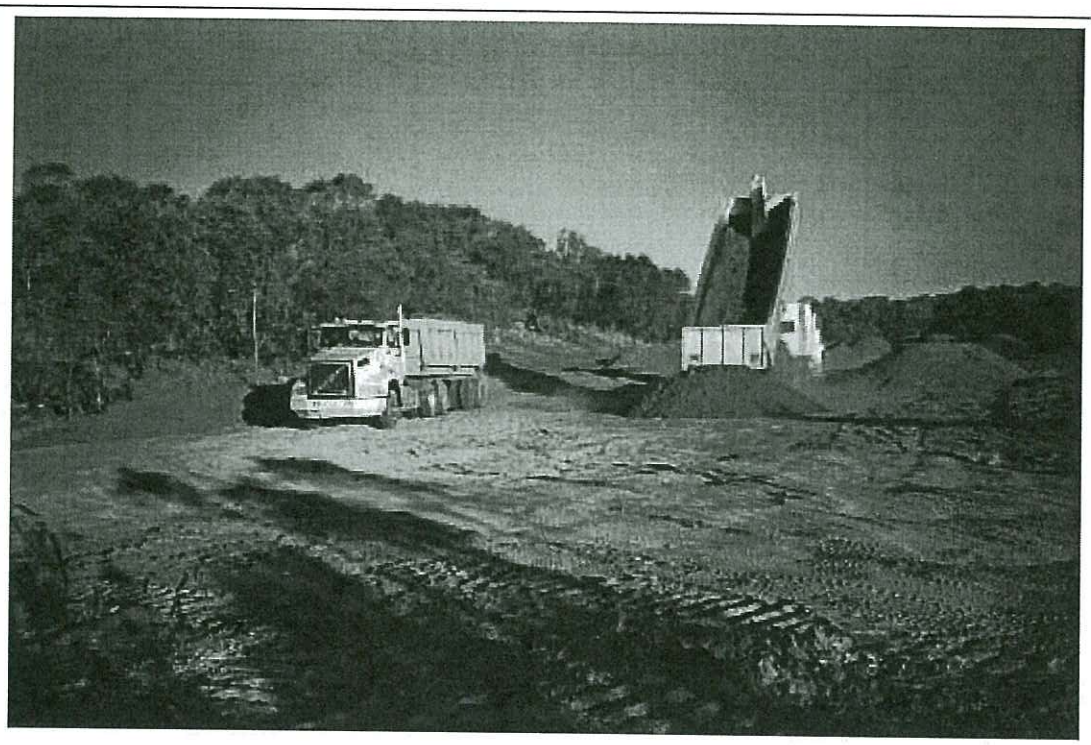
AURIONGOLD



Replacement of reprofiled hardstand area surface with clean sand and soil

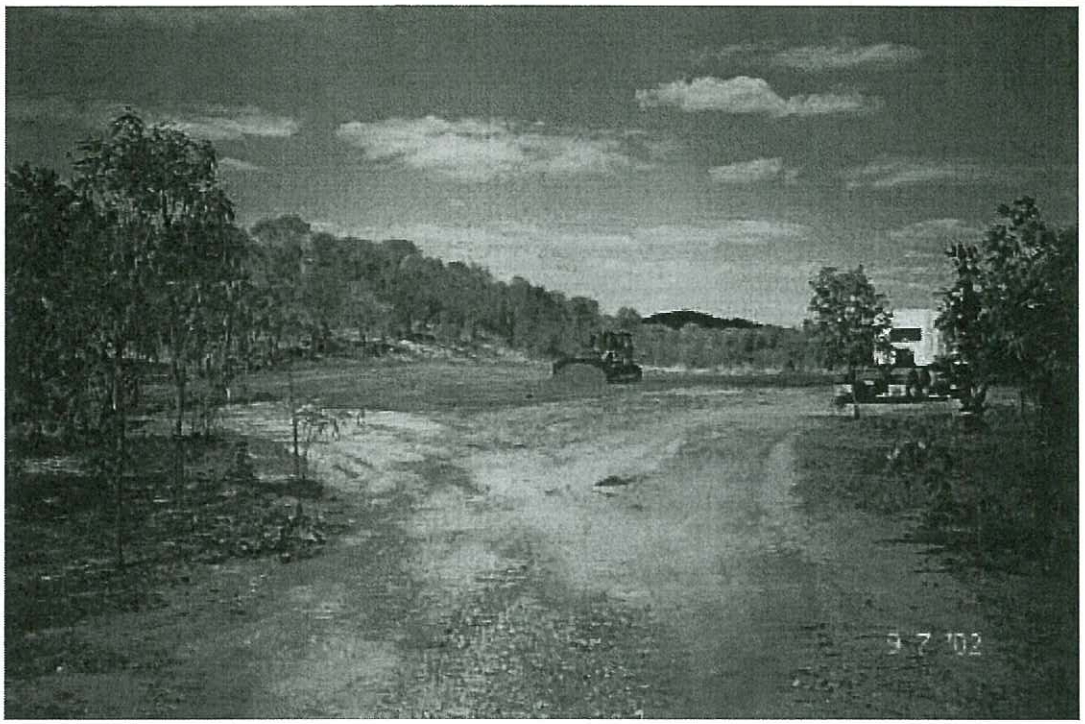
Dumping of sand and soil ready for spreading over hardstand area – 8 July 2002

AURIONGOLD



Dumping of sand and soil continues ready for spreading over hardstand area – 8 July 2002

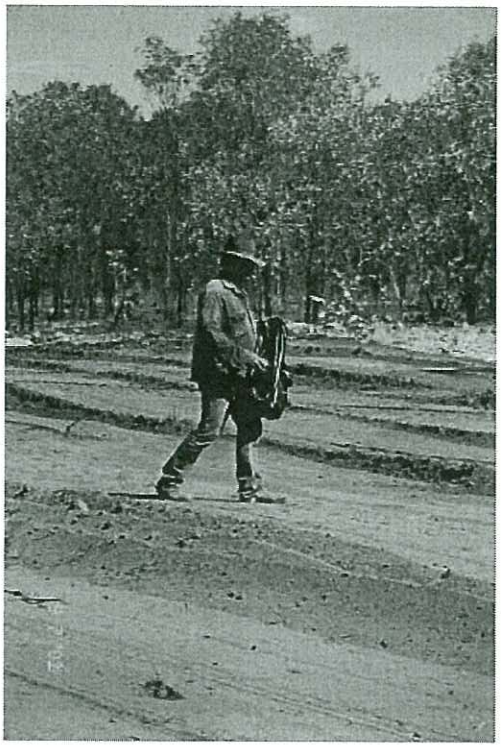
Spreading sand and soil over hardstand area – 9 July 2002



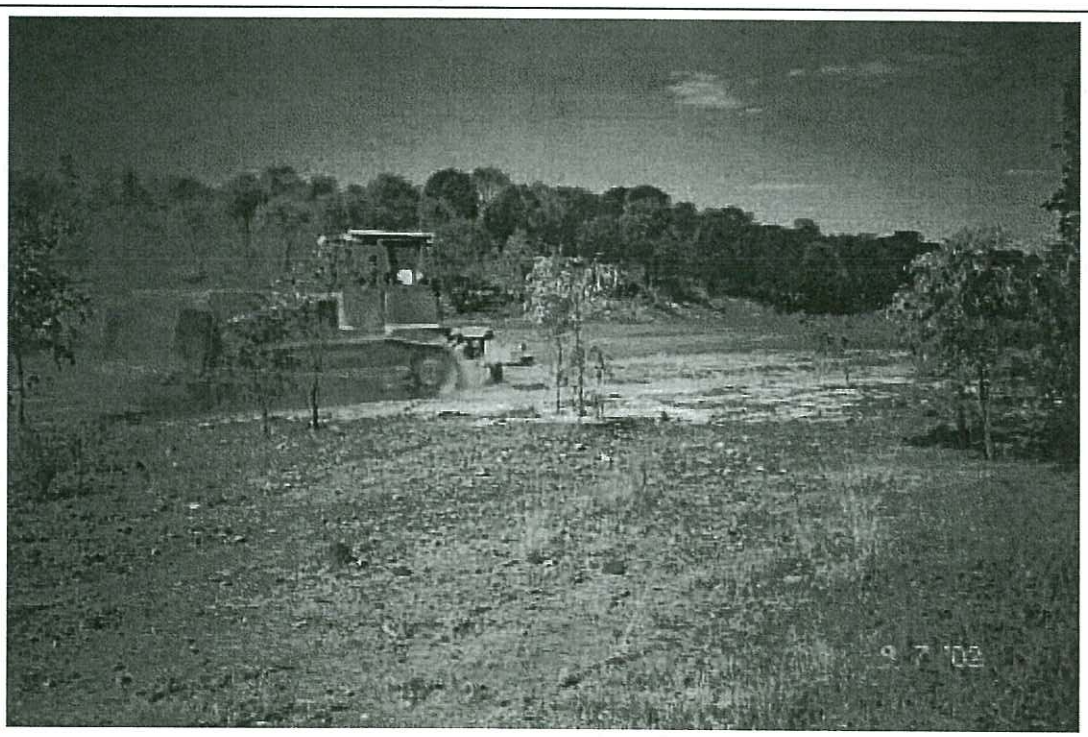
Spreading sand and soil continues over hardstand area – 9 July 2002

Spreading sand and soil continues over hardstand area – 9 July 2002

AURIONGOLD



Spreading locally collected grass seed on Content hardstand area – 9 July 2002

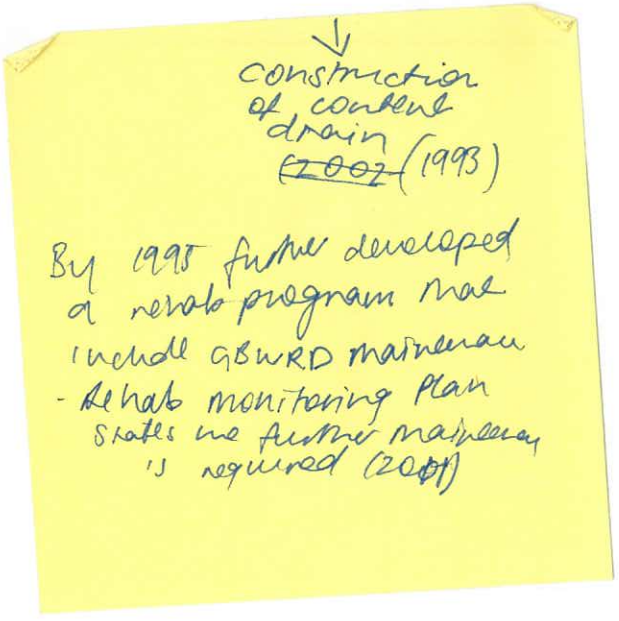


Ripping to relieve compaction in hardstand area – 9 July 2002

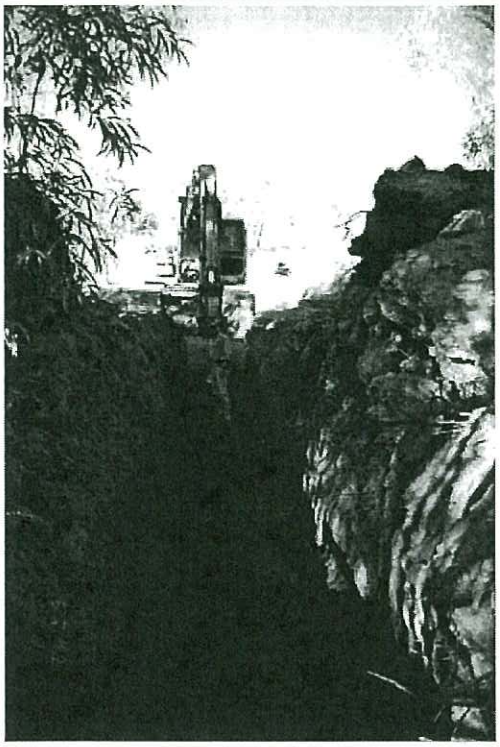
AURIONGOLD

Appendix 4

Photographs showing construction of rock-filled drains designed to keep groundwater table lower between waste dump and Content pit, 6 – 9 July 2002



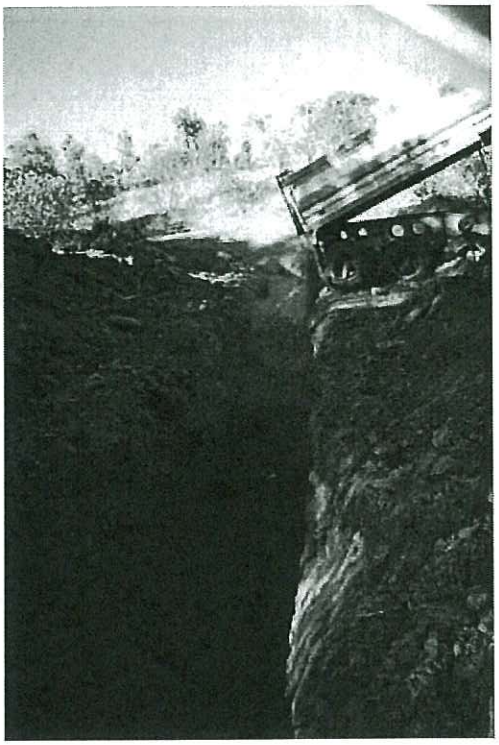
AURIONGOLD



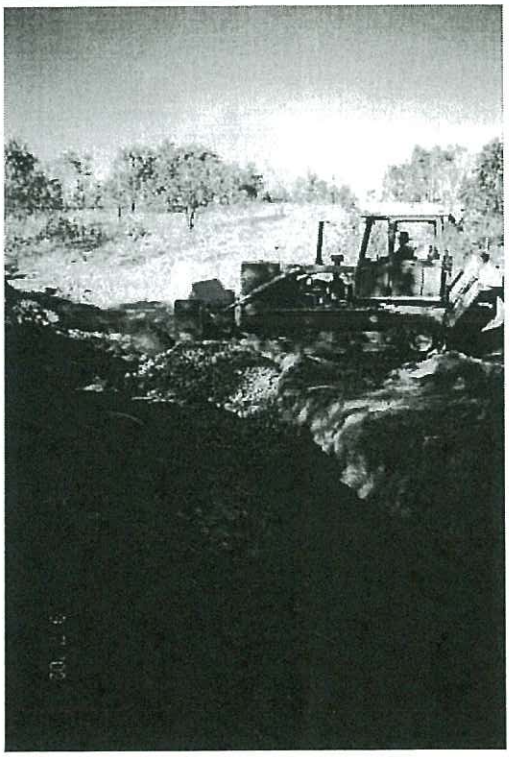
First drain from waste dump to Content pit being cut – 6 July 2002

Groundwater encountered near toe of Content waste dump

AURIONGOLD



Screened river rock being placed in first drain to Content pit – 9 July 2002



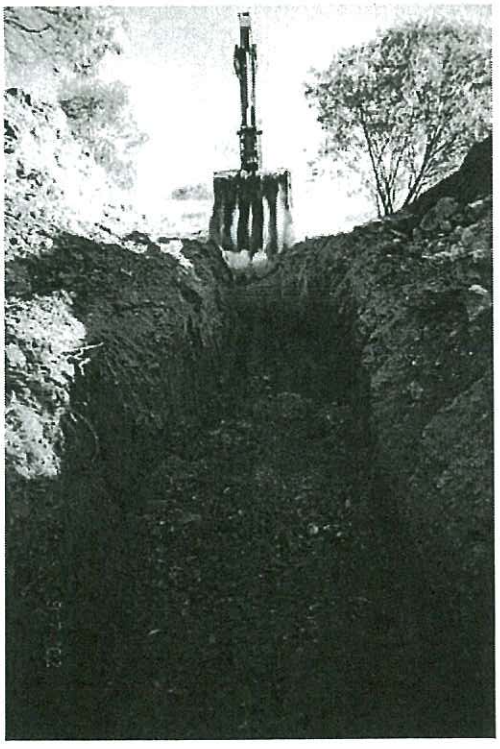
Section of first drain filled with screened river rock

AURIONGOLD

Dumping more screened river rock ready for placing with excavator in drains to Content pit

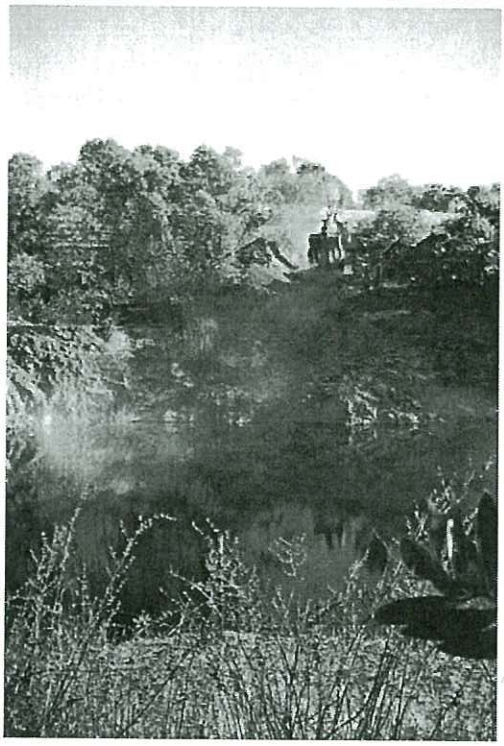
Finishing excavation of lateral waste dump toe drains before backfilling with screened river rock

Cutting second drain from waste dump into Content pit



Filling second drain into Content pit with screened river rock

AURIONGOLD



Finishing filling second drain to Content pit with screened river rock

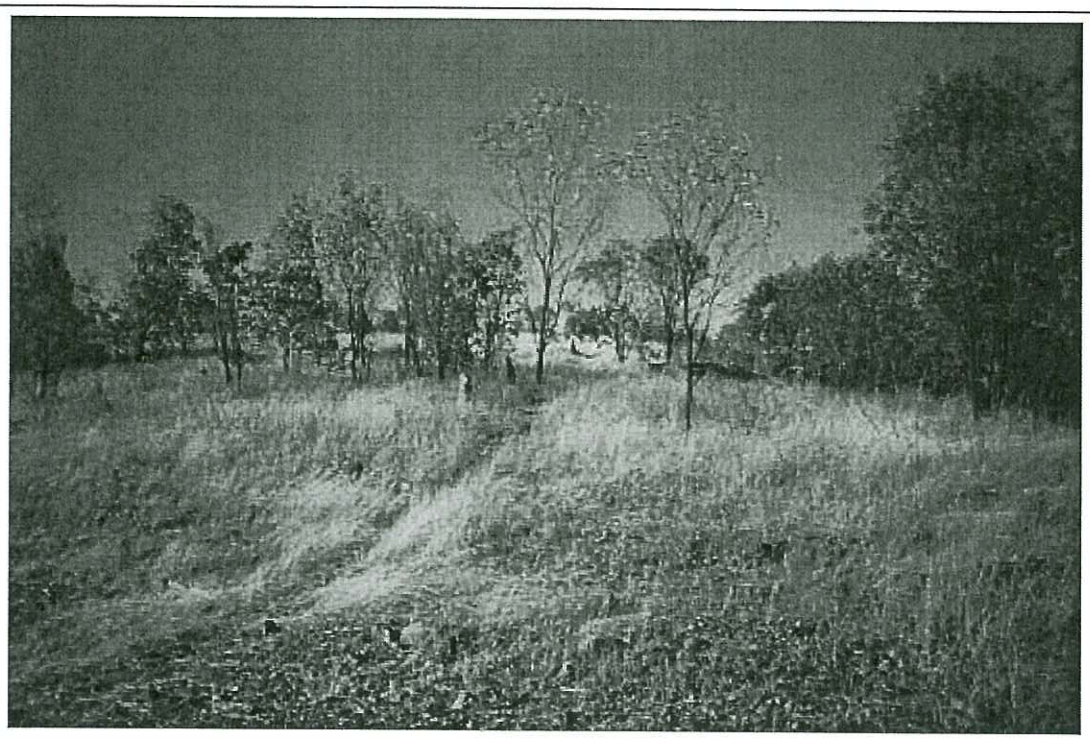
Area between waste dump and Content pit now with 2 cross drains and connecting lateral toe drain, backfilled with screened river rock, compacted and levelled

AURIONGOLD

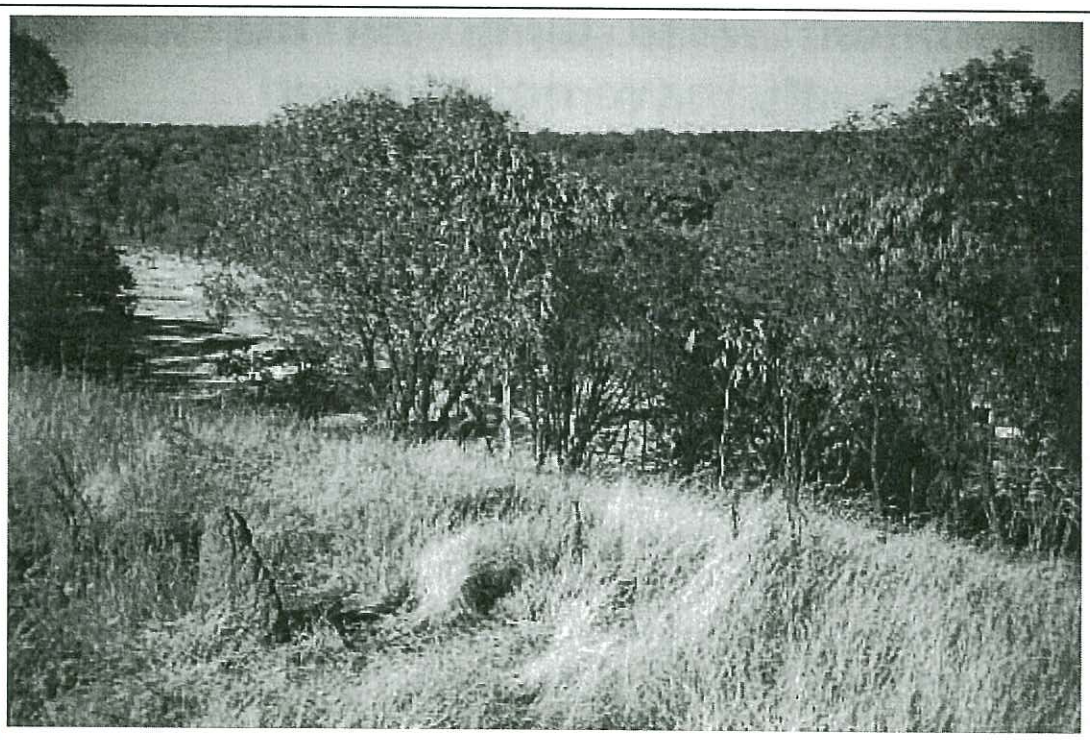
Appendix 5

Photographs showing vegetative cover on Content waste dump and that white surface salts have not affected surrounding vegetation, 5 – 9 July 2002

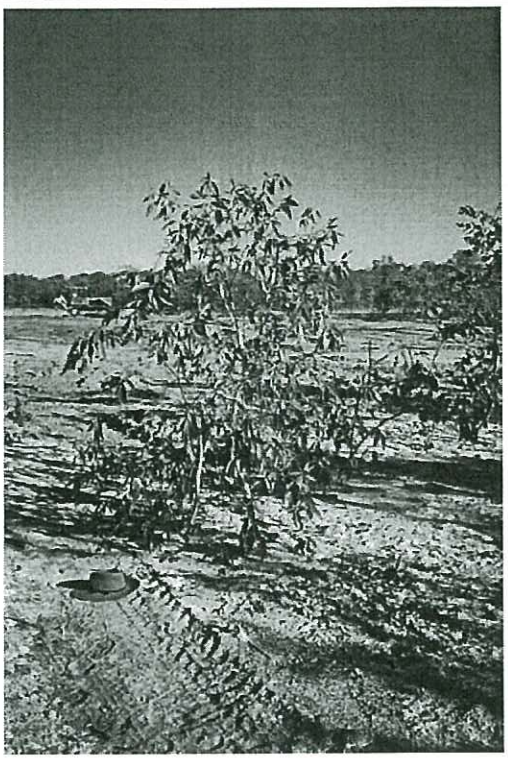
AURIONGOLD



General view of Content waste dump – note animal tracks and termite mounds – 5 July 2002



View down from waste dump to hardstand area – note healthy vegetative cover on waste dump and white salts below – 5 July 2002



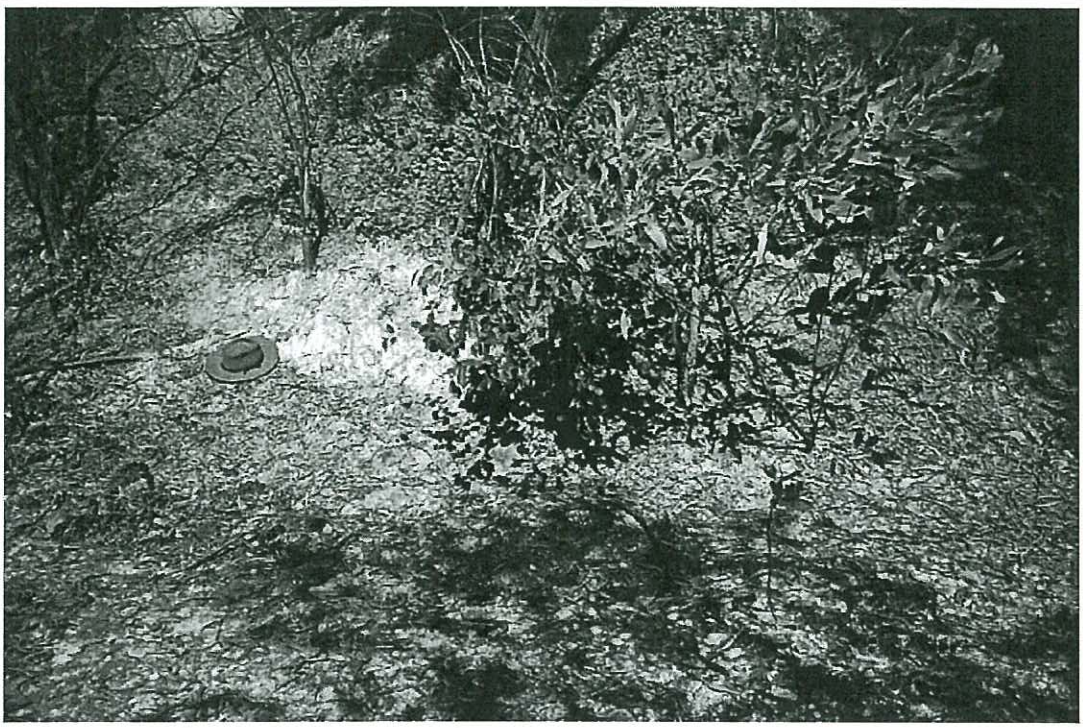
Healthy tree with white salts on surrounding ground surface – 7 July 2002

Larger area showing healthy trees with white salts on surrounding ground surface

AURIONGOLD

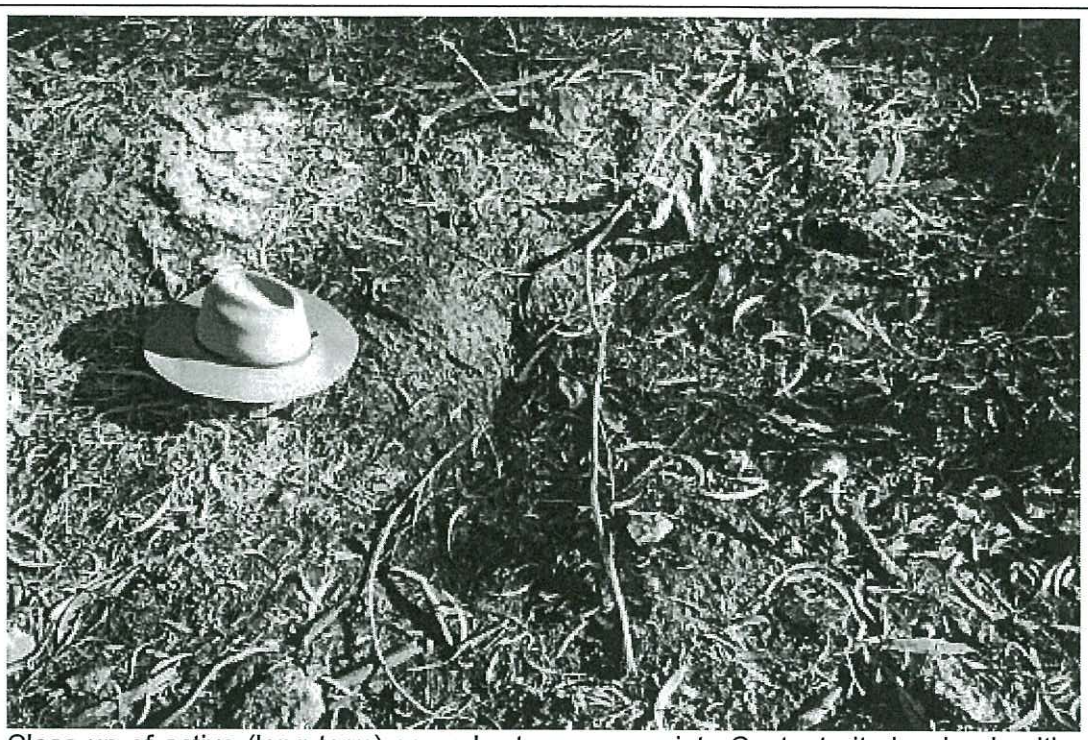
Further area showing healthy trees and grasses with white salts on surrounding ground surface

Another area showing healthy trees and grasses with white salts on surrounding ground surface



Area of dried-up groundwater inflow to pit showing healthy trees with white salts on surrounding ground surface

Area of active groundwater inflow to Content pit showing healthy surrounding vegetation – looking from pit up towards bunded crest with waste dump behind



Close-up of active (long term) groundwater seepage into Content pit showing healthy acacia seedling and white salts

High TDS groundwater showing as dark wet layer with white salts on wall above, just under crest of Content pit – note healthy vegetation growing in seepage area

High TDS groundwater seepage on waste dump side of Content pit with white salts on rock surfaces and healthy fern growth

Flowering paperbark and native passionfruit growing at water's edge in Content pit

AURIONGOLD

Appendix 6

Analysis of white salts from Content hardstand area

AURIONGOLD

CERTIFICATE OF ANALYSIS

CONTACT:	MR G THOMAS	**BATCH:**	EB47234
CLIENT:	WIRRALIE GOLD MINES PTY LTD	**SUB BATCH:**	0
ADDRESS:		**LABORATORY:**	BRISBANE
	P O BOX 898	**DATE RECEIVED:**	11/07/2002
	NORTH SYDNEY NSW 2059	**DATE COMPLETED:**	24/07/2002
		SAMPLE TYPE:	SALT
ORDER No.:	SS 222101	**No. of SAMPLES:**	1
PROJECT:	CROYDON		

COMMENTS

Results apply to sample(s) as submitted. Results determined on a 1:100 salt/water extract. Results reported on sample as received. ALS is not NATA accredited for the analysis of Salt.

NOTES

This is the Final Report and supersedes any preliminary reports with this batch number.
All pages of this report have been checked and approved for release.

ISSUING LABORATORY: BRISBANE

Address
32 Shand Street
Stafford QLD 4053
Australia

Phone: 61-7-3243 7222
Fax: 61-7-3243 7218
Email: geoff.lecornu@alsenviro.com

Signatory

This Laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of accreditation. This document shall not be reproduced except in full.

NATA No. 825

AURIONGOLD

Batch: EB47234
Sub Batch: 0
Date of Issue: 24/07/2002
Client: WIRRALIE GOLD MINES PTY LTD
Client Reference: CROYDON

CERTIFICATE OF ANALYSIS

				SAMPLE IDENTIFICATION									
		Laboratory I.D.		1									
		Date Sampled											
METHOD	ANALYSIS DESCRIPTION	UNIT	LOR	SURFACE SALTS									
ED-005S	Calcium - Soluble	mg/kg	5	691									
ED-010S	Magnesium - Soluble	mg/kg	5	33.6g/kg									
ED-015S	Sodium - Soluble	mg/kg	5	24.0g/kg									
ED-020S	Potassium - Soluble	mg/kg	5	1620									
ED-025	Hydroxide as CaCO3	meq/kg	1	<1									
ED-030	Carbonate as CaCO3	meq/kg	1	<1									
ED-040S	Sulphate - Soluble	mg/kg	5	458g/kg									
ED-045S	Chloride - Soluble	mg/kg	5	940									
EG-005S	Iron - Soluble	mg/kg	5	502									

AURIONGOLD

Batch: EB47234
Sub Batch: 0
Date of Issue: 24/07/2002
Client: WIRRALIE GOLD MINES PTY LTD
Client Reference: CROYDON

QUALITY CONTROL REPORT

				SAMPLE IDENTIFICATION										
		Laboratory I.D.		200	201									
		Date Sampled												
METHOD	ANALYSIS DESCRIPTION	UNIT	LOR	Method Blank 1	Inorg 1 LCS % Rec									
				CHECKS AND SPIKES										
ED-005S	Calcium - Soluble	mg/kg	5	<5	----									
ED-010S	Magnesium - Soluble	mg/kg	5	<5	----									
ED-015S	Sodium - Soluble	mg/kg	5	<5	----									
ED-020S	Potassium - Soluble	mg/kg	5	<5	----									
ED-025	Hydroxide as CaCO3	meq/kg	1	----	----									
ED-030	Carbonate as CaCO3	meq/kg	1	----	----									
ED-040S	Sulphate - Soluble	mg/kg	5	<5	----									
ED-045S	Chloride - Soluble	mg/kg	5	<5	101%									
EG-005S	Iron - Soluble	mg/kg	5	<5	----									

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Appendix 7

Analysis of soil from Content hardstand area

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Natural Resource Sciences Laboratories
Block B, 80 Meiers Road
INDOOROOPILLY QLD 4068

Enquiries:
Telephone 07 3896 9475
Facsimile 07 3896 9623

Queensland Government
Natural Resources and Mines

Reference: **SOI 02 / 372**

Printed: 8-8-2002

FINAL REPORT

The results pertain to the sample(s) as received by this laboratory, and relate only to the items tested.

Soil

Sample taken from dozer rip line parallel with and about 40 m from toe of Content waste dump in an area devoid of vegetation

Category: Diagnostic
Sampled: 18-7-2002
Received: 18-7-2002
Number of Samples: 1

Client: Auriongold Limited
C/-Gareth Thomas
PO Box 898
NORTH SYDNEY 2058

Laboratory Contact: Graham Wobcke
Senior Laboratory Technician
Indooroopilly

AURIONGOLD

Natural Resource Sciences Laboratories
Block B, 80 Meiers Road
INDOOROOPILLY QLD 4068

FINAL REPORT

Soil

Queensland Government
Natural Resources and Mines

Auriongold Limited
C/-Gareth Thomas
PO Box 898
NORTH SYDNEY QLD 2058

Reference: **SOI 02 / 372**
Printed: 8-8-2002
Page: 2 of 3

Analyte	*Lab Nº* / Senders' ID / Description / Depth	*8409* Croydon Project 0-.30
pH	-	3.8
Electrical Conductivity, (1)	mS/cm	0.485
Chloride, (1)	mg/kg	< 6
Nitrate Nitrogen, aqueous	mg/kg	1
Phosphorus, Colwell	mg/kg	2
Organic Carbon, (1)	%	0.34
Sulfate Sulfur (1)	mg/kg	450
Calcium, pH 7, (2)	meq/100g	0.24
Magnesium, pH7, (2)	meq/100g	0.54
Sodium, pH 7, (2)	meq/100g	0.11
Potassium, pH 7, (2)	meq/100g	0.08
Copper, extractable	mg/kg	22
Zinc, extractable	mg/kg	2.9
Manganese, extractable	mg/kg	21
Iron, extractable	mg/kg	13
Total Aluminium (3)	%	1.3
Total Barium	mg/kg	240 ← ?
Total Calcium, (3)	%	0.047
Total Cobalt	mg/kg	< 2.8
Total Chromium, (1)	mg/kg	34
Total Copper	mg/kg	22
Total Iron	%	0.625
Total Potassium, (6)	%	0.789
Total Magnesium	%	< 0.013
Total Manganese	mg/kg	160
Total Sodium	%	0.03
Total Nickel	mg/kg	< 10
Total Phosphorus, (5)	%	0.016
Total Lead	mg/kg	42
Total Sulfur, (4)	%	0.055
Total Silicon	%	41.2
Total Strontium	mg/kg	14
Total Titanium	%	0.17
Total Vanadium	mg/kg	20
Total Zinc, (2)	mg/kg	13

For Manager
Analytical Services

AURIONGOLD

Natural Resource Sciences Laboratories
Block B, 80 Meiers Road
INDOOROOPILLY QLD 4068

FINAL REPORT

Soil

Queensland Government
Natural Resources and Mines

Auriongold Limited
C/-Gareth Thomas
PO Box 898
NORTH SYDNEY QLD 2058

Reference: **SOI 02 / 372**
Printed: 8-8-2002
Page: 3 of 3

Methods used to Analyse Samples

Analyte	DNR	ALHS *	Reprod %	Quant	Unit	Method Description
pH	IEC-S4A1	4A1	2.0	0.1	-	Aqueous 1:5, electrode
Electrical Conductivity, (1)	IEC-S3A1	3A1	7.0	0.01	mS/cm	Electrical Conductivity
Chloride, (1)	IEC-S5A2	5A2	10.4	6	mg/kg	Aqueous, 1:5 soil:water
Nitrate Nitrogen, aqueous	IEC-S7B1	7B1	15.0	0.65	mg/kg	Aqueous as NO3-N,colorimetry
Phosphorus, Colwell	IEC-S9B2	9B2	20.0	1	mg/kg	0.5M NaHCO3 extr. colorimetry
Organic Carbon, (1)	IEC-S6A1	6A1	5.0	0.01	%	Organic Carbon, colorimetry
Sulfate Sulfur (1)	IEC-S10B3	10B3	11.5	0.6	mg/kg	0.01M Ca(H2PO4)2 extr. ICP
Calcium, pH 7, (2)	IEC-S15A1	15A1_Ca	5.8	0.026	meq/100g	Exch. aqueous NH4Cl pH 7
Magnesium, pH7, (2)	IEC-S15A1	15A1_Mg	11.6	0.01	meq/100g	Exch. aqueous NH4Cl pH 7
Sodium, pH 7, (2)	IEC-S15A1	15A1_Na	9.2	0.012	meq/100g	Exch. aqueous NH4Cl pH 7
Potassium, pH 7, (2)	IEC-S15A1	15A1_K	4.0	0.02	meq/100g	Exch. aqueous NH4Cl pH 7
Copper, extractable	IEC-S12A1	12A1_Cu	5.3	0.1	mg/kg	0.005M DTPA extractable, ICP
Zinc, extractable	IEC-S12A1	12A1_Zn	7.8	0.02	mg/kg	0.005M DTPA extractable, ICP
Manganese, extractable	IEC-S12A1	12A1_Mn	4.0	0.1	mg/kg	0.005M DTPA extractable, ICP
Iron, extractable	IEC-S12A1	12A1_Fe	12.0	0.1	mg/kg	0.005M DTPA extractable, ICP
Total Aluminium (3)		1X1_Al	5.0	0.03	%	Total Al XRF
Total Barium		1X1_Ba	5.0	10	mg/kg	Total Ba XRF
Total Calcium, (3)		1X1_Ca	5.0	0.003	%	Total Ca XRF
Total Cobalt		1X1_Co	5.0	2.8	mg/kg	Total Co XRF
Total Chromium, (1)		1X1_Cr	5.0	4.3	mg/kg	Total Cr XRF
Total Copper		1X1_Cu	5.0	8.6	mg/kg	Total Cu XRF
Total Iron		1X1_Fe	5.0	0.004	%	Total Fe XRF
Total Potassium, (6)		17A1	3.5	0.05	%	Total K XRF
Total Magnesium		1X1_Mg	5.0	0.013	%	Total Mg XRF
Total Manganese		1X1_Mn	5.0	4.2	mg/kg	Total Mn XRF
Total Sodium		1X1_Na	5.0	0.015	%	Total Na XRF
Total Nickel		1X1_Ni	5.0	10	mg/kg	Total Ni XRF
Total Phosphorus, (5)		9A1	6.1	0.006	%	Total P XRF
Total Lead		1X1_Pb	5.0	15	mg/kg	Total Pb XRF
Total Sulfur, (4)		10A1	12.2	0.005	%	Total S XRF
Total Silicon		1X1_Si	5.0	1.3	%	Total Si XRF
Total Strontium		1X1_Sr	5.0	5.2	mg/kg	Total Sr XRF
Total Titanium		1X1_Ti	5.0	0.003	%	Total Ti XRF
Total Vanadium		1X1_V	5.0	7	mg/kg	Total V XRF
Total Zinc, (2)		1X1_Zn	5.0	9	mg/kg	Total Zn XRF

*** Australian Laboratory Handbook of Soil and water chemical methods**

For Manager
Analytical Services

AURIONGOLD

Queensland Government

Natural Resource Sciences Laboratories

Department of Natural Resources

ANALYTICAL REPORT

Lab. Reference: EWM02068
Project:
Sample Type: Soil
Date Received: 22/07/02
Date Reported: 07/08/02 Report: Final

Client: Gareth Thomas
Auriongold Ltd
PO Box 898
NORTH SYDNEY
NSW 2059

Sample ID	Lab No	Cd	As
Croydon hardstand	EWM02068/1957	0.09	24.7
UNITS		mg/kg	mg/kg
Report Limit		0.010	0.60
Method		S.02	S.01

The results pertain to the sample(s) as received by this laboratory and relate only to the items tested

GA BARRY (SENIOR CHEMIST)

Enquiries: GA Barry
Natural Resource Sciences Laboratories
80 Meiers Road Indooroopilly Qld 4068

Telephone: 3896 9306
Facsimile: 3896 9623

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Appendix 8

Review of 2001/2002 Water Quality Monitoring Data

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Appendix 9

Sketch of completed works at Content hardstand and waste dump area

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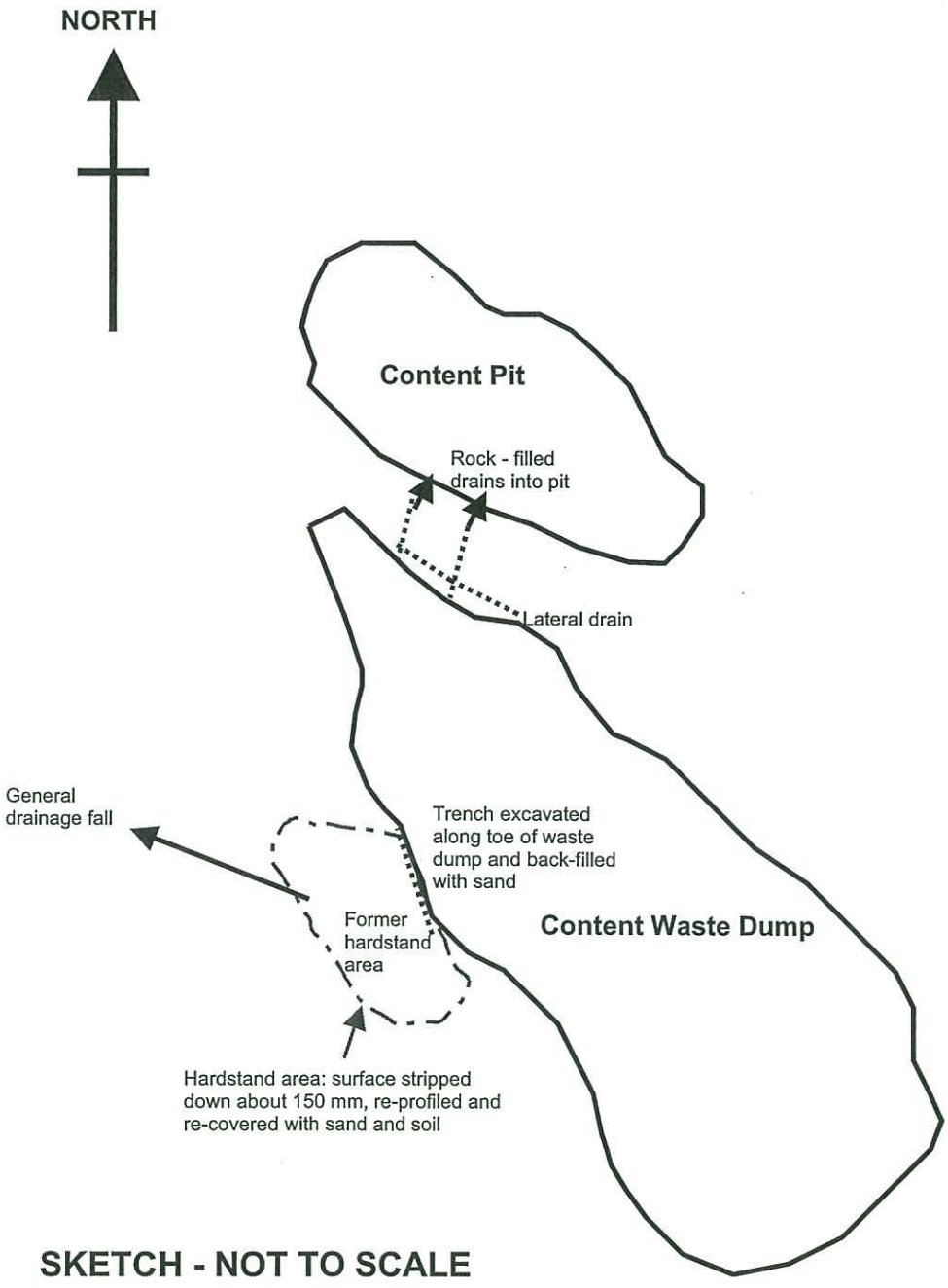
Sketch of 2 rock-filled drains from waste dump into Content pit plus toe trench and re-topsoiled hardstand area on western side of Content waste dump.



SKETCH - NOT TO SCALE

AURIONGOLD

BACKGROUND

Mining recommenced at the Croydon Gold Project in 1987 as a joint venture between Central Coastal Exploration NL and Pancontinenntal Mining Limited (Pancon). Mining commenced in December 1988 at the Golden Butterfly Pit and over the next two years expanded to include the mining of Golden Butterfly North Pit, Content Pit and Lady Isabella Pit. Mining on the lease ceased in April 1990 by which time approximately 445,000 tonnes of ore had been treated to produce around 63,000 ounces of gold. All processing of ore was done off lease ML 5248 and no tailings material was ever stored on the lease.

On cessation of mining activity Pancon relinquished a portion of the original mining lease and only retained those areas that contained permanent mine landforms such as the mine pits, waste rock dumps and original hardstands (ore stockpile and crusher pad areas). The total lease area covers 174.hectares and consists of a western section covering approximately 67 hectares (containing the Content open cut pit and waste dump and the Lady Isabella open cut) and an eastern section covering about 95 ha containing the Golden Butterfly and Golden Butterfly North open cut voids and their associated waste rock dump. These two areas are joined by a haul road approximately 100 m wide and 1.4 km in length. The lease also contains hardstand areas, a haul ramp, numerous exploration bores and historical (pre-1914) open shafts and adits.

The final landform concept is to achieve a stable post-mining landform that is able to meet the identified post-mining landuse and rehabilitation objectives.

COMPLETED RECLAMATION

Mine decommissioning was completed by late 1993 after which rehabilitation activities took place. The rehabilitation programme focused on environmental concerns relating to:

- Development of acidic water in the open pits.
- Acid Mine Drainage (AMD) within Slaughteryard Creek from the Golden Butterfly Waste Rock Dump and adjacent hardstands.
- Off-lease movement of groundwater from the Golden Butterfly pit.
- Erosion and potential instability of mining related landforms.

The programme included the re-profiling of the two waste rock dumps, construction of drainage control structures and the „bunding" of all pits. In 1995 on acquiring the lease Goldfields undertook a comprehensive rehabilitation review and established the following rehabilitation objectives:

- Secure the site for the long term by inhibiting the formation and release of AMD to the surrounding environment.
- Enhance the overall stability and sustainability of the developed landforms.

Based on these objectives Goldfields developed a rehabilitation programme that included the flowing works:

- Clay capping and rock fill surface protection of the entire Golden Butterfly Waste Rock Dump including construction of a key trench around the dump perimeter.
- Re-shaping of outer slopes, clay fill capping and rock fill surface protection of the entire Content Waste Rock Dump. This excluded the western slope as the existing rehabilitation was considered adequate.

- Removal of potentially acid producing waste rock from the Golden Butterfly and Content Hardstand areas. The excavated material being placed in Golden Butterfly pit.
- Removal of potentially contaminated channel bed sediments from the drainage network that discharges into Slaughteryard Creek.
- General collection and removal of all rubbish and mining plant.
- Construction of surface drainage structures down gradient of Content Waste Rock Dump.
- Backfilling of open bores and mine shafts.
- Re-vegetation of disturbed areas including the reworked waste rock dumps.
- Introduction of a rehabilitation monitoring programme and annual reporting regime.

A set of *Relinquishment Criteria* was proposed to, and accepted by, DME in 1996. These formed the bases for the November 2001 Compliance Audit undertaken by HLA-Envirosciences and in late 2001 AurionGold submitted a Draft Final Rehabilitation Report to the Queensland Government. This was rejected due to the following concerns:

- AMD from the Content waste rock dump – hardstand area.
- Pit lake water quality not meeting stock water quality standards (although this was not a relinquishment criteria).
- Poorer than expected vegetation growth on a portion of Content Waste Rock Dump.
- Presence of Calotrope on the lease.

In 2006 Barrick acquired the lease through the Placer acquisition. Placer had put the lease under Care and Maintenance and at that stage it was not administered under a formal Environmental Authority. Since the acquisition Barrick have undertaken extensive consultation with the Department of Environment and Resource Management (DERM) to contemporise all approvals. An Environmental Management Plan was developed in 2007 and submitted for approval. A Plan of Operations was submitted and approved in 2008.

Since the acquisition Barrick have completed the followings actions as part of the above approvals:

- Additional monitoring bore installation
- Vegetation Monitoring / maintenance
- Surface water / groundwater monitoring
- Geotechnical survey
- Cultural heritage survey

REMAINING RECLAMATION WORKS
Waste Rock Dumps

The upper surface of the northern most end of Content Waste Rock Dump experiences a degree of ponding during high rainfall periods and exhibits some initial gully formation along the crest of the dump. This requires intervention to avoid any significant long term erosion risk. An initial inspection of the area (in late 2006) suggested that although the northern end

of the waste rock dump suffered some surface ponding and gully formation along the dump crest, there appeared little evidence of leaching or seepage from the waste dump.

Proposed works

- Regrading portions of the upper surface of the northern half of the Content Waste Rock Dump to provide a gentle slope to the northeast to drain excess surface runoff down the ramp and into Content Pit. .
- Repair of gullies forming on crest bund along the western side of dump.
- Manual re-seeding

Laydown Areas

The only area of on-going concern is the Content hardstand to the immediate west of Content Waste Rock Dump. The accumulation of salts to the immediate west of the waste rock dump appears to be linked to the original hardstand area. During mining operations this area was filled with waste rock to form a level surface on which a crushing plant was located and ore stockpiled. A Total of 44,950 m^3 of material was removed from this site during the 1996 rehabilitation work. It would appear that material was only excavated to the original ground surface and that a certain amount of contamination must have taken place in the underlying subsurface material. The area now forms a slight depression in the local topography and during the wet season a degree of ponding occurs which, coupled with a perched groundwater table, results in salts being brought to the surface. The ponding effect is exacerbated by a number of old drainage bunds that have been constructed to divert surface runoff towards the sediment dam.

Proposed works

This area needs to be investigated, remediation done and properly rehabilitated. In order to avoid all further environmental risk it may be found necessary to construct a subsurface drain that discharges into Content Pit. The following works are envisaged:

- A geotechnical investigation to identify whether a series of subsurface drains needs to be constructed in order to avoid any future drainage problems
- Excavation and removal of all material from the hardstand area. Material to be disposed of in Golden Butterfly Pit. Area to be backfilled with a slightly domed surface that blends into the local topography.
- Install a series of shallow subsurface drains that discharge into Content Pit. These would connect into a subsurface drain located along the western foot of Content Waste Rock Dump.
- Examine the effectiveness of existing drainage bunds located to the west of Content Waste Rock Dump and possibly redesign these so as to avoid any further ponding of water in close proximity to the Content hardstand area.

Mining Pits

All four mine pits have perimeter earthen abandonment bunds and exclusion fencing has been erected to limit access by humans and domesticated animals.

Proposed works

- Check the adequacy of the abandonment bund, perimeter fence and signage at all pit lakes. Where necessary relocate and/or repair infrastructure.
- Locate gauge plates within each pit lake.
- Decommission the upper portions of all pit access ramps to deny vehicle access.

Surface Drainage Control

An accurate land survey of the lease and field inspection during 2009 indicated that seasonal ponding occurred at several localities on the lease and potentially increase infiltration and recharge of the pit lakes. At several locations surface runoff from the sealed Normanton-

Croydon Development Road is channelled onto the Mining Lease where it eventually ponds in local depressions and borrow pits. The relatively flat nature of much of the northern area with no clearly defined creeks or drainage lines effectively means all surface flow is contained within the mining lease. The ponded water provides the hydraulic head to drive infiltration where breaks/gaps occur in the underlying shallow ferricrete layer which overlies the fractured mineralised zone in which the orebodies are located. Once below the ferricrete layer the water moves rapidly along preferential flow paths (fractured and fissured bedrock) to recharge the adjacent pit lakes.

Proposed works
Existing flow channels / drainage lines will be gently diverted away from their current course so that these discharge into the existing road drain on the western side of the Gulf Development Road. This will involve the extension of the existing road drain so that all water effectively discharges via the storm culvert located at the start of the Belmore Station access road. An additional shallow storm drain will be constructed along the length of the lease northeast boundary to ensure that any sheet flow from the catchment area between the two pits is channelled away from the NE corner and discharges via the Belmore Station road.

MONITORING PROGRAMME

The current monitoring programme is focused on rehabilitation performance monitoring and is a refinement of the programme that has been in place since 1996. The emphasis is on water and vegetation monitoring and will continue until sufficient data is available to confirm rehabilitation trends such that stakeholders may be assured that no unforeseen closure liabilities remain.

Water monitoring
All water monitoring is done in accordance with Australian national standards as documented in Australian Guidelines for Water Quality Monitoring and Reporting, National Water Quality Management Strategy Report No 7 (ANZECC, 2000).

Vegetation monitoring
Vegetation monitoring is based on Landscape Function Analysis (LFA), a method developed by the CSIRO. The basis of LFA is to measure how well a rehabilitated landscape is using water and nutrients, its ability to resist erosion and the landscapes progress towards becoming a stable self-sustaining unit in comparison with selected control sites with similar topography. Species richness, species frequency, plant density and growth rate are parameters addional to LFA. These parameters and LFA are measured at permanent locations on the rehabilitated and control sites. Monitoring began in 1997 and is done at the end of the dry season, considered the most appropriate time for monsoonal tropics.

Reporting Standards
Annual reporting is done in accordance with Australian national standards as documented in Australian Guidelines for Water Quality Monitoring and Reporting, National Water Quality Management Strategy Report No 7 (ANZECC, 2000).

MINE COMPLETION OBJECTIVES

The objectives of the closure program aim to facilitate well-planned and effective mine reclamation, closure and decommissioning (and therefore mine completion) for the Project by providing a process (adapted from ANZMEC and MCA, 2000) to:

- enable all stakeholders to have their interests considered during the mine completion process;
- allow completion to occur in an orderly, cost-effective and timely manner;
- enable the cost of completion to be adequately represented in Company accounts;
- provide clear accountability, and adequate resources, for completion;
- establish a set of indicators which will demonstrate the success of the completion process; and

- reach a point where the Company has met agreed completion criteria to the satisfaction of the relevant authority.

The following table provides some indication of the proposed mine completion schedule and major milestones.

Completion Activity/Milestone	Completion date
Additional remediation and rehabilitation work	2009 -2011
Rehabilitation Performance Monitoring	Each year till objectives met (2009 – 2020)
Annual rehabilitation performance reporting	Report due annually end March
Annual closure cost estimate	Dec of each year
Stakeholder consultation	2019
Develop Grazing Management Plan	2019
Submission of Final Rehabilitation Report & Audit Statement	2020
Achieve final EPA sign-off	2020 - 2022

1) Owners and Addresses of Lots

See attached searches that have been undertaken on the below lots which show the holders of the lots in question. The addresses for the lots have been given as per the table.

Lot Number	Holders	Addresses
Lot 952 on C3591	Reserve for Township - Shire of Croydon	Croydon Shire Council PO Box 17 Croydon QLD 4871
Lot 231 on SP109395	QR Network Pty Ltd	Attn: Howard Ellems QR Network Pty Ltd GPO Box 1429 BRISBANE, QLD 4001
Lot 2 on SP116187	QR Network Pty Ltd	Attn: Howard Ellems QR Network Pty Ltd GPO Box 1429 BRISBANE, QLD 4001

2) Address for Lot 3 MPH22368 and all others referenced "as per 7" in previous listing supplied

The address that has been given for this lot is
The State of Queensland (Dept or Natural Resources and Water)
State Asset Land Management
PO Box 937
CAIRNS, QLD 4870

3) Owners and Addresses of Lots

See attached searches that have been undertaken on the below lots which show the holders of the lots in question. The addresses for the lots have been given as per the table.

Lot Number	Holders	Addresses
Lot 59 on USL656	The State of Queensland (Dept or Natural Resources and Water)	State Asset Land Management PO Box 937 CAIRNS, QLD 4870
Lot 91 on USL656	The State of Queensland (Dept or Natural Resources and Water)	State Asset Land Management PO Box 937

30/3/2010

		CAIRNS, QLD 4870
Lot 949 on C3591	Reserve for Pound – Shire of Croydon	Croydon Shire Council PO Box 17 Croydon QLD 4871

4) and 5) Statements of Renewal Use and Renewal Area required

I attach to this document that outlines activities undertaken on Mining Lease 5248 ('the Lease') to present and the rehabilitation activities going forward.

As presented in the attached document, the Lease is subject to an approved Environmental Management Plan with the Department of Environment and Resource Management. The holder requires the title to remain in force to undertake the work required to satisfy the Environmental Management Plan.

The area of the Lease has already been the subject of a reduction in size which means that the area presently in place covers the areas of mining disturbance with access routes between the different pit locations. It is felt that the current area is required to be maintained in the renewal phase to allow for the ability to complete the rehabilitation activities required.

6) Use of Land In Renewal Period

The primary purpose that the registered holder is seeking renewal of the Lease is to be able to undertake the required reclamation works and activities on the Lease as outlined in the Reclamation Document attached to this summary.

The Lease has no identified resources. Interest has been shown, however, in undertaking some additional exploratory works on the Lease to see if there is any further mineralisation on the Lease area. At this stage no further mining activities are proposed unless exploratory works reveal mineable mineralisation. These exploratory works are not intended to be undertaken in the immediate future.

7) Technical Resources

Barrick (Kalgoorlie) Limited {"BKL"} is a member of the Barrick Gold Corporation Group of companies and a subsidiary of Barrick (PD) Australia Limited. As such BKL has access to and use of the Australian Reclamation Team run by Mr David Blaxland, who is based in Brisbane, as well as technical expertise from our Perth and Salt Lake City Offices and other external technical advisors.

Through Barrick (Australia Pacific) Limited, BKL has a number of consulting firms, such as Resource Stratagies, working on the Croydon site on a regular basis as well as the internal expertise from Mr Blaxland and Mr Walter Benko.

30/3/2010

Mr Blaxland is the Reclamation and Closure Manager for Barrick's Australia and Pacific region. Prior to that he was the Environmental Manager for the Cowal Gold Project for over three years.

David has over 18 years experience in environmental management in the mining, oil, gas and civil construction industries. He has industry experience in all states and territories of Australia with offshore experience in South East Asia, Africa and the Americas.

8) Compensation Agreements

Compensation arrangements to be reviewed and it is noted that this matter is to be referred to the Land Court.

9) Consent Caveat

Barrick (Kalgoorlie) Limited is currently not holding a record showing the details of this Caveat which is believed to be related to an old Joint Venture arrangement in which Central Coast Exploration NL was a participant.

Records show that Central Coast Exploration NL was delisted in July 1992.

30/3/2010

0 GULF DEVELOPMENTAL RD, CROYDON, QLD 4871

Owner Details

Owner Name RESERVE FOR TOWNSHIP

Owner Address: N/A

Owner Type:

Property Details

RPD: L952 SP178689:PT (NON-SPECIFIC) RESERVE 59:PAR CROYDON

Valuation	Date:	Property Type: Other
Valuation	Date:	Area: 2,160 ha
Pri Land Use: VACANT RURAL LAND (EXCL	2nd Land Use: STATE(SECONDARY LAND	Tenure Type: State Land [Non-Valued]
Local Authority: CROYDON		Water/Sewerage Yes / Yes

Zoning

Plan #	LG Zoning	Parish
SP178689		CROYDON

Sales History

30/3/2010

This report has been compiled on 09/03/10 with the permission of Veda Advantage Solutions Group Pty Ltd.

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197

0 HELEN ST, CROYDON, QLD 4871

Owner Details

Owner Name QR NETWORK PTY LTD

Owner Address: N/A

Owner Type:

Property Details

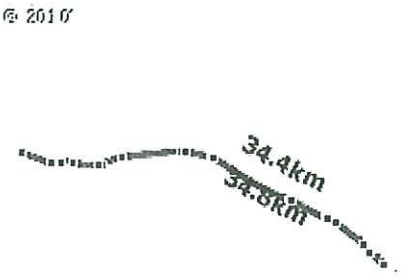
UBD Ref:

RPD: L151-153 SP109389 & L21-22 SP109390 & L51-55 SP109391 & L91-92 SP109392 & L151-152 SP109393 & L191-192 SP109394 & L231 SP109395 & L2,4,6 SP116187:PAR BLACKBULL

Valuation	Date:	Property Type: Commercial
Valuation	Date:	Area: 700.56 ha
Pri Land Use: GENERAL INDUSTRY	2nd Land Use: STATE(SECONDARY LAND	Tenure Type: State Land [Non-Valued]
Local Authority: CROYDON		Water/Sewerage No / No

Zoning

Plan #	LG Zoning	Parish
SP109389	COMMUNITY INFRASTRUCTURE	BLACKBULL
SP109389	COMMUNITY INFRASTRUCTURE	BLACKBULL



Sales History

30/3/2010

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197

0 HELEN ST, CROYDON, QLD 4871

Owner Details

Owner Name QR NETWORK PTY LTD

Owner Address: N/A

Owner Type:

Property Details

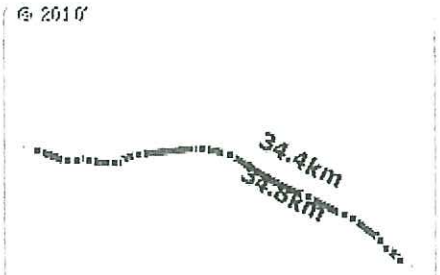
UBD Ref:

RPD: L151-153 SP109389 & L21-22 SP109390 & L51-55 SP109391 & L91-92 SP109392 & L151-152 SP109393 & L191-192 SP109394 & L231 SP109395 & L2,4,6 SP116187:PAR BLACKBULL

Valuation	Date:	Property Type: Commercial
Valuation	Date:	Area: 700.56 ha
Pri Land Use: GENERAL INDUSTRY	2nd Land Use: STATE(SECONDARY LAND	Tenure Type: State Land [Non-Valued]
Local Authority: CROYDON		Water/Sewerage No / No

Zoning

Plan #	LG Zoning	Parish
SP109389	COMMUNITY INFRASTRUCTURE	BLACKBULL
SP109389	COMMUNITY INFRASTRUCTURE	BLACKBULL



Sales History

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Lot 3 MPH 22368

197

0 ELIZABETH ST, CROYDON, QLD 4871

Owner Details

Owner Name	THE STATE OF QUEENSLAND (REPRESENTED BY THE DEPARTMENT OF NATURAL RESOURCES AND WATER)	Owner Address:	N/A
		Owner Type:	

Property Details

UBD Ref:

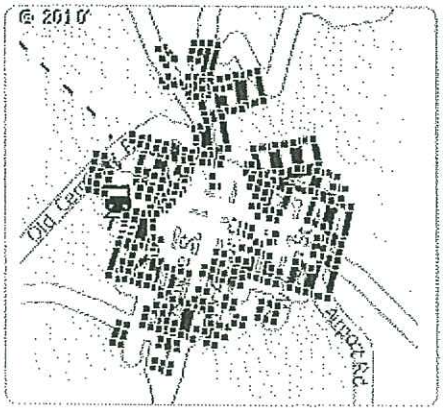
RPD: L33,35 B14468 & L1-5 MPH124 & L108-109,113-117,603,607-608,613,615,703-712,714,716-717 MPH14026 & L1-10,12-13,23-26,35-36,41-45 MPH15912 & L22,24-39 MPH15914 & L79,82,85-87,128,148,150,159-161,163,165-166,168,170,172,177,179-190,251,276-277,280,282-287,295,298-304,307-310,312-315,323-332,335-337,358-360,362-363,366-373,375-379,417-428,430-431,444-445,483-484,489-498,501-537,592-594,597-611 MP MORE

Valuation	Date:	Property Type: Vacant Land
Valuation	Date:	Area: 67.75 ha
Pri Land Use: VACANT URBAN LAND	2nd Land Use: STATE(SECONDARY LAND	Tenure Type: State Land [Non-Valued]
Local Authority: CROYDON		Water/Sewerage Yes / No

Zoning

Plan #	LG Zoning	Parish
B14468	RURAL	CROYDON
B14468	RURAL	CROYDON

Sales History



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Lot 59 USL 656 197

0 ELIZABETH ST, CROYDON, QLD 4871

Owner Details

Owner Name	THE STATE OF QUEENSLAND (REPRESENTED BY THE DEPARTMENT OF NATURAL RESOURCES AND WATER)	Owner Address:	N/A
		Owner Type:	

Property Details

UBD Ref:

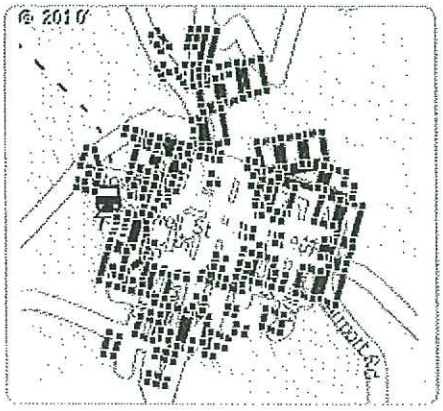
RPD: L33,35 B14468 & L1-5 MPH124 & L108-109,113-117,603,607-608,613,615,703-712,714,716-717 MPH14026 & L1-10,12-13,23-26,35-36,41-45 MPH15912 & L22,24-39 MPH15914 & L79,82,85-87,128,148,150,159-161,163,165-166,168,170,172,177,179-190,251,276-277,280,282-287,295,298-304,307-310,312-315,323-332,335-337,358-360,362-363,366-373,375-379,417-428,430-431,444-445,483-484,489-498,501-537,592-594,597-611 MP MORE

Valuation	Date:	Property Type: Vacant Land
Valuation	Date:	Area: 67.75 ha
Pri Land Use: VACANT URBAN LAND	2nd Land Use: STATE(SECONDARY LAND	Tenure Type: State Land [Non-Valued]
Local Authority: CROYDON		Water/Sewerage Yes / No

Zoning

Plan #	LG Zoning	Parish
B14468	RURAL	CROYDON
B14468	RURAL	CROYDON

Sales History



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Ld 91 USL 656

197

0 ELIZABETH ST, CROYDON, QLD 4871

Owner Details

Owner Name	THE STATE OF QUEENSLAND (REPRESENTED BY THE DEPARTMENT OF NATURAL RESOURCES AND WATER)	Owner Address:	N/A
		Owner Type:	

Property Details

UBD Ref:

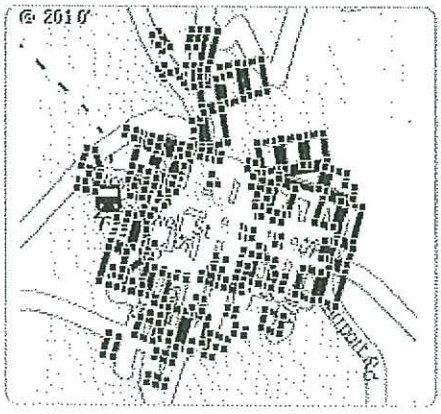
RPD: L33,35 B14468 & L1-5 MPH124 & L108-109,113-117,603,607-608,613,615,703-712,714,716-717 MPH14026 & L1-10,12-13,23-26,35-36,41-45 MPH15912 & L22,24-39 MPH15914 & L79,82,85-87,128,148,150,159-161,163,165-166,168,170,172,177,179-190,251,276-277,280,282-287,295,298-304,307-310,312-315,323-332,335-337,358-360,362-363,366-373,375-379,417-428,430-431,444-445,483-484,489-498,501-537,592-594,597-611 MP MORE

Valuation	Date:	Property Type: Vacant Land
Valuation	Date:	Area: 67.75 ha
Pri Land Use: VACANT URBAN LAND	2nd Land Use: STATE(SECONDARY LAND	Tenure Type: State Land [Non-Valued]
Local Authority: CROYDON		Water/Sewerage Yes / No

Zoning

Plan #	LG Zoning	Parish
B14468	RURAL	CROYDON
B14468	RURAL	CROYDON

Sales History



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RECEIVED
8 JUL 2011
DEPT OF MINES & ENERGY - MAREEBA

0 GULF DEVELOPMENTAL RD, CROYDON, QLD 4871

Owner Details

Owner Name RESERVE FOR POUND

Owner Address: N/A

Owner Type:

Property Details

UBD Ref:

RPD: L949 C3591:(NON-SPECIFIC) RESERVE 29:PAR CROYDON

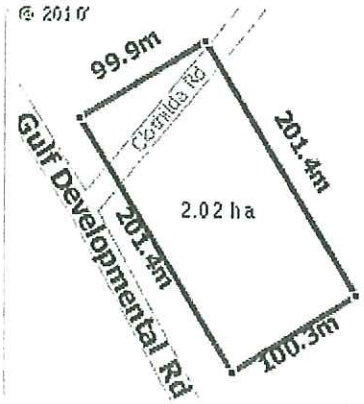
Valuation
Valuation
Pri Land Use: VACANT - LARGE
Local Authority: CROYDON

Date:
Date:
2nd Land Use: STATE(SECONDARY LAND

Property Type: Vacant Land
Area: 2.02 ha
Tenure Type: State Land [Non-Valued]
Water/Sewerage No / No

Zoning

Plan #	LG Zoning	Parish
C3591	COMMUNITY INFRASTRUCTURE	CROYDON



Sales History

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APPENDIX K CROYDON GOLD MINE PLAN OF OPERATIONS

CROYDON GOLD MINE

PLAN OF OPERATIONS

01 JULY 2018- 01 JULY 2019

JULY 2018

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Appendix A Post Mine Landuse Plan

Appendix B Emergency Response/Contingency Plan

Appendix C Cultural Heritage Management Program

Appendix D Water Management Strategy

Appendix E Erosion and Sediment Control Plan

Appendix F Receiving Environment Monitoring Program

1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low-grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring, investigations and reclamation works (as required). Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, it was then acquired by Barrick Gold of Australia (Barrick) in 2005. Wilson Minerals Pty Ltd (Wilson) now holds Environmental Authority (EA) No. EPML00950913 for the Project.

1.1 BACKGROUND

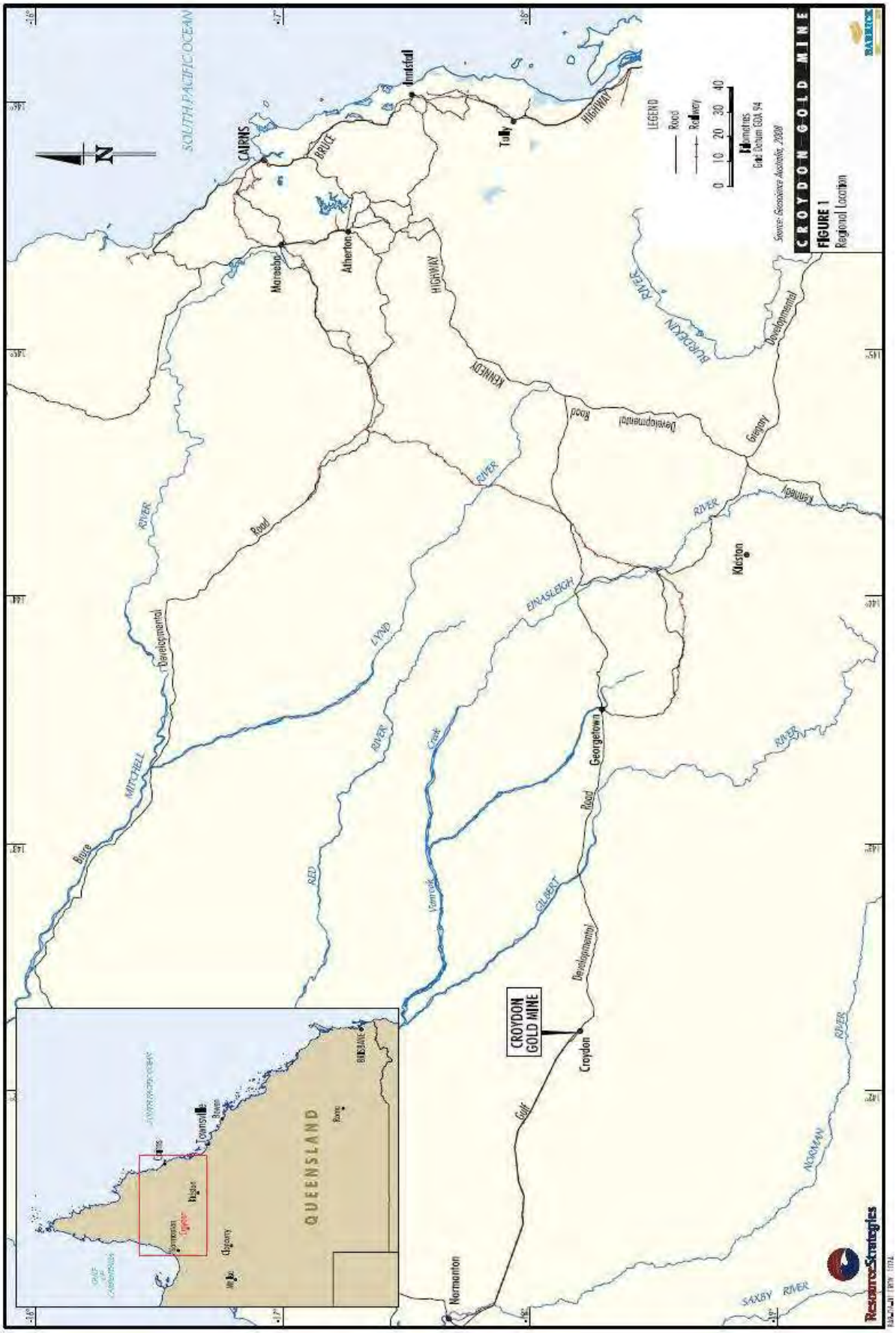
Extensive gold mining at the Project commenced in the late 1880s for approximately 30 years, before recommencing in 1987. Operational mining ceased in 1990 and the Project was decommissioned by late 1993 (Wilson, 2008). Reclamation performance was audited in 1996/1997 and significant additional reclamation works were undertaken in 1996 and 1997 (Wilson, 2008).

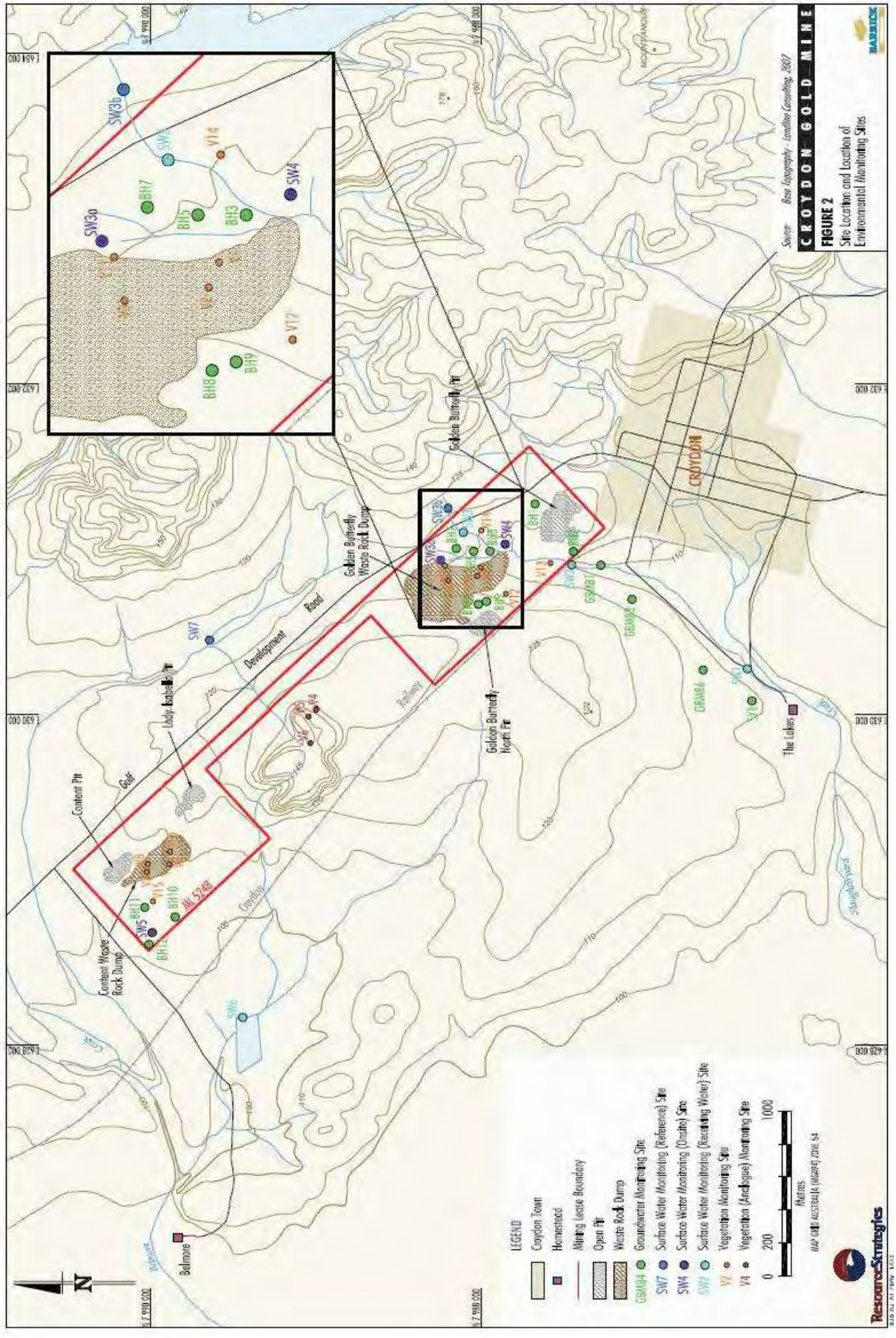
The mining-related landforms on ML 5248 comprise of waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps.

Specifically they include (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Golden Butterfly waste rock dump;
- Content Pit;
- Content waste rock dump;
- Lady Isabella Pit;
- abandonment bunds across the access ramps of the four open pits;
- hardstand areas adjacent tothe Content and Golden Butterfly waste rock dumps;
- water diversion bunds and sediment dams adjacent to the Content and Golden Butterfly waste rock dumps; and
- roads and tracks.

Schematic diagrams of the final landforms, inclusive of drainage features, are provided in Figure 3 of the Post Mine Landuse Plan (PMLP) (Appendix A). The final landform concept is to achieve a stable post-mining landform that is able to meet the identified post-mining landuse and rehabilitation objectives.


SOUTH PACIFIC OCEAN
CAIRNS
Innisfail
Tully
Mareeba
Atherton
HIGHWAY
BRUCE
KENNEDY
Developmental
Road
RIVER
MITCHELL
Normanton
Georgetown
Croydon
CROYDON GOLD MINE
QUEENSLAND
BRISBANE
Townsville
Mount Isa
Charters Towers
Cloncurry
LEGEND
Road
Railway
Kilometres
Grid Datum GDA 94
Source: Geoscience Australia, 2008
CROYDON GOLD MINE
FIGURE 1
Regional Location
ResourceStrategies


CROYDON GOLD MINE
FIGURE 2
Site Location and Location of Environmental Monitoring Sites
Source: Base Topography - Landflow Consulting, 2007
LEGEND
Croydon Town
Homestead
Mining Lease Boundary
Open Pit
Waste Rock Dump
Groundwater Monitoring Site
Surface Water Monitoring (Reference) Site
Surface Water Monitoring (Onsite) Site
Surface Water Monitoring (Receiving Water) Site
Vegetation Monitoring Site
Vegetation (Analogue) Monitoring Site
Metres
MAP GDA AUSTRALIA (WGS84) ZONE 54
Resource Strategies
Golden Butterfly Waste Rock Dump
Golden Butterfly North Pit
Development Road
Content Pit
Content Waste Rock Dump
Lady Isabella Pit
Gulf
Railway
Creek
Bellmore
The Lakes
CROYDON
MOUNT ANGUS
SW3b
SW3a
SW4
SW7
SW6
SW5
BH1
BH2
BH3
BH4
BH5
BH6
BH7
BH8
BH9
BH10
VT1
VT2
VT3
VT4
GBM84
GBM87
GBM88
M 5248

1.2 REPORT STRUCTURE

This Plan of Operations is structured as follows:

Section 2: Provides a summary of the statutory background and requirements, duration of this Plan of Operations, and mining tenements.

Section 3: Describes the Project and provides a summary of the activities to be undertaken during the term of this Plan of Operations.

Section 4: Describes the action program and explains how Wilson will comply with the conditions of EA No. EPML00950913 and implement relevant control strategies in the Croydon Gold Mine Environmental Management Plan (Wilson, 2008) (EM Plan).

Section 5: Provides a cost estimate for the rehabilitation of the Project during the term of this Plan of Operations.

Section 6: Presents the environmental audit statement for this Plan of Operations.

Section 7: Lists the references cited in this Plan of Operations.

2 PLAN OF OPERATIONS

2.1 REGULATORY REQUIREMENTS

EM Plan and Plan of Operations

This Plan of Operations has been developed in accordance with Section 288(3) of the QLD Environmental Protection Act, 1994 (EP Act) and the QLD Department of Environment and Heritage Protection (DEHP) guideline Preparing a Plan of Operations and Audit Statement for Level 1 Mining Projects. This Plan of Operations describes how the Project will comply with the conditions of EA No. EPML00950913 and implement the environmental protection commitments and control strategies included in the EM Plan.

Specifically, the Plan of Operations:

- describes the relevant mining leases for EA No. EPML00950913;
- describes the land to which the mining leases apply;
- describes the land to which the Plan of Operations applies;
- identifies the period to which the Plan of Operations applies;
- shows where activities are to be carried out on the land;
- presents an action program (Section 4) that states how Wilson will comply with the conditions of EA No. EPML00950913 and implement the relevant control strategies presented in the EM Plan;
- states the proposed amount of financial assurance for the period of the Plan of Operations; and
- presents an audit statement that states the extent to which the Plan of Operations complies with the conditions of EA No. EPML00950913.

Environmental Authority

Wilson is the holder of EA No. EPML00950913 issued under the EP Act for mining related activities. EA No. EPML00950913 was issued by DEHP in August 2008.

2.2 PLAN PERIOD

The Plan of Operations covers the one year planning period from 01 July 2018 to 01 July 2019. Maintenance, monitoring and further reclamation works will be conducted at the Project during the period ofthis Plan of Operations.

2.3 MINING TENEMENTS

This Plan of Operations relates to all activities to be conducted by Wilson within ML 5248 under EA No. EPML00950913.

3 ACTIVITIES COVERED BY THIS PLAN OF OPERATIONS

Activities at the Project during the term of the Plan of Operations will focus on maintenance, monitoring, investigations and reclamation works. Table 1 provides a list of the various post mining landforms, areas of disturbance and rehabilitation objectives.

3.1 RECLAMATION ACTIVITIES

A description of reclamation activities proposed during the term of the Plan of Operations is provided below.

Waste Rock Dump Areas

Specific rehabilitation works required in accordance with Condition C1-2 of EA No. EPML00950913 for the Content Waste Rock Dump have been completed. Similarly, specified rehabilitation works detailed in the previous operations planning period have been completed. Any further rehabilitation works at either waste rock dump area will involve preventative erosion works in response to emergent need.

Other Reclamation Activities

Other reclamation activities proposed during the term of the Plan of Operations include:

- maintenance of lease boundary fences and gates to control domesticated stock access;
- maintenance of mine pit and lease boundary perimeter fences, gates and signage to limit unauthorised human entry; and
- on-going implementation of weed control measures.

TABLE 1: POST-MINING LAND DESCRIPTION, DISTURBANCE AREA AND REHABILITATION OBJECTIVES

Landform (refer Figure 2)	Surface area (hectares)	Rehabilitation Objectives		
		Post-mine land description	Land classification[1]	Analogue site identification
Golden Butterfly North Pit	1.6	Non-beneficial land use	Class VIII	Sites to be rehabilitated to a standard nominated in the rehabilitation program developed in accordance with Condition C2-1 based on analogue sites.
Golden Butterfly Pit	5.1	Non-beneficial land use	Class VIII	
Lady Isabella Pit	1.7	Non-beneficial land use	Class VIII	
Content Pit	2.1	Non-beneficial land use	Class VIII	
Content Dump	6.3	L.I.G.[2]/disturbed native habitat	Class VI or better	
Golden Butterfly Dump	15.2	L.I.G.[2]/disturbed native habitat	Class VI or better	
Content Hardstand	2.0	L.I.G.[2]/disturbed native habitat	Class VI or better	
Golden Butterfly Hardstand	0.5	L.I.G.[2]/disturbed native habitat	Class VI or better	
Sediment Dams	1.5	L.I.G.[2]/disturbed native habitat	Class VI or better	
Roads / Tracks	3.5	L.I.G.[2]/disturbed native habitat	Class VI or better	

[1]QLD department of Minerals and Energy(2008).

[2]L.I.G. (Low Intensity Grazing) defined by criteria listed in Land Use Acceptance Criteria.

3.2 INVESTIGATIONS

A description of investigations proposed during the term of the Plan of Operations is provided below.

Hydrogeological Investigation

In accordance with Condition F4-6 of EA No. EPML00950913, ongoing hydrogeological investigations and monitoring will continue to aid in confirming the conceptual hydrogeological model described in the EM Plan. Hydrogeological investigations will include:

- Compiling and analysing groundwater quality data from the various on-site monitoring bores.
- Obtaining possible additional geological information, regional groundwater use and bore water levels.
- Surveying pit lake water levels.
- Pit water level fluctuations and behaviour.

In accordance with Condition F5-4 of EA No. EPML00950913, additional monitoring bores were constructed in 2008. The need for possible further additional monitoring bores will be determined from a review of the existing hydrological information.

Once the hydrogeological investigations have been completed, these results will be used to guide long-term water management at the CGM and will be incorporated into the Water Management Strategy.

3.3 MONITORING ACTIVITIES

Monitoring activities will be conducted at the Project during the term of this Plan of Operations in accordance with EA No. EPML00950913 and the Rehabilitation Monitoring Program (RMP) (Attachment A of Appendix A). Monitoring activities will include:

- surface water monitoring;
- stream sediment monitoring;
- groundwater monitoring;
- rehabilitation monitoring; and
- erosion and final cover system monitoring.

Details of these monitoring activities are provided in the RMP (Attachment A of Appendix A). The monitoring sites for the monitoring activities identified above are shown on Figure 2.

3.4 NOTIFIABLE ACTIVITIES

"Notifiable activities" are defined in Schedule 2 and set out in Schedule 22 of the EP Act. The Notifiable activity of relevance to the Project is identified below:

> *24 Mine wastes – (a) Storing hazardous mine or exploration wastes, including, for example, tailings dams, overburden or waste rock dumps containing hazardous contaminants.*

Waste rock from the Project is stored within the Golden Butterfly and Content waste rock dumps (Figure 2).

4 ACTION PROGRAM

In accordance with Section 288(3) of the EP Act, the action program included in this section (Table 2) states how Wilson will comply with the conditions of EA No. EPML00950913 and implement the relevant control strategies presented in the EM Plan during the period of this Plan of Operations.

Table 2 Action Program Summary Table

EA Condition	Control Strategy	Action Program
(A1-1) The environmental authority holder must: (a) install all measures, plant and equipment necessary to ensure compliance with the conditions of this environmental authority and the general environmental duty; (b) maintain such measures, plant and equipment in a proper condition; (c) operate such measures, plant and equipment in a proper manner; and (d) ensure that all instruments and devices used for the measurement or monitoring of any parameter under any condition of this environmental authority must be calibrated and appropriately operated and maintained.	Wilson will install, operate and maintain measures, plant and equipment as required to maintain compliance with the conditions of the EA.	Plant and equipment will be installed, maintained and operated in accordance with the manufacturer's specifications and/or the details in the EM Plan during the period if this Plan of Operations.
(A1-2) No change, replacement or alteration of any plant or equipment is permitted if the change, replacement or alteration increases, or is likely to substantially increase, the risk of environmental harm caused by the mining activities.	Wilson will not change, replace or alter any plant or equipment if it will increase, or is likely to substantially increase, the risk of environmental harm caused by the mining activity.	Prior to any change, replacement or alteration of plant and equipment, an assessment of the risk of an increase in the potential for environmental harm as a result of the change, replacement or alteration of plant and equipment will be conducted. The decision to proceed with the change, replacement or alteration of plant and equipment will be based on an assessment outcome which confirms the change, replacement or alteration would not increase or be likely to substantially increase the risk of environmental harm.
(A2-1) This environmental authority does not authorise environmental harm unless a condition contained within this authority explicitly authorises that harm. Where there is no condition or the authority is silent on a matter, the lack of a condition or sile	Wilson will comply with the conditions of the EA.	Conduct all activities/operations at the Project in accordance with the conditions of the EA.
(A2-2) In carrying out the mining activity, reasonable and practicable measures must be taken to prevent or minimise the likelihood of environmental harm being caused.	Wilson will take reasonable and practicable measures to prevent or minimise the likelihood of environmental harm being caused.	Reasonable and practicable measures will be taken during activities/operations at the Project to prevent or minimise the likelihood of environmental harm.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(A2-3) All land subject to mining activities must be rehabilitated to a non polluting, stable and self sustaining landform.	Wilson will rehabilitate land subject to mining activities to a non-polluting, stable and self sustaining landform. Landforms will be rehabilitated in accordance with the landform rehabilitation objectives specified in Schedule C – Table 1 of the EA.	Rehabilitation activities have been implemented since Project decommissioning in 1993, with significant additional reclamation works undertaken in 1996/97 (Wilson, 2008). Monitoring of rehabilitation performance and vegetation has been on-going since completion of these works. Rehabilitation of remaining disturbed areas will be completed in accordance with the PMLP (Appendix A). Specific measures will include: • erosion control works on the surface of the wasterock dumps as required; • maintenance of lease boundary fences and gates to control stock access; • maintenance of mine pit and lease boundary perimeter fences, gates and signage to limit unauthorised human entry; and • on-going implementation of weed control measures.
(A2-4) Any management or monitoring plans, systems or programs required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm as often as necessary but at least every two years and amended promptly if required.	Wilson will review management and monitoring plans, systems or programs prepared in accordance with the EA at least every two years for their effectiveness in minimising the likelihood of environmental harm.	The following management plans, programs and strategies will be reviewed for their effectiveness in minimising the likelihood of environmental harm at least every two years: • Post Mine Landuse Plan (PMLP); • Rehabilitation Monitoring Program (RMP); • Grazing Management Plan (GMP); • Emergency Response/Contingency Plan (ER/CP); • Cultural Heritage Management Program (CHMP); • Water Management Strategy (WMS); and • Erosion and Sediment Control Plan (ESCP). The relevant plan, program or strategy will be revised as necessary and submitted to DEHP.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(A2-5) The environmental authority holder must record, compile, evaluate and keep all monitoring results, records and documents for a period of at least 5 years required by this environmental authority, and any complaints received about the mining activity, and produce copies, or make available for inspection all or any of these records upon request by t h e administering authority.	Wilson will record all monitoring results and any complaints received and keep these records for a minimum of five years.	Records of monitoring results and complaints will be compiled and maintained by Wilson. Copies of these records will be made available to DEHP upon request.
(A3-2) The environmental authority holder must not implement risk control measures that contravenes or prevents the implementation of any condition of this environmental authority.	Wilson will not implement any risk control measures that contravene or prevent the implementation of any condition of the EA.	Prior to the implementation of any risk control measures, an assessment of the possibility that the implementation of the risk control measure could contravene or prevent the implementation of any condition of the EA will be conducted. The decision to proceed with the implementation of the risk control measure will be based on an assessment outcome which confirms relevant measures would not contravene or prevent implementation of any EA Condition.
(A3-3) An emergency response/contingency plan must be developed and implemented within the current plan of operations to manage the high risk categories identified in the risk assessment.	Wilson will develop and implement an ER/CP to manage the high risk categories identified in the risk assessment.	The ER/CP is provided in Appendix B. Wilson will implement the ER/CP for the duration of the term of the Plan of Operations. The ER/CP will be revised to include the high risk categories identified in the mining activities risk assessment.
(A4-1) The environmental authority holder must notify the administering authority by telephone or facsimile immediately after becoming aware of any emergency or incident resulting in, or having the potential to cause, environmental harm or any breach of condition of this environmental authority concerning releases of contaminants to the environment.	Wilson will notify DEHP as soon as practicable of any emergency or incident that results in, or may result in, the release of contaminants not authorised under the EA.	Any emergency or incident which results in the release of contaminants or threatens the release of contaminants not authorised to be caused under the EA will be reported to DEHP as soon as practicable after becoming aware of the emergency or incident.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(A4-2) The notification in condition (A4-1) must include the following: (a) the environmental authority number and name of holder; (b) the name and telephone number of the designated contact person; (c) the location of the emergency or incident; (d) the date and time of the incident; (e) the time the holder of the environmental authority became aware of the incident; (f) the estimated quantity and type of any substances involved in the incident; (g) a description of the nature and effects of the incident including environmental harm caused, threatened, or suspected to be caused by the incident; (h) any sampling conducted or proposed, relevant to the emergency or incident; and (i) immediate actions taken to prevent any further release and mitigate any environmental harm caused by the release.	Wilson will include the information required in Condition A4-2 of the EA in their notification to DEHP of an emergency or incident that results in, or may result in, the release of contaminants not in accordance with the EA.	As soon as practicable after becoming aware of an emergency or incident resulting in a release of contaminants, or potential environmental harm, not in accordance with the EA, Wilson will notify DEHP of the incident. The notification will include, but not be limited to, the information required by Condition A4-2 of the EA.
(A4-3) Within fourteen (14) days following the initial notification of an emergency or incident, further written advice must be provided to the administering authority, including the following: (a) results and interpretation of all samples taken and analysed (if available, if not yet available nominate a timeframe); (b) outcomes of actions taken at the time to prevent or minimise environmental harm; and (c) proposed actions to prevent a recurrence of the emergency or incidence.	Wilson will provide further written advice (including the information required by Condition A4-3 of the EA) to DEHP, within 14 days following the initial notification of an emergency or incident that results in, or may result in, the release of contaminants.	As soon as practicable (within 14 days) after notifying DEHP of an environmental incident Wilson will provide written advice of the information listed below: (a) results and interpretation of any samples taken and analysed; (b) outcomes of actions taken to minimise environmental harm or nuisance; and (c) proposed actions to prevent reoccurrence of the emergency or incident.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(A4-4) As soon as practicable, but not more than six (6) weeks following the conduct of any environmental monitoring performed in relation to the emergency or incident, which results in the release of contaminants not in accordance, or reasonably expected to be not in accordance with the conditions of this environmental authority, written advice must be provided of the results of any such monitoring performed to the administering authority.	Wilson will provide to DEHP, not more than six (6) weeks following the initial notification of an emergency or incident that results in, or may result in, the release of contaminants, the information required as per Condition A4-4 of the EA.	Not more than six (6) weeks after notifying DEHP of an environmental incident, Wilson will provide written advice of the results of any monitoring performed in relation to the emergency or incident.
(A5-1) All records must be kept of all environmental complaints received about the mining activities including the following details: (a) name, address and contact number for complainant (if not available record – not identified); (b) time and date of complaint; (c) reasons for the complaint; (d) investigations undertaken; (e) conclusions formed; (f) actions taken to resolve complaint; (g) any abatement measures implemented; and (h) person responsible for resolving the complaint. This information must be made available for inspection by the administering authority on request.	Wilson will establish a compliant handling system to record all environmental complaints received. The records will contain the information required as per Condition A5-1 of the EA and will be made available for inspection by DEHP on request.	A record of all environmental complaints received will be kept and will include the following information: (a) name, address and contact number for complainant (if not available record – not identified); (b) time and date of complaint; (c) reasons for the complaint; (d) investigations undertaken; (e) conclusions formed; (f) actions taken to resolve complaint; (g) any abatement measures implemented; and (h) person responsible for resolving the complaint. This information must be made available for inspection by the administering authority on request.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(A5-2) When requested by the administering authority, the environmental authority holder must undertake relevant specified monitoring within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint of environmental harm at any sensitive place or commercial place. The results of the investigation (including an analysis and interpretation of the monitoring results) and abatement measures implemented must be provided to the administering authority within fourteen (14) days of completion of the investigation.	Wilson will monitor and investigate any complaint of environmental harm received. Wilson will notify DEHP of the results within 14 days. Where necessary, Wilson will implement abatement measures to mitigate any environmental harm.	The following complaint handling system will be initiated by the Wilson. In the event of a complaint regarding environmental impacts, the following will be undertaken: (a) the complainant will be consulted by Wilson within a reasonable timeframe regarding resolution of the complaint; (b) where a resolution is not forthcoming through consultation, monitoring results will be assessed and/or additional monitoring undertaken; (c) the results of monitoring will be forwarded to DEHP within 14 days; and (d) where the above assessment indicates the need, mitigation measures will be investigated and implemented in consultation with the complainant and DEHP.
(A6-1) Compliance with the conditions of this environmental authority must be audited by a suitably qualified third party auditor, nominated by the environmental authority holder and accepted by the administering authority once every two years.	Wilson will nominate a suitably qualified third party auditor to conduct an audit to identify compliance with the conditions of the EA.	An audit will be conducted once every two years, by a suitably qualified third party auditor, nominated by Wilson, to identify compliance with the conditions of the EA.
(A6-2) The third party auditor must submit a final version of the auditor's report to the administering authority within twenty-eight (28) days of completing the audit.	The third party auditor will submit a final version of the auditor's report to DEHP within 28 days of completing the audit.	The final version of the auditor's report will be submitted to DEHP within 28 days of completing the audit.
(A6-3) The third party auditor must certify the independent findings of the audit in the report.	The third party auditor will certify the independent findings of the audit in the report.	The independent findings of the audit will be certified by the third party auditor.
(A6-4) The financial cost of the third party audit is the responsibility of the holder of this environmental authority.	The financial cost of the third party audit will be the responsibility of Wilson.	Wilson will assume the financial responsibility of the third party audit.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(A7-1) Prior to the commencement of mining activities under this environmental authority, the environmental authority holder must provide a financial assurance of an amount and in a form determined in accordance with the Queensland Environmental Protection Agency's Guideline Financial assurance for mining activities, as approved and requested by the administering authority.	Wilson will submit the financial assurance in the amount and form required by DEHP.	The amount of financial assurance has been calculated in accordance with DEHP guidelines and is presented in Section 5.3. The amount will be submitted in acceptable form when approved and requested by the Department of Mines and Energy.
(A7-2) The financial assurance must remain in force until the administering authority notifies the environmental authority holder that it is satisfied that no claim on the assurance will be required.	Not applicable.	Not applicable.
(A8-1) The holder of this environmental authority must establish, promote and maintain easily accessible lines of communication between residents and land owners to the satisfaction of the Administering Authority and provide evidence of this on an annual basis.	Wilson will establish, promote and maintain easily accessible lines of communication between residents and landowners and will provide evidence of this when requested by DEHP.	A complaint handling system will be established to promote and maintain easily accessible lines of communication between residents and land owners.
(A9-1) The holder of the environmental authority must develop and implement a Cultural Heritage Management Program covering European cultural heritage for all mining leases.	Wilson will develop and implement a CHMP to manage any European cultural heritage items on ML 5248.	A European cultural heritage survey has been conducted. The Cultural Heritage Management Program is included in Appendix C.
A9-2) The Cultural Heritage Management Program must be included in the Plan of Operations.	The CHMP will be included in the Plan of Operations.	The CHMP is provided in Appendix C.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
Schedule B – Air		
(B1-1) The release of dust or any other airborne contaminant resulting from the mining activities must not cause environmental harm at any sensitive place or commercial place.	Wilson will conduct all operations/activities in a manner that does not result in the release of dust or any other airborne contaminant resulting from the mining activities that causes environmental harm at any sensitive place or commercial place.	Where necessary, dust and other airborne contaminant matter will be minimised by: (a) watering of unsealed roads; and (b) dust suppression sprays at locations that produce excessive dust.
(B1-2) In the event of a complaint, the environmental authority holder must ensure that dust generated by the mining activities does not cause any of the following criteria at any sensitive place or commercial place to be exceeded: (a) dust deposition of 120 milligrams per square metre per day, averaged over one month, when monitored in accordance with the most recent version of Australian Standard AS 3580.10.1 Methods for sampling and analysis of ambient air – Determination of particulate matter – Deposited matter – Gravimetric method; (b) total suspended particulates (TSP) of 130 micrograms per cubic metre expressed as an 24 hour average, when monitored in accordance with any method for measuring TSP recommended in the latest edition of the Environmental Protection Agency's Air Quality Sampling Manual; c) a concentration of particulate matter with an aerodynamic diameter of less than 10 micrometres (PM10) suspended in the atmosphere of 150 micrograms per cubic metre over a 24 hour averaging time, when monitored in accordance with the most recent version of Australian Standard AS 3580.9.6 Determination of suspended particulate matter - PM (sub) 10 high volume sampler with size-selective inlet - Gravimetric method; and (d) total suspended particulates (TSP) of 200 micrograms per cubic metre expressed as a one hour average, when monitored in accordance with any method for measuring TSP recommended in the latest edition of the Environmental Protection Agency's Air Quality Sampling Manual.	Wilson will conduct all operations/activities in a manner that does not result in an exceedance of the air quality criteria outlined in Condition B1-2 of the EA at any sensitive place or commercial place.	Where necessary, dust and other airborne contaminant matter will be minimised by: (a) watering of unsealed roads; and (b) dust suppression sprays at locations that produce excessive dust. In the event of a complaint, a review of the dust minimisation methods currently being implemented will be conducted and, if necessary, monitoring will be conducted at the affected sensitive or commercial place to determine if the criteria specified in the EA have been exceeded.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(B1-3) If monitoring indicates limits in condition (B1-2) have been exceeded and is attributable to the licensed activity, the environmental authority holder must implement dust abatement measures so that emissions of dust generated by the mining activities cease to exceed limits in condition (B1-2).	Wilson will implement dust abatement measures if monitoring conducted in accordance with Condition B1-2 of the EA indicates limits in Condition B1-2 of the EA have been exceeded and is attributable to the licensed activity.	Dust and other airborne contaminant matter will be minimised by: (a) watering of unsealed roads; and (b) dust suppression sprays at locations that produce excessive dust. In the event of an exceedance, a review of the dust minimisation methods currently being implemented will be conducted.
Schedule C – Land		
(C1-1) Land disturbed by mining activities must be rehabilitated in accordance with Schedule C – Table 1.	Wilson will undertake yearly monitoring as detailed in the RMP, and will rehabilitate the landforms as defined in Schedule C – Table 1.	Rehabilitation of the land disturbed will be in accordance with Schedule C – Table 1. Monitoring of rehabilitation performance is detailed in the RMP (Attachment A of Appendix A). The areas and frequencies of monitoring are described in the RMP.
(C1-2) Drain the surface of the Content Waste Rock Dump to Content Pit, fill low-lying areas on the Content Waste Rock Dump and import additional growth medium to the Content Waste Rock Dump.	Wilson will undertake rehabilitation works in the area of the Content waste rock dump.	Rehabilitation works of the Content waste rock dump were performed during the term of the previous Plan of Operations.
(C1-3) All waste rock dump slopes must be covered with a regrowth medium to support vegetation regrowth and limit erosion.	Wilson will cover all waste rock dump slopes with a regrowth medium to support vegetation regrowth and limit erosion.	Where rehabilitation monitoring indicates that the slopes of the waste rock dumps require additional regrowth media through signs of poor revegetation performance and the occurrence of accelerated erosion, regrowth medium will be applied.
(C2-1) A Post Mine Land Use Plan for the licensed place must be developed and implemented for a nominal period of:(a) at least thirty (30) years following the cessation of mining activities on the licensed place; or (b) a shorter period if the licensed place is proven to be geo-technically and geo-chemically stable and it can be demonstrated to the satisfaction of the administering authority that no release of contaminants from the site will result in environmental harm and be prepared at least 18 months prior to cessation of mining activities on the licensed place.	Wilson will develop and implement the PMLP in accordance with Condition C2-1 of the EA.	The PMLP is provided in Appendix A.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
C2-2) The Post Mine Land Use Plan must be included in the Plan of Operations and updated with each subsequent Plan of Operations, describing how the rehabilitation objectives in Schedule C – Table 1 will be achieved. The Post Mine Land Use Plan must include: (a) schematic representation of final land form inclusive of drainage features; and (b) slope designs; and (c) cover design including a report on the effectiveness of existing cover systems; and (d) drainage design; and (e) erosion controls on reformed land; and (f) description of experimental design for monitoring of analogue and rehabilitated areas inclusive of statistical design; and (g) proposed revegetation criteria including: i. species diversity, abundance and composition; ii. projective cover; iii. dry matter production; and iv. stocking rates to ensure self-sustaining vegetation is maintained; and (h) proposed revegetation methods inclusive of plant species Selection, re-profiling, respreading soil, soil ameliorants/amendments, surface preparation and method of propagation; and i) materials balance including available top soil and low permeability encapsulation media for capping; and (j) research program and associated milestones; (k) geotechnical, geochemical and hydrological studies; (l) chemical, physical and biological properties of soil and water; (m) measurable completion criteria for each rehabilitation indicator that enables determination of rehabilitation success for each isturbance type; and (n) rehabilitation monitoring program, including the monitoring of: i. surface water quality; ii. groundwater quality; iii. erosion rates; iv. integrity and effectiveness of final cover of final cover systems; and v. health and resilience of vegetative cover. (o) grazing management plan; and (p) operation and maintenance of: i. the surface water management system; ii. groundwater monitoring network; iii. final cover systems; and iv. vegetative cover.	Wilson will update the PMLP with each subsequent Plan of Operations and include the requirements of EA Condition C2-2.	The PMLP includes the components identified in Condition C2-2 of the EA (Appendix A). The RMP is provided as Attachment A of the PMLP. The GMP is provided as Attachment B of the PMLP.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(C3-1) The holder of the environmental authority must conduct a Rehabilitation Monitoring Program on at least a yearly basis, which must include sufficient spatial and temporal replication to enable scientifically justifiable conclusions as established under the rehabilitation program or other methodology to the satisfaction of the Administering Authority.	Wilson will conduct a RMP on at least a yearly basis and will include sufficient spatial and temporal replication to enable scientifically justifiable conclusions to be established.	A RMP has been prepared and includes the following monitoring programs: • surface water monitoring; • stream sediment monitoring; • groundwater monitoring; • rehabilitation monitoring; and • erosion and final cover monitoring. Monitoring data will be collected at the timing, frequency and locations that will provide sufficient data continuity to enable scientifically justifiable conclusions to be established. The RMP is provided in Attachment A of Appendix A.
(C3-2) The rehabilitation monitoring program must be developed by 1 October 2008 and be implemented by a person nominated by the environmental authority holder possessing appropriate qualifications and experience in the field of rehabilitation management.	Wilson will develop the RMP by 1 October 2008 and will be implemented by a person possessing appropriate qualifications and experience in the field of rehabilitation management as nominated by Wilson.	The RMP was submitted to DEHP on 30 September 2008 in which Landline Consulting was nominated by Wilson to implement the RMP. This has been superseded by the methodology detailed in Appendix A - Attachment A: Rehabilitation Monitoring Plan. The implementation of the requirements of the rehabilitation monitoring plan is contracted to appropriately qualified individuals as availability and rates dictate.
(C3-3) Verification of rehabilitation success is to be determined by comparison with the criteria documented in the Post Mine Land Use Plan required under Condition C2-1.	Wilson will verify the rehabilitation success with the criteria documented in the PMLP required under Condition C2-1 of the EA.	Rehabilitation success will be verified with the criteria documented in the PMLP. The PMLP is provided in Appendix A.
(C4-1) All infrastructure, mining equipment and plant erected and/or used for the mining activities must be removed from the licensed place prior to surrender, except where agreed in writing by the administering authority, landowner and the Minister administering the Mineral Resources Act 1989.	All infrastructure, mining equipment and plant will be decommissioned and removed from the mining lease (unless otherwise agreed with DEHP, local landowner and the Minister administering the Mineral Resources Act, 1989).	The majority of mining related infrastructure, mining equipment and plant have been removed from the site. If any infrastructure (e.g. roads) is to be maintained for beneficial use by the landowner, Wilson will obtain agreement from DEHP, landowner and the Minister administering the Mineral Resources Act, 1989.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(C5-1) Residual voids, or the contents of residual voids, must not cause any environmental harm other than the environmental harm caused within the footprint of the residual void itself.	Wilson will manage the residual voids, and the contents of the residual voids, in such a way that they will not cause any environmental harm other than the environmental harm caused by the residual void itself.	A hydrogeological study conducted by HLA-Envirosciences (2001) concluded that the pit lakes are expected to act as groundwater sinks and have a limited capacity to influence groundwater beyond the footprint of the pits. In accordance with Condition F4-6 of the EA hydrogeological investigations will continue to enable the conceptual hydrogeological model provided by HLA-Envirosciences to be reviewed and updated in view of the new information. Reclamation works relevant to residual voids have been implemented at the Project (Wilson, 2008), and include the following: • construction of diversion bunds around residual voids; and • re-vegetation of disturbed areas. Monitoring of groundwater and surface waters (including pits and receiving waters) will continue to be implemented in accordance with the RMP (Attachment A of Appendix A).
(C6-1) All explosives, hazardous chemicals, corrosive substances, toxic substances, gases and dangerous goods must be stored and handled in accordance with the relevant Australian Standard.	Wilson will store and handle all explosives, hazardous chemicals, corrosive substances, toxic substances, gases and dangerous goods in accordance with the relevant Australian Standard.	No explosives, hazardous chemicals, corrosive substances, toxic substances, gases and dangerous goods are currently stored or used on site. If required in the future, explosives, hazardous chemicals, corrosive substances, toxic substances, gases and dangerous goods will be stored and handled in accordance with the relevant Australian Standard.
(C6-2) Flammable and combustible liquids, including petroleum products and associated piping and infrastructure, must be stored and handled in accordance with the latest edition of Australian Standard 1940 – The Storage and Handling of Flammable and Combustible Liquids.	Wilson will store and handle all flammable or combustible liquids in accordance with Australian Standard 1940 – The Storage and Handling of Flammable and Combustible Liquids.	No flammable or combustible liquids are currently stored onsite. If required in the future, flammable or combustible liquids will be stored and handled in accordance with Australian Standard 1940 – The Storage and Handling of Flammable and Combustible Liquids.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(C6-3) Any chemicals and flammable or combustible liquids stored on the licensed place that have the potential to cause environmental harm must be stored in or serviced by an effective containment system that is impervious to the materials stored and managed to prevent the release of liquids to waters or land. Where no relevant Australian Standard is available, the following must be applied: (a) storage tanks must be bunded so that the capacity and construction of the bund is sufficient to contain at least 110% of a single storage tank or 100% of the largest storage tank plus 10% of the second largest storage tank in multiple storage areas; and (b) drum storages must be bunded so that the capacity and construction of the bund is sufficient to contain at least 25% of the maximum design storage volume within the bund.	Wilson will store chemicals and flammable or combustible liquids that have the potential to cause environmental harm in accordance with Condition C6-3 of the EA.	No chemicals and flammable or combustible liquids are currently stored or used on site. If required in the future, chemicals and flammable or combustible liquids will be stored in accordance with Condition C6-3 of the EA.
(C6-4) All containment systems for chemicals and flammable or combustible liquids must be designed to minimise rainfall collection within the system.	Wilson will design all containment systems for chemicals and flammable or combustible liquids in such a way to minimise rainfall collection within the system.	No containment systems for chemicals and flammable or combustible liquids are currently onsite. If in the future, containment systems for chemicals and flammable or combustible liquids are required, the containment systems will be designed to minimise rainfall collection within the system.
(C7-1) Undertake a contaminated land assessment / investigation of the licensed place in accordance with DEHP Guidelines for the Assessment & Management of Contaminated Land in Queensland.	A contaminated land assessment/investigation of ML 5248 in accordance with DEHP Draft Guidelines for the Assessment & Management of Contaminated Land (EPA, 1998) will be conducted.	A site investigation was carried out by HLA-Envirosciences in May 2002. This was performed in accordance with the Draft Guideline for the Assessment and Management of Contaminated Land in Queensland. The report has been submitted to the DEHP (EPA file number BNE1050). The report concluded that in accordance with the Contaminated Land Guidelines, a stage 2 detailed site investigation is not required, and no remediation plan was necessary.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
Schedule D – Waste		
(D1-1) The environmental authority holder shall not cause, allow or permit any waste generated outside the mine to be received at the mine for storage, treatment, processing or disposal.	Wilson will not cause, allow or permit any waste generated outside the mine to be received at the mine for storage, treatment, processing or disposal.	No waste will be caused, allowed or permitted to be received at the mine for storage, treatment processing or disposal.
(D2-1) Where regulated waste is removed from the licensed place (other than by a release as permitted under another schedule of this environmental authority), the holder of this environmental authority must ensure that: (a) the removal and transport of such wastes, where it constitutes an environmentally relevant activity under the Environmental Protection Regulation 1998, is carried out by a person licensed for carrying out this activity under the Environmental Protection Act 1994; and (b) records are kept of the following: (i) the date, quantity and type of waste removed; and (ii) name of the regulated waste transporters that removed the waste; and (iii) the intended treatment/disposal destination of the waste.	Wilson will remove all regulated waste from the site in accordance with Condition D2-1 of the EA.	There is no known regulated waste currently at the site. If in the future regulated waste is required to be removed from the site, Wilson will remove the waste in accordance with Condition D2-1 of the EA.
(D3-1) If the holder of this environmental authority becomes aware that a person has removed regulated waste from the licensed place and disposed of the regulated waste in a manner which is not authorised by this environmental authority or improper or unlawful, then the holder of this environmental authority must, as soon as practicable, notify the administering authority of all relevant facts, matters and circumstances known concerning the disposal.	Wilson will notify DEHP as soon as practicable after becoming aware that a person has removed regulated waste from the licensed place and disposed of the regulated waste in a manner which is not authorised by this environmental authority or is improper or unlawful.	There is no known regulated waste currently at the site. If in the future a person has removed regulated waste from the site and disposed of the regulated waste in a manner which is not authorised by the EA or is improper or unlawful, Wilson will notify DEHP as soon as practicable after becoming aware that incident. All relevant facts, matters and circumstances known concerning the disposal will be provided to DEHP.
D3-2) Regulated waste generated by maintenance of plant and equipment and absorbent materials used to clean up spills must only be disposed off at a facility whose operator is permitted to accept such waste in accordance with the requirements of the Environmental Protection Act 1994.	Wilson will dispose of regulated generated by maintenance of plant and equipment and absorbent materials used to clean up spills at a facility whose operator is permitted to accept such waste in accordance with the requirements of the EP Act.	No regulated waste is currently generated by maintenance of plant and equipment at the site. If any additional rehabilitation works produce regulated waste, Wilson will dispose of the waste at a facility whose operator is permitted to accept such waste in accordance with the requirements of the EP Act.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
Schedule E – Noise and Vibration		
(E1-1) Noise from the mining activity must not cause environmental harm at any sensitive place or commercial place.	Wilson will conduct activities/operations in such a manner so as not to produce noise that causes environmental harm at any sensitive place or commercial place.	As activity at the site is minor and infrequent, potential noise impacts are considered negligible. Notwithstanding the above, Wilson will conduct all activities/operations in such a manner so as not to produce noise that causes environmental harm at any sensitive place or commercial place.
(E1-2) In the event of a complaint made to the administering authority (which is neither frivolous or vexatious) about noise generated in carrying out the licensed activity, and the noise is considered by the administering authority to be an unreasonable noise, the holder of this Environmental Authority must take action to ensure that it is no longer an unreasonable noise.	Wilson will take action in the event that the noise is considered unreasonable by DEHP. Measures will be implemented to prevent the noise from being considered an unreasonable noise.	In the event of a noise complaint, Wilson will implement a complaint handling system and will record all noise complaints in accordance with Condition A5-1 of the EA. In the event that the noise is considered unreasonable by DEHP, action (e.g. change work times) will be taken to prevent the noise being considered unreasonable.
Schedule F – Water		
(F1-1) Contaminant that will, or have the potential to cause environmental harm, must not be released directly or indirectly to any water except as permitted under the conditions of this EA.	Wilson will not release contaminants directly or indirectly to any waters except as permitted under the conditions of this EA.	A WMS has been prepared in accordance with Condition F7-1 of the EA. The WMS details the site water management system (including site containment structures). The WMS is provided in Appendix D.
(F1-2) The release of contaminants directly or indirectly to waters must not: (a) produce any visible discolouration of receiving waters; or (b) produce any slick or other visible or odorous evidence of oil, grease or petrochemicals nor contain visible floating oil, grease, scum, litter or other objectionable matter.	Wilson will not release contaminants directly or indirectly to any waters except as permitted under the conditions of this EA.	A WMS has been prepared in accordance with Condition F7-1 of the EA. The WMS details the site water management system (including site containment structures). The WMS is provided in Appendix D.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(F1-3) All determinations of water quality must be: (a) performed by a person or body possessing appropriate experience and qualifications to perform the required measurements; (b) made in accordance with methods prescribed in the latest edition of the Administering Authority's monitoring and sampling manual; (c) collected from the monitoring locations identified within this environmental authority, within 2 hours of each other (reference/downstream) where possible; (d) carried out on representative samples; and, (e) laboratory testing must be undertaken using a laboratory accredited (e.g. NATA) for the method of analysis being used.	Wilson will carry out sampling and analysis of water quality as per conditions of this EA.	Waters will be sampled using the method set out in the latest edition of DEHP Water Quality Sampling Manual and from location stipulated in this EA. Sample analysis will be performed by a NATA Certified laboratory.
(F1-4) The following information must be recorded in relation to all water monitoring required under the conditions of this environmental authority and submitted to the administering authority in the specified format when requested: (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; (d) the measured or estimated daily quantity of the contaminants released from all release points; (e) the release flow rate at the time of sampling for each release point; (f) the results of all monitoring and details of any exceedances with the conditions of this environmental authority; and (g) water quality monitoring data must be provided to the administering authority in the specified electronic format upon request.	Wilson will record all information in relation to water monitoring as per conditions of this EA.	Water sampling procedures will include recording of all necessary information as per conditions of this EA.
(F2-1) The release of contaminants to waters must only occur from the release points specified in Schedule F - Table 1 (Contaminant Release Points) and depicted in Schedule H - Map 3 (Location of Monitoring sites on Belmore Creek).	Wilson will take action to ensure release of contaminants to waters can only occur from the release points specified in Schedule F - Table 1 (Contaminant Release Points) and depicted in Schedule H - Map 3 (Location of Monitoring sites on Belmore Creek).	A WMS has been prepared in accordance with Condition F7-1 of the EA. The WMS details the site water management system (including site containment structures). The WMS is provided in Appendix D.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(F2-2) The release of contaminants to waters from the release points must be monitored at the locations specified in Schedule F - Table 1 (Contaminant Release Points) for each quality characteristic and at the monitoring frequency specified in Schedule F - Table 2 (Contaminant Release Limits).	Wilson will monitor waters at the locations specified in Schedule F - Table 1 (Contaminant Release Points) for each quality characteristic and at the monitoring frequency specified in Schedule F - Table 2 (Contaminant Release Limits).	Locations specified in Schedule F - Table 1 (Contaminant Release Points) for each quality characteristic and at the monitoring frequency specified in Schedule F - Table 2 (Contaminant Release Limits) will be included in the routine water quality monitoring programme. Monitoring will be conducted in accordance with the requirements in DEHP Water Quality Sampling Manual.
(F2-3) The release of contaminants to waters must not exceed the contaminant release limits stated in Schedule F - Table 2 (Contaminant Release Limits) for each quality characteristic.	Wilson will take action to ensure release of contaminants to waters must not exceed the contaminant release limits stated in Schedule F - Table 2 (Contaminant Release Limits) for each quality characteristic.	A WMS has been prepared in accordance with Condition F7-1 of the EA. The WMS details the site water management system (including site containment structures). The WMS is provided in Appendix D.
(F3-1) The holder of this environmental authority must install, operate and maintain a stream flow gauging station to determine and record stream flows at the locations upstream of each release point as specified in Schedule F - Table 1 (Contaminant Release Points) for any receiving water into which a release occurs.	Wilson will install, operate and maintain a stream flow gauging station to determine and record stream flows at the locations specified in this EA.	A discharge flow measuring flume has been installed at Content Pit to be used in conjunction with the Content Pit lake water height monitoring equipment. Water depth gauge boards are installed at Belmore Creek with the cross-section profile recorded.
(F3-2) At the time of release the water flow volume in the respective receiving water must be at least twenty (20) times the volume at which respective mine affected waters are released.	Wilson will take action to ensure at the time of release the water flow volume in the respective receiving water must be at least twenty (20) times the volume at which respective mine affected waters are released.	A WMS has been prepared in accordance with Condition F7-1 of the EA. The WMS details the site water management system (including site containment structures). The WMS is provided in Appendix D.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(F4-1) Receiving waters must be monitored at the locations and frequencies defined in Schedule F Table 3.	Wilson will undertake monitoring of waters in Schedule F - Table 3.	Monitoring of waters in Schedule F - Table 3 for each sample site listed will be included in the routine environmental monitoring programme. Monitoring will be conducted in accordance with the requirements in DEHP Water Quality Sampling Manual.
(F4-2) If quality characteristics of the receiving water at the downstream monitoring points identified in Schedule F - Table 3 exceed any of the trigger levels specified in Schedule F - Table 4 the holder of this environmental authority must compare the downstream results to the reference site results in the receiving waters and: (a) where the downstream result is the same or a lower value than the reference site value for the quality characteristic during the same sampling event then no action is to be taken; or (b) where the downstream results exceed the reference site complete an investigation in accordance with the ANZECC & ARMCANZ 2000 methodology, into the potential for environmental harm and provide a written report to the administering authority within three months, outlining: (i) details of the investigations carried out (ii) details of the environmental impacts observed; and (iii) actions taken to prevent environmental harm.	If quality characteristics of the receiving water at the downstream monitoring points identified in Schedule F - Table 3 exceed any of the trigger levels specified in Schedule F - Table 4 and where the downstream results exceed the reference site complete an investigation in accordance with the ANZECC & ARMCANZ 2000 methodology, into the potential for environmental harm and provide a written report to the administering authority within three months, outlining: (i) details of the investigations carried out (ii) details of the environmental impacts observed; and (iii) actions taken to prevent environmental harm.	In the event downstream results exceed the reference site complete an investigation in accordance with the ANZECC & ARMCANZ 2000 methodology, into the potential for environmental harm and provide a written report to the administering authority within three months which includes details regarding: (i) details of the investigations carried out (ii) details of the environmental impacts observed; and (iii) actions taken to prevent environmental harm.
(F4-3) The release of contaminants to waters must not exceed the contaminant release limits stated in Schedule F - Table 4 (Receiving Water Trigger and Contaminant Limits) for each quality characteristic.	Wilson will undertake monitoring of waters in Schedule F - Table 4 (Receiving Water Trigger and Contaminant Limits) for each quality characteristic to determine if the contaminant limits are exceeded.	Monitoring of waters in Schedule F - Table 4 (Receiving Water Trigger and Contaminant Limits) for each quality characteristic listed will be included in the routine environmental monitoring programme. Monitoring will be conducted in accordance with the requirements in DEHP Water Quality Sampling Manual.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(F5-1) Sediment quality of receiving waters and reference waters must be monitored at the monitoring locations and frequency defined in Schedule F - Table 5 (Receiving Water Monitoring Locations) and identified on Schedule H - Map 2 (Surface Water, Sediment and Groundwater Monitoring Sites) and Map 3 (Location of Monitoring Sites on Belmore Creek) for the parameters defined in Schedule F - Table 6 (Stream Sediment Trigger and Contaminant Levels).	Wilson will monitor the sediment quality of receiving waters at the locations and frequencies identified in Schedule F - Table 5 (Receiving Water Monitoring Locations) and identified on Schedule H - Map 2 (Surface Water, Sediment and Groundwater Monitoring Sites) and Map 3 (Location of Monitoring Sites on Belmore Creek) for the parameters defined in Schedule F - Table 6 (Stream Sediment Trigger and Contaminant Levels).	Wilson will monitor the sediment quality of receiving waters at the locations and frequencies identified in Schedule F - Table 5 (Receiving Water Monitoring Locations) and identified on Schedule H - Map 2 (Surface Water, Sediment and Groundwater Monitoring Sites) and Map 3 (Location of Monitoring Sites on Belmore Creek) for the parameters defined in Schedule F - Table 6 (Stream Sediment Trigger and Contaminant Levels). Monitoring will be conducted in accordance with the requirements in the AS 5667.12 Guidance on Sampling of Bottom Sediments of 1998 and other relevant standards.
(F5-2) If the bed of the receiving water exceed any of the trigger levels specified in Schedule C - Table 6 (Stream Sediment Trigger and Contaminant Levels), the holder of this environmental authority must compare the results of the downstream site to the data from reference monitoring sites and: (a) if the level of contaminants at the downstream site does not exceed the reference monitoring site data, then no action is to be taken; or (b) if the level of contaminants at the downstream site is greater than the reference monitoring site data, complete an investigation in accordance with the ANZECC & ARMCANZ 2000 methodology, into the potential for environmental harm and provide a written report to the administering authority within three (3) months, outlining: (i) details of the investigations carried out; (ii) details of the environmental impacts observed; and (iii) actions taken to prevent environmental harm.	If the bed of the receiving water exceed any of the trigger levels specified in Schedule C - Table 6 (Stream Sediment Trigger and Contaminant Levels), and where the downstream results exceed the reference site complete an investigation in accordance with the ANZECC & ARMCANZ 2000 methodology, into the potential for environmental harm and provide a written report to the administering authority within three months, outlining: (i) details of the investigations carried out (ii) details of the environmental impacts observed; and (iii) actions taken to prevent environmental harm.	In the event downstream results exceed the reference site complete an investigation in accordance with the ANZECC & ARMCANZ 2000 methodology, into the potential for environmental harm and provide a written report to the administering authority within three months which includes details regarding: (i) details of the investigations carried out (ii) details of the environmental impacts observed; and (iii) actions taken to prevent environmental harm.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(F5-3) Releases of contaminants must not result in an exceedence of sediment contaminant limits stated in Schedule F - Table 6 (Stream Sediment Trigger and Contaminant Levels).	Wilson will take action to ensure release of contaminants must not result in an exceedence of sediment contaminant limits stated in Schedule F - Table 6 (Stream Sediment Trigger and Contaminant Levels).	A WMS has been prepared in accordance with Condition F7-1 of the EA. The WMS details the site water management system (including site containment structures). The WMS is provided in Appendix D.
(F5-4) All stream sediment sampling must be undertaken in accordance with the most recent version of Australian Standard AS 5667.12 Guidance on Sampling of Bottom Sediments of 1998.	Wilson will carry out stream sediment sampling which will be undertaken in accordance with AS 5667.12 1999 Guidance on Sampling of Bottom Sediments.	All stream sediment sampling will be undertaken in accordance with AS 5667.12 1999 Guidance on Sampling of Bottom Sediments.
(F6-1) Water storages stated in Schedule F - Table 7 (Water Storage Monitoring) must be monitored for the water quality characteristics specified in Schedule F - Table 8 (Onsite Water Storage Contaminant Limits).	Wilson will monitor water storages stated in Schedule F - Table 7 (Water Storage Monitoring) must be monitored for the water quality characteristics specified in Schedule F - Table 8 (Onsite Water Storage Contaminant Limits).	Wilson will monitor water storages stated in Schedule F - Table 7 (Water Storage Monitoring) must be monitored for the water quality characteristics specified in Schedule F - Table 8 (Onsite Water Storage Contaminant Limits). Monitoring will be conducted in accordance with the requirements in DEHP Water Quality Sampling Manual.
(F6-2) In the event that waters defined in Schedule F – Table 7 exceed the contaminant limits defined in Schedule F – Table 8, the holder of the environmental authority must implement measures to prevent access to waters by all livestocks and minimise access by native fauna.	In the event that waters defined in Schedule F – Table 7 exceed the contaminant limits defined in Schedule F – Table 8,Wilson will implement suitable measures to prevent access by all livestock and minimise access by native fauna.	In the waters defined in Schedule F – Table 7 exceed the contaminant limits defined in Schedule F – Table 8, fencing will be installed to prevent access by all livestock and to minimise access by native fauna. Completed reclamation activities during the previous plan periods:• SW5 (i.e. Sediment Dam at the lease boundary) has been fenced; and • suitable barriers (i.e. abandonment bunds) were constructed across the access ramps to the Golden Butterfly, Golden Butterfly North, and Lady Isabella Pits to restrict vehicle access.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(F7-1) Groundwaters must be monitored at the locations and frequencies defined in Schedule F – Table 9 & Schedule H – Map 2 for parameters identified in Schedule F – Table 10.	Wilson will monitor the locations and frequencies defined in Schedule F – Table 9 & Schedule H – Map 2 for parameters identified in Schedule F – Table 10:	Wilson will monitor the locations and frequencies defined in Schedule F – Table 9 & Schedule H – Map 2 for parameters identified in Schedule F – Table 10:
(F7-2) If groundwaters from compliance bores identified in Schedule F – Table 9 exceed any of the trigger levels stated in Schedule F – Table 10, the environmental authority holder must complete an investigation in accordance with the ANZECC (2000) methodology, into the potential for environmental harm, and provide a written report to the administering authority within 3 months of the date of the original exceedence, outlining: (i) details of the investigations carried out; and (ii) actions taken to prevent environmental harm.	In the event groundwaters from compliance bores identified in Schedule F – Table 9 exceed any of the trigger levels stated in Schedule F – Table 10, Wilson will conduct an investigation in accordance with the ANZECC (2000) methodology, into the potential for environmental harm, and provide a written report to the administering authority within 3 months of the date of the original exceedence, outlining: (i) details of the investigations carried out; and (ii) actions taken to prevent environmental harm.	In the event groundwaters from compliance bores identified in Schedule F – Table 9 exceed any of the trigger levels stated in Schedule F – Table 10, produce the required report as per the conditions of this EA. The report will specify the details of the investigation and actions taken to prevent environmental harm. The investigation will consider factors such as the available historical monitoring results, hydrogeology and potential water quality impacts.
(F7-3) Groundwaters from bores identified in Schedule F – Table 9, must not exceed any of the limits defined in Schedule C –Table 11.	Wilson will undertake monitoring of the groundwaters at the locations identified in Schedule F – Table 9 to determine if the contaminant limits defined in Schedule F – Table 11 are exceeded.	Wilson will undertake monitoring of the groundwaters at the locations identified in Schedule F – Table 9 to determine if the contaminant limits defined in Schedule F – Table 11 are exceeded.
(F7-4) Annual groundwater monitoring reports analysing groundwater chemistry and hydrogeological status of all groundwater bores and groundwater conditions are to be prepared by November each year as an element of the water management strategy review.	Wilson will prepare annual groundwater monitoring reports analysing the groundwater chemistry and hydrogeological status of all groundwater bores and groundwater conditions.	An annual groundwater monitoring report analysing the groundwater chemistry and hydrogeological status of all groundwater bores and groundwater conditions will be prepared and submitted by January of each year as a component of the annual WMS review.
(F7-5) Construct additional monitoring bores BH10, BH11 & BH12 to the west of the Content Waste Rock Dump and BH 8 & BH9 between the Golden Butterfly North Pit and the Golden Butterfly Waste Rock Dump and SY1 on Slaughteryard Creek.	Wilson will construct additional monitoring bores BH10, BH11 and BH12 to the west of the Content Waste Rock Dump and BH 8 and BH9 between the Golden Butterfly North Pit and the Golden Butterfly Waste Rock Dump and SY1 on Slaughteryard Creek.	Additional monitoring bores BH8, BH9, BH10, BH11, BH12 and SY1 were constructed in 2009.

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(F7-6) Before 30 June 2009 conduct additional investigations / monitoring to confirm the conceptual licensed place hydro-geological model, including: (a) Obtaining additional hydro-geological information (e.g. geological information, bore and pit water levels). (b) Compile and analyse existing groundwater quality data from the town water supply bores. (c) Installing an additional deep monitoring bore (SY1) between the Golden Butterfly Pit and Slaughteryard Creek to supplement the existing monitoring network. (d) Surveying of pit lake water levels and erection of water level gauging stages. (e) Investigate the state of equilibrium of pit water levels. (f) Include the latest information obtained from the additional hydro-geological investigations/monitoring in subsequent amendments to the Croydon Gold Mine EM Plan. (g) Conduct a bore census of the area surrounding the licensed place.	Wilson will conduct additional hydrogeological investigations and monitoring to confirm the current conceptual hydrogeological model described in the EM Plan by 30 June 2008.	Additional hydrogeological investigations and monitoring are ongoing to confirm the current conceptual hydrogeological model described in the EM Plan. The investigations and monitoring will include: (a) obtaining additional hydro-geological information (e.g. geological information, bore and pit water levels); (b) compiling and analysing existing groundwater quality data from the town water supply bores; (c) surveying of pit lake water levels and erection of water level gauging stages; (d) investigating the state of equilibrium of pit water levels; (e) the latest information obtained from the additional hydro-geological investigations / monitoring in subsequent amendments to the Project EM Plan; and (f) conducting a bore census of the area surrounding the licensed place. A report summarising the outcomes of the additional hydrogeological investigations has been provided to DEHP.
(F8-1) An erosion and sediment control plan must be developed and implemented for the activities on the licensed place which has been certified by a Certified Professional in Sediment and Erosion Control (CPESC), or a professional with appropriate experience and / or qualifications accepted by the Administering Authority and be included in the Plan of Operations.	Certified Professional in Sediment and Erosion Control, or a professional with appropriate experience and / or qualifications accepted by DEHP will develop and implement an ESCP.	An ESCP has been developed and will be implemented during the term of this Plan of Operations and is provided in Appendix E.
(F8-2) Erosion protection measures and sediment control measures must be implemented and maintained to minimise erosion and the release of sediment and contamination of storm water.	Wilson will implement and maintain erosion protection measures and sediment control measures to minimise erosion and the release of sediment and contamination of storm water.	During the implementation of the ESCP, erosion protection and sediment control measures will be implemented and maintained to minimise erosion and the release of sediment and contamination of storm water. Details of the control measures to be undertaken are provided in the ESCP (Appendix E).

Table 2 (Continued)
Action Program Summary Table

EA Condition	Control Strategy	Action Program
(F9-1) All reasonable and practicable measures must be implemented to prevent hazardous leachate being directly or indirectly released or likely to be released as a result of the activity to any groundwater or water course.	Wilson will implement all reasonable and practicable measures to prevent hazardous leachate being directly or indirectly released or likely to be released as a result of the activity to any groundwater or water course.	All reasonable and practicable measures will be implemented to prevent hazardous leachate being directly or indirectly released, or likely to be released, as a result of an activity to any groundwater or water course. The measures to be implemented are detailed in the WMS (Appendix D) and the ESCP (Appendix E).
(F10-1) A water management strategy must be prepared for inclusion in the Plan of Operations. The strategy will include: (a) Data collation and identify existing data requirements; (b) Design and detail additional works as required; and (c) Implement / construct additional works.	Wilson will prepare a WMS in accordance with Condition F7-1 of the EA.	A WMS has been prepared in accordance with Condition F7-1 of the EA and is provided in Appendix D.
(F10-2) An annual review of the water management strategy must be submitted by November each year.	Wilson will submit an annual review of the WMS by November of each year.	An annual review of the WMS will be submitted by November of each year.
(F11-1) The environmental authority holder must develop and implement a Receiving Environment Monitoring Program (REMP) by 31 July 2013 to monitor, identify and describe any adverse impacts to surface water environmental values, quality and flows due to the authorised mining activity. This must include monitoring the effects of the mine on the receiving environment periodically (under natural flow conditions) and while mine affected water is being discharged from the site.	Wilson will develop and implement a REMP as stipulated in this EA.	A REMP has been developed and documented that includes the requirements detailed in clause F11-2. The REMP has been submitted to the DEHP. A copy of the REMP has been provided in Appendix F.

5 REHABILITATION COST ESTIMATE AND PERFORMANCE CATEGORY

5.1 DECOMMISSIONING AND REHABILITATION COSTS

The decommissioning and rehabilitation costs for the Project are detailed in Table 2.

Cost estimates are produced using the DEHP Financial Assurance Calculator (downloaded May 2018 - https://www.business.qld.gov.au/running-business/environment/licences-permits/rehabilitation/security-deposit).

Table 3 Project Decommissioning and Rehabilitation Costs ($) 2018–2019

Domain	Rehabilitation Liability
Domain 1: Infrastructure	$98,875
Domain 2: Tailings Storage Facilities (1)	$0
Domain 2: Tailings Storage Facilities (2)	$0
Domain 2: Tailings Storage Facilities (3)	$0
Domain 3: Overburden & Waste Dumps (1)	$18,840
Domain 3: Overburden & Waste Dumps (2)	$9,960
Domain 3: Overburden & Waste Dumps (3)	$0
Domain 4: Water Management	$68,903
Domain 5: Pits (1)	$0
Domain 5: Pits (2)	$0
Domain 5: Pits (3)	$0
Domain 6: Other Management Issues	$106,410
Subtotal	**$302,988**

Contingencies		Rehabilitation Liability
Project Management	10%	$30,299
Environmental Maintenance and Monitoring	5%	$15,149
Subtotal		**$45,448**

Total Rehabilitation Liability for the Operation (excl. GST)	**$348,436**

5.2 PERFORMANCE CATEGORY

The performance category for the Project is Category 3 (Table 4).

Table 4 Environmental Performance Discount Criteria Assessment

Discount category	Criteria	Discount Rate
4	The criteria for Category 3 are not all met	Nil
3	The holder(s) is able to demonstrate: two years of good environmental performance at the site at the beginning of the plan of operations (e.g. during the preceding two years, audits have shown compliance with EA conditions; no transitional environmental programs were in place; and no prosecutions for environmental offences occurred).	10 percent
2	All requirements in Category 3 are met and progressive rehabilitation has been undertaken on the site to the extent that is feasible	20 percent
1	All requirements in Categories 3 and 2 are met and progressive rehabilitation successfully achieves best practice expectations (e.g. granted certification), progressive rehabilitation continues to be undertaken to the maximum extent that is feasible	30 percent

6 REFERENCES

Australian and New Zealand Environment and Conservation Council (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*

Wilson Minerals Pty Ltd (2017) *Croydon Gold Mine Project Environmental Management Plan*.

Environmental Protection Agency (1998) Draft Guidelines for the Assessment and Management of Contaminated Land.

Environmental Protection Agency (1999) *Water Quality Sampling Manual*. For use in Testing for Compliance with the *Environmental Protection Act 1994* . Third Edition.

Department of Environment and Resource Management, *Preparing a Plan of Operations and Audit Statement for Level 1 Mining Projects*.

DEHP *Guideline – Financial Assurance under the Environmental Protection Act 1994,* http://www.ehp.qld.gov.au/management/non-mining/documents/fa-guideline.pdf, accessed 17th Nov 2014.

HLA-Envirosciences (2001) *Draft Final Rehabilitation Report – Croydon Gold Mine*. Report prepared for Goldfields Limited.

Appendix A

POST MINE LANDUSE PLAN

CROYDON GOLD MINE

POST MINE LANDUSE PLAN

DECEMBER 2011

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1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring, investigations and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Barrick holds Environmental Authority No. MIN100401906 (EA) for the Project.

This Post Mine Landuse Plan (PMLP) has been prepared in accordance with EA Condition C2 1:

(C2-1) A Post Mine Land Use Plan for the licensed place must be developed and implemented for a nominal period of:

(a) at least thirty (30) years following the cessation of mining activities on the licensed place; or

(b) a shorter period if the licensed place is proven to be geo-technically and geo-chemically stable and it can be demonstrated to the satisfaction of the administering authority that no release of contaminants from the site will result in environmental harm and be prepared at least 18 months prior to cessation of mining activities on the licensed place.

In addition, EA Condition C2 2 outlines the components of the PMLP (Table 1). A summary of where the components of the PMLP are addressed in this report is also provided in Table 1.

In accordance with EA Condition C2 2, this PMLP will be included in the Project Plan of Operations and will be updated with each subsequent Plan of Operations.

The remainder of this PMLP is structured as follows:

Section 2: Describes the rehabilitation concepts for the Project.

Section 3: Provides a description of the Geotechnical Assessment.

Section 4: Provides a description of the Geochemical Assessment.

Section 5: Describes the Hydrology and Hydrogeology of the Project.

Section 6: Describes the Rehabilitation Monitoring Program.

Section 7: Details the Grazing Management Plan.

Section 8: Identifies the Completion Criteria for the Project.

Section 9: Outlines the Research Programs for the Project.

Section 10: Describes the review process for this PMLP.

Section 11: Lists the references cited in this PMLP.

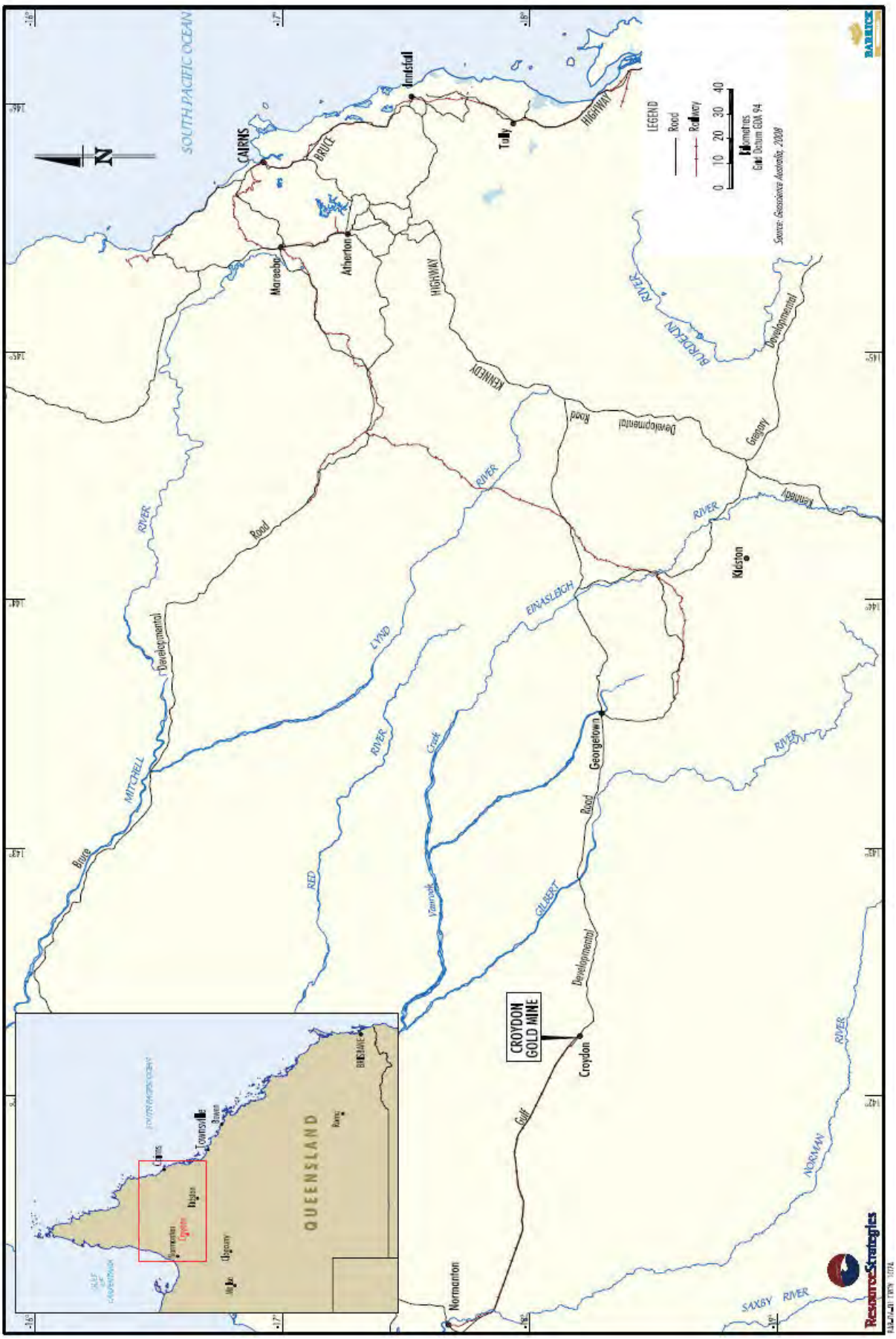

Figure 1: Regional Location

Table 1: Components of the Post Mine Landuse Plan

Component of PMLP		Section of this Report
C2-2	*The Post Mine Land Use Plan must be included in the Plan of Operations and updated with each subsequent Plan of Operations, describing how the rehabilitation objectives in Schedule C – Table 1 will be achieved. The Post Mine Land Use Plan must include:*	
(a)	*schematic representation of final land form inclusive of drainage features;*	Section 2.2
(b)	*slope designs;*	Section 2.3
(c)	*cover design;* *including a report on the effectiveness of existing cover systems;*	Section 2.3 Section 2.3.1
(d)	*drainage design;*	Section 2.4
(e)	*erosion controls on reformed land;*	Section 2.5
(f)	*description of experimental design for monitoring of analogue and rehabilitated areas inclusive of statistical design;*	Section 6
(g)	*proposed revegetation criteria including:* *(i) species diversity, abundance and composition;* *(ii) projective cover;* *(iii) dry matter production; and* *(iv) stocking rates to ensure self sustaining vegetation is maintained;*	Section 8.2
(h)	*proposed revegetation methods inclusive of plant species selection, re-profiling, respreading soil, soil ameliorants/amendments, surface preparation and method of propagation;*	Section 2.1
(i)	*materials balance including available top soil; and* *low permeability encapsulation media for capping;*	Section 2.6 Section 2.3
(j)	*research program and associated milestones;*	Section 9
(k)	*geotechnical;* *geochemical; and* *hydrological studies;*	Section 3 Section 4 Section 5
(l)	*chemical, physical and biological properties of soil; and* *chemical, physical and biological properties of water;*	Sections 2.3.2 and 4 Section 5
(m)	*measurable completion criteria for each rehabilitation indicator that enables determination of rehabilitation success for each disturbance type;*	Section 8
(n)	*rehabilitation monitoring program, including the monitoring of:* *(i) surface water quality;* *(ii) groundwater quality;* *(iii) erosion rates;* *(iv) integrity and effectiveness of final cover of final cover systems; and* *(v) health and resilience of vegetative cover;*	Section 6 and Attachment A
(o)	*grazing management plan;*	Section 7 and Attachment B
(p)	*operation and maintenance of:* *(i) the surface water management system;* *(ii) groundwater monitoring network;* *(iii) final cover systems; and* *(iv) vegetative cover.*	 Section 2.4 Section 5.2.1 Section 2.3.1 Section 2.3.1

2 REHABILITATION CONCEPTS

The rehabilitation concepts for the Project provide for the re establishment of a stable and sustainable ecosystem which is consistent with the proposed post mine landuse of low intensity grazing/disturbed native habitat, with exception of the open pits (Section 2.2). This section provides a description of the revegetation, final landforms, slope and cover design, effectiveness of the cover system, soil properties, drainage design, erosion and sediment control and the materials balance at the Project. Any additional rehabilitation works required at the Project will be conducted utilising similar rehabilitation concepts described in this section.

2.1 REVEGETATION

The revegetation methods undertaken in the 1996 Rehabilitation Program are outlined below. The rehabilitation works conducted in 1996 are fully reported in Fawcett (2001) and HLA Enviroscience (2001a). In the event additional rehabilitation works are required at the Project, similar revegetation methods to those described below will be implemented.

Selection of Plant Species

Sixteen tree and shrub species were included in the seed mix used during the 1996 revegetation program. Additional tree and shrub species have been recorded at the revegetation monitoring transects most likely self seeding from the adjacent vegetation. HLA Enviroscience (2001a) reported 19 species at the vegetation monitoring sites, including seven species of *Acacias*, seven species of *Eucalypts* and five species belonging to other genera including *Melaleuca*, *Atalaya*, *Erythrophleum* and *Hakea*.

Any additional rehabilitation works required at the Project will utilise a similar selection of plant species in the seed mix as mentioned above.

Re-profiling, Soil Respreading and Surface Preparation

Minor re profiling on both waste rock dumps was conducted to remove surface irregularities. Soil was respread with appropriate earth moving equipment (e.g. grader). Immediately prior to seeding all areas were ripped along contour to a depth of 250 millimetres (mm) to 300 mm. All ripped areas were aerial topdressed with an NPK fertiliser at a rate of 500 kilograms per hectare (Fawcett, 2001).

Any additional rehabilitation works required at the Project will conduct appropriate re profiling and utilise similar soil respreading and surface preparation methods as mentioned above.

Method of Propagation and Soil Ameliorant

An aerial application of DAP fertiliser to the rehabilitation sites in 2004 has markedly improved the phosphorus status of the soil but has had no lasting impact on the nitrogen status. It is considered that the most practical method of improving soil nitrogen status in the long term is to sow groundcover legumes, such as Seca stylo (*Stylosanthes scabra*) and Verano stylo (*S. hamata*) which are well adapted to the Gulf country area (Landline Consulting, 2007).

Any additional rehabilitation works required at the Project will utilise similar propagation and soil ameliorant methods as mentioned above.

Weed Management

A weed control program was initiated in 1996 to control isolated Calotrope (*Calotropis procera*) plants observed around the southern end of the Golden Butterfly waste rock dump (Fawcett, 2001). This weed species is ubiquitous in the Croydon area. Where necessary, a similar weed management program to that initiated in 1996 will be conducted at the Project.

2.2 FINAL LANDFORMS

The mining related landforms on ML 5248 comprise of waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps.

Specifically they include (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Golden Butterfly waste rock dump;
- Content Pit;
- Content waste rock dump;
- Lady Isabella Pit;
- abandonment bunds across the access ramps of the four open pits;
- hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps;
- water diversion bunds and sediment dams adjacent to the Content and Golden Butterfly waste rock dumps; and
- roads and tracks.

The final landform concept is to achieve a stable post mining landform that is able to meet the identified post mining landuse and rehabilitation objectives. The post mining land descriptions and rehabilitation objectives are specified in Schedule C – Table 1 of the EA, which is reproduced in Table 2.

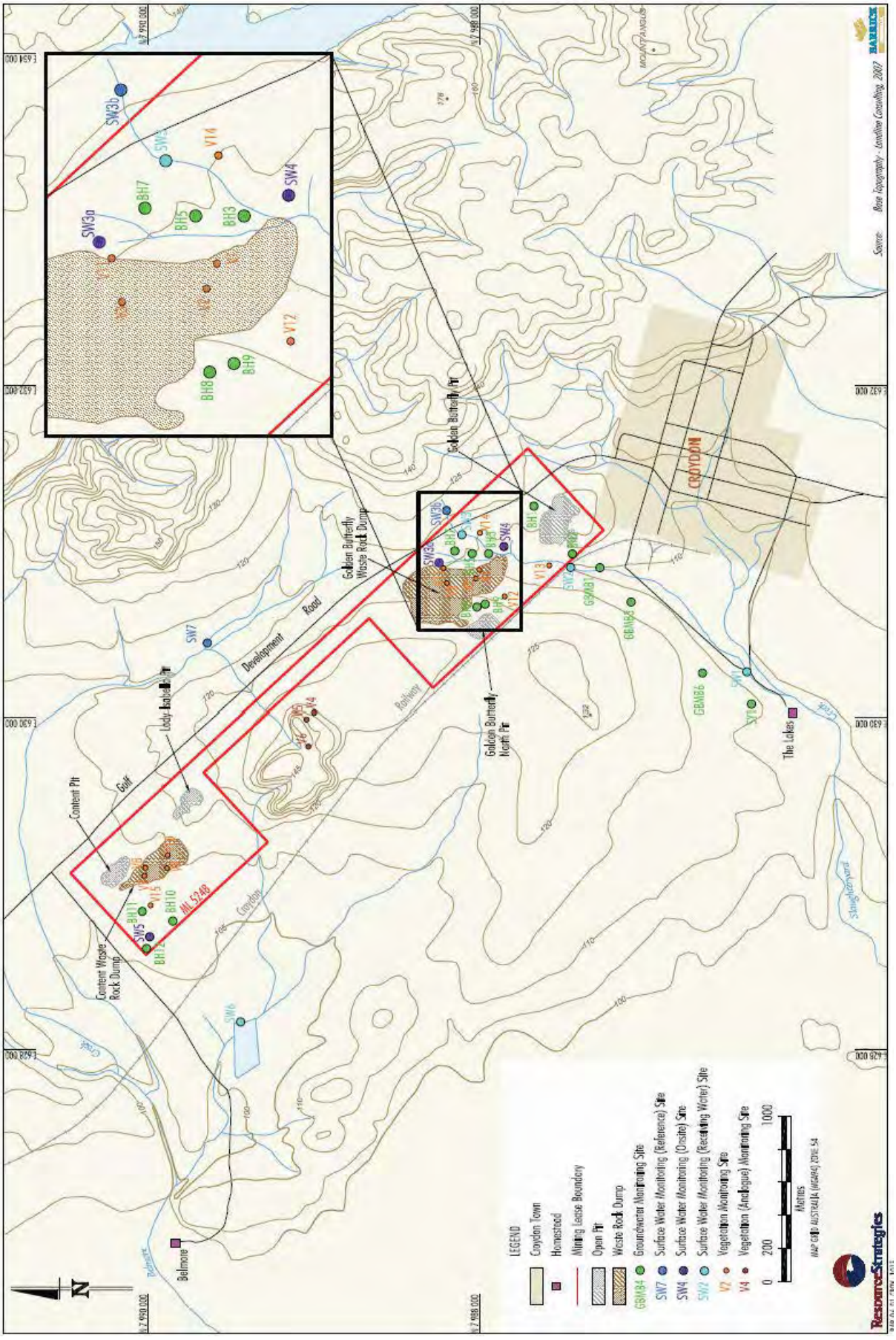

Figure 2: Site Location and Location of Environmental Monitoring Stations

Table 2:Post-Mining Land Description and Rehabilitation Objectives

Landform (refer Schedule H – Map 1)	Surface area (hectares)	Rehabilitation Objectives		
		Post-mine land description	Land classification[1]	Analogue site identification
Golden Butterfly North Pit	1.6	Non beneficial land use	Class VIII	Sites to be rehabilitated to a standard nominated in the rehabilitation program developed in accordance with Condition C2 1 based on analogue sites.
Golden Butterfly Pit	5.1	Non beneficial land use	Class VIII	
Lady Isabella Pit	1.7	Non beneficial land use	Class VIII	
Content Pit	2.1	Non beneficial land use	Class VIII	
Content Dump	6.3	L.I.G.[2]/disturbed native habitat	Class VI or better	
Golden Butterfly Dump	15.2	L.I.G.[2]/disturbed native habitat	Class VI or better	
Content Hardstand	2.0	L.I.G.[2]/disturbed native habitat	Class VI or better	
Golden Butterfly Hardstand	0.5	L.I.G.[2]/disturbed native habitat	Class VI or better	
Sediment Dams	1.5	L.I.G.[2]/disturbed native habitat	Class VI or better	
Roads / Tracks	3.5	L.I.G.[2]/disturbed native habitat	Class VI or better	

[1] QLD department of Minerals and Energy (2008).

[2] L.I.G. (Low Intensity Grazing) defined by criteria listed in Land Use Acceptance Criteria.

The final landforms were constructed when the Project was decommissioned/ closed in 1993 and additional rehabilitation works were substantially completed in 1996/1997. The final landforms on ML 5248 are dominated by low hills (i.e. waste rock dumps) which are compatible with the surrounding topography in terms of elevation and slope and final voids.

Schematic diagrams of the final landforms, inclusive of drainage features, are provided in Figure 3.

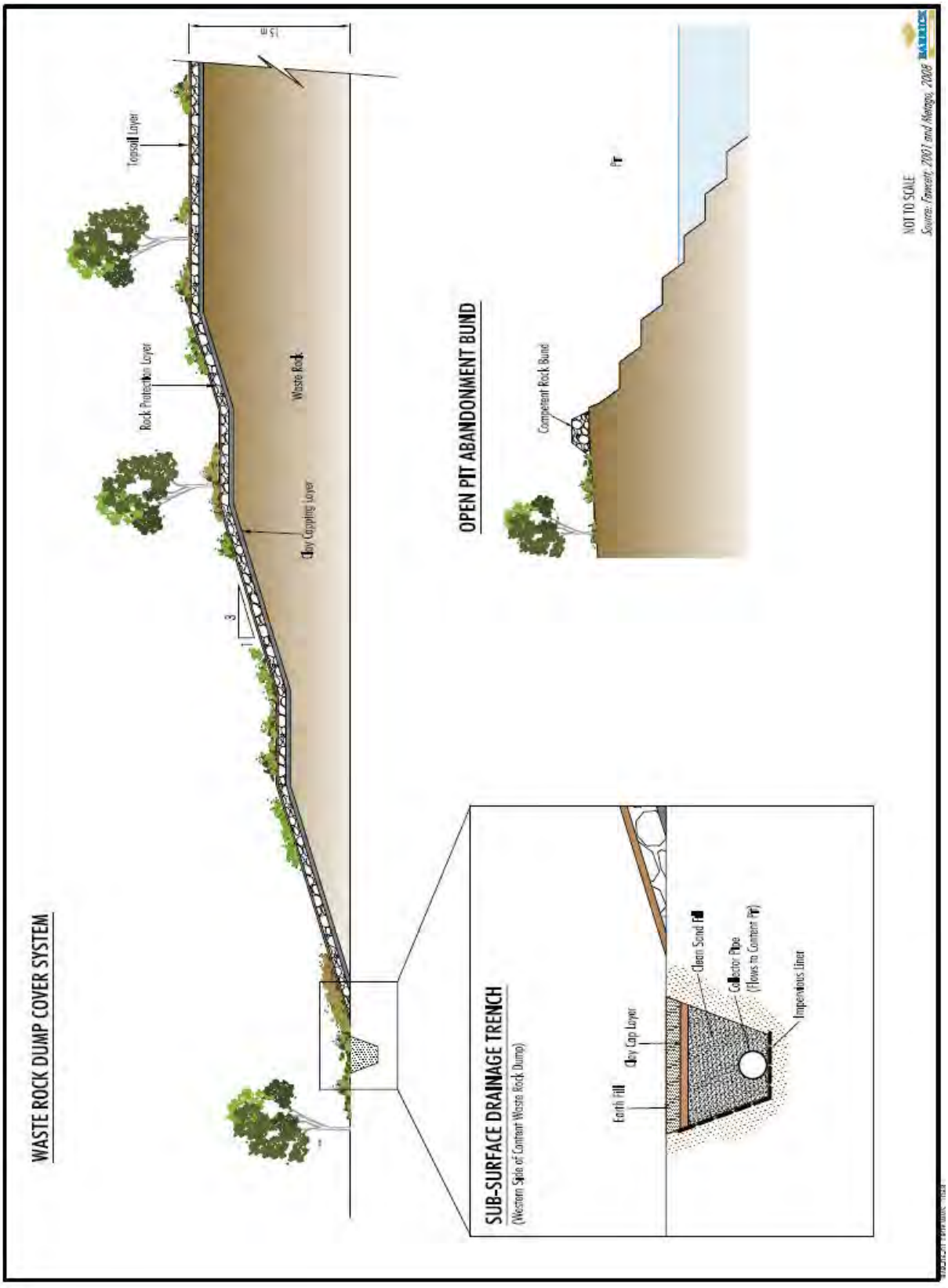

Figure 3: Waste Rock Dump Cover System and Open Pit Abandonment Bund Cross Section Schematics

2.3 SLOPE AND COVER DESIGN

Since the Project was decommissioned/closed, reclamation works were conducted on the final landforms identified in Section 2.2. Full details of the reclamation works are reported in Fawcett (2001) and HLA Enviroscience s (2001a) .

The slope and cover design of the waste rock dumps have been developed to provide low permeability encapsulation. The reclamation work in 1996/1997 on both the Golden Butterfly and Content waste rock dumps involved (Figure 3):

- battering of slopes to 3H:1V minimum, with benches of 5 metres (m) width provided at a maximum of 5 m[1] vertical spacing; and
- construction of an engineered cover system consisting of a clay capping layer, a rock fill surface protection layer and a layer of topsoil.

Following preparation of the engineered cover system, all areas were sown with a seed mix of native tree and shrub species broadly representative of species found in the surrounding undisturbed woodlands .

2.3.1 Effectiveness of Cover System

The performance of the final cover system at the Project is monitored indirectly via erosion, vegetation and water monitoring. These monitoring parameters provide an indirect indication of the integrity of the final cover system. Details of the final cover system monitoring program are provided in the Rehabilitation Monitoring Program (Attachment A).

Golden Butterfly Waste Rock Dump Cover System

Monitoring indicates that the cover system on the Golden Butterfly waste rock dump is effective. The following monitoring sites provide an indication of the effectiveness of the cover system of the Golden Butterfly waste rock dump (Figure 2):

- on site surface water monitoring sites, SW3a and SW4;
- receiving water monitoring sites, SW1, SW2 and SW3, downstream of the Golden Butterfly waste rock dump; and
- vegetation monitoring sites, V1, V2, V3 and V11, on the surface of the Golden Butterfly waste rock dump.

On-site Surface Water Monitoring

On site surface water monitoring site SW3a (i.e. Golden Butterfly waste rock dump toe drain) (Figure 2) is consistently of good quality and records no exceedances of the contaminant limits specified in Schedule F – Table 8 of the EA..

On site monitoring site SW4 (i.e. stock water dam) (Figure 2) recorded one aluminium EA contaminant limit (5 mg/L) exceedance of 11mg/L in February 2005 and one pH range contaminant limit (greater than 4 pH units and less than 9 pH units) exceedance of 9.3 pH units in January 2007 during the period 2001 to 2011. No contaminant limit exceedances have been recorded since the pH range exceedance in 2007 at site SW4.

[1] HLA Enviroscience s (2001a) stated the vertical spacing of the Golden Butterfly and Content waste rock dumps as 50 m. However, it is considered the correct vertical spacing elevation of the waste rock dumps is 5 m.

Receiving Waters Monitoring

Each receiving water monitoring site surrounding the Golden Butterfly waste rock dump (i.e. SW1, SW2 and SW3) (Figure 2) displayed low pH levels and elevated levels of electrical conductivity (EC), sulphate, arsenic, cadmium, iron, manganese, lead and zinc during the period 1994 and 1995 (Landline Consulting, 2007). Following the reclamation works and clay capping of the Golden Butterfly waste rock dump in 1996, water quality at each receiving water monitoring site has improved. Since 1996, only short term exceedances of the contaminant limits specified in Schedule F – Table 3 of the EA have been recorded at these receiving water monitoring sites. Schedule F – Table 3 is reproduced in Section 8.

During the period 2001 and 2011, receiving water monitoring site SW1 has recorded two pH range contaminant limit exceedances, recording 9.1 pH units in February 2006 and 9.2 pH units in April 2006. No contaminant limit exceedances have been recorded since these pH range exceedances in 2006 at monitoring site SW1.

At receiving water monitoring site SW2, pH and aluminium exceeded the contaminant limits specified in Schedule F – Table 3 of the EA during the period 2001 to 2011. The pH contaminant limit range was exceeded on one occasion reaching 9.1 pH units in April 2006. The aluminium contaminant limit (5 mg/L) was exceeded on one occasion to 18 mg/L in January 2007. No contaminant limit exceedances have been recorded since 2007 at site SW2.

No contaminant limit exceedances have been recorded at receiving water monitoring site SW3 during the period 2001 to 2011.

Vegetation Monitoring

The groundcover monitoring results at the vegetation monitoring sites V1, V2, V3 and V11, on the surface of the Golden Butterfly waste rock dump were recorded in 2010 and are provided in Table 3. Data show that the Golden Butterfly waste rock dump fell below the recommended success criteria of 75% of the appropriate analogue areas for ground cover. However a significant portion of this failure is a result of inadvertent sampling during the low point in the vegetative production cycle which compromised the ability to identify all grass species. Further complicating identification of grasses as well as the overall evaluation was over utilization of forage by horses illegally pastured on the Golden Butterfly Waste Dump. However, rock and litter are major components of the cover system on the Golden Butterfly and Content waste rock dumps. Rock cover is considered an effective cover system component for preventing soil erosion.

An additional component to ground cover monitoring, and a criterion for successful rehabilitation, is species diversity, which can be a measure of biodiversity. There are two optional success criteria for species diversity. The landform must either exhibit: 1) greater than three non exotic species with greater than 2% relative cover, or 2) 50% of the number of non exotic species with greater than 2% relative cover from the appropriate analogue area. The Golden Butterfly waste rock dump exceeded both of these optional success criteria based on the analogue areas.

The Golden Butterfly waste rock dump display good potential for adequate and diverse plant communities. However, illegal grazing is significantly impacting the landform in terms of vegetative cover and limiting the ability of the monitoring program to produce data to demonstrate achievement of success criteria. Despite this situation, the fact that the waste rock dump is a target for illegal grazing demonstrates vegetation performance and that the Golden Butterfly waste rock dump is effective.

Table 3: Groundcover Monitoring Results for Croydon Waste Rock Dump Vegetation Monitoring Sites

	Scientific Name	Area --> Common Name	Content Dump	Golden Butterfly	Boiler Analogue	V Analogues
Grasses						
P	*Aristida sp.*	Wire Grass	0.42	0.04	2.03	4.19
A	*Brachiaria sp.*	Armgrass	-	-	-	0.07
P	*Cymbopogon bombycinus*	Silky Oilgrass	-	-	-	0.28
P	*Cyperus sp.*	Sedge	0.57	-	-	-
A	*Eriachne armitii*	Longawn Wanderrie Grass	2.24	-	-	-
I	*Pennisetum ciliare*	Buffelgrass	-	0.58	-	-
P	*Sedge sp.*	Sedge	-	-	-	0.07
A	*Setaria surgens*	Pigeon Grass	-	-	-	0.07
	Unidentifiable	**Grazed beyond recognition**	11.70	4.90	11.68	-
Herbaceous						
P	*Anisomeles malabarica*	Chodhava	-	-	-	0.03
P	*Cheilanthes brownii*	Lip Fern	-	-	-	0.03
E	*Hyptis suaveolens*	Horehound	0.76	0.31	1.55	0.69
E	*Sida cordifolia*	Flannel Weed	0.04	-	-	-
A	*Striga curviflora*	Witchweed	-	-	-	0.17
I	*Stylosanthes scabra*	Shrubby Stylo	0.15	6.29	-	-
A	*Triumfetta pannosa*	Chinese Burr	-	-	-	0.45
Shrubs and Trees						
P	*Acacia eleocantha*	White Thorn	0.08	-	-	0.14
P	*Acacia holosericea*	Silver-leaved Wattle	0.38	0.49	-	-
P	*Acacia julifera*	Wattle	-	-	0.12	-
P	*Acacia leptostachya*	Slender Wattle	-	-	-	0.03
P	*Corymbia confertiflora*	Broad leaved Carbeen	0.04	-	0.12	-
P	*Corymbia gummifera*	Red Bloodwood	0.08	-	-	-
P	*Corymbia pocillum*	Bloodwood	-	0.13	-	-
P	*Corymbia polycarpa*	Long-fruited Bloodwood	-	0.09	-	-
P	*Corymbia setosa*	Rough-leaved Bloodwood	0.08	0.22	-	-
P	*Erythrophleum chlorostachys*	Red Ironwood	-	-	-	0.07
P	*Eucalyptus chartaboma*	Queensland Flaky-bark	-	-	-	0.10
P	*Eucalyptus polycarpa*	Long-fruited Bloodwood	0.04	-	-	-
Overstory Hits						
P	*Acacia eleocantha*	White Thorn	11.30	-	-	3.44
P	*Acacia holosericea*	Silver-leaved Wattle	1.85	1.10	-	-
P	*Acacia julifera*	Wattle	-	-	32.40	-
P	*Acacia leptostachya*	Slender Wattle	-	-	-	4.78
P	*Acacia shirleyi*	Lancewood	4.30	2.45	-	-
P	*Adenanthera abrosperma*	Red Sandalwood	-	-	-	2.22
P	*Alphitonia excelsa*	Red Ash	-	-	-	3.89
P	*Corymbia aparrerinja*	Ghost Gum	-	0.35	-	-
P	*Corymbia confertiflora*	Broad leaved Carbeen	0.10	-	7.10	-
P	*Corymbia gummifera*	Red Bloodwood	0.05	-	-	-
P	*Corymbia papuana*	Ghost Gum	0.60	0.20	-	-
P	*Corymbia pocillum*	Desert Gum	-	1.80	-	-
P	*Corymbia polycarpa*	Long-fruited Bloodwood	0.75	4.20	-	-
P	*Corymbia setosa*	Rough-leaved Bloodwood	1.05	-	0.60	-
P	*Erythrophleum chlorostachys*	Red Ironwood	-	-	-	1.89
P	*Erythroxylum ellipticum*	Kerosene Tree	-	-	0.20	0.22
P	*Eucalyptus chartaboma*	Queensland Flaky-bark	-	-	-	20.06
P	*Eucalyptus polycarpa*	Long-fruited Bloodwood	4.05	-	-	-
P	*Gardenia vilhelmii*	Gardenia	-	-	-	0.50
P	*Petalostigma banksii*	Quinine Bush	-	-	0.10	-
P	*Terminalia aridicola*	Brown Damson	-	-	-	0.61
		Understory Plant Cover	**16.56**	**13.08**	**15.50**	**6.41**
		Rock (> 5 mm)	19.33	23.78	12.04	17.05
		Litter	32.92	41.94	29.74	37.26
		Bare Ground	7.14	11.10	2.32	1.66
		Overstory Plant Cover	**24.05**	**10.10**	**40.40**	**37.61**
		Total Plant Cover	**40.61**	**23.18**	**55.90**	**44.02**
		Annual and Perennial Cover (excluding exotics and unidentifiables)	**28.11**	**17.97**	**42.66**	**43.33**

Source: Barrick 2011.

To maintain the revegetation performance at this eastern section of ML 5248 (i.e. Golden Butterfly mining area) it is proposed that controlled low intensity grazing by domesticated stock on the area surrounding the Golden Butterfly waste rock dump occur only during the dry season. No grazing is to occur on the waste rock dump. Further details of the grazing management measures for the Project are provided in the Grazing Management Plan (Attachment B).

It is considered from the on site surface waters, receiving waters and vegetation monitoring results provided above that the cover system of the Golden Butterfly waste rock dump is effective and no works are proposed.

Content Waste Rock Dump Cover System

Monitoring indicates that the cover system on the Content waste rock dump is effective, with the exception of the western side on the waste rock dump. During the reclamation works conducted in 1996, the rehabilitation performance on the western batter was considered adequate and the western batter was not capped with the engineered cover system identified in Section 2.3. Seepage has affected the hardstand area to the west of the Content waste rock dump and may be a source of elevated parameters at site SW 5 (i.e. Sediment Dam) at the north western corner of ML 5248.

The following monitoring sites provide an indication of the effectiveness of the cover system of the Content waste rock dump (Figure 2):

- on site surface water monitoring sites, SW5;
- receiving water monitoring sites, SW6; and
- vegetation monitoring sites, V7, V8, V9 and V10, on the surface of the Content waste rock dump.

On-site Surface Water Monitoring

During the period 2001 to 2011, water quality at monitoring site SW5 demonstrated consistently low pH levels and elevated levels of aluminium and arsenic exceeding the contaminant limits specified in Schedule F – Table 8 of the EA. Schedule F – Table 8 of the EA is reproduced in Section 8. In addition a single exceedance of the cadmium contaminant limit was recorded in April 2011, while the nickel contaminant limit (1 mg/L) was exceeded on four occasions since 2001, with the last exceedance occurring March 2010.

The proposed reclamation works to be conducted during the term of this Plan of Operations (Section 3.1 of the Plan of Operations [Barrick, 2011]) includes excavation of the Sediment Dam (i.e. SW5), sampling and characterisation of the excavated and residual material in the Sediment Dam and the installation of a subsurface drainage trench at the western foot of the Content waste rock dump. However, these proposed works are dependent upon the outcomes of the refinement of the Content Pit hydrological model. At the completion of the proposed reclamation works, monitoring at the Sediment Dam will continue to assess the effectiveness of the works.

Receiving Waters Monitoring

Monitoring commenced at receiving water monitoring site SW6 in 1999 in response to the deterioration of water quality at the on site monitoring site SW5. During the period 2001 to 2011, aluminium exceeded the contaminant limit (5 mg/L) on seven occasions. No other contaminants exceeded the contaminant limits specified in Schedule F – Table 3 during the period 2001 to 2011 at monitoring site SW6. Schedule F – Table 3 of the EA is reproduced in Section 8.

Vegetation Monitoring

The groundcover monitoring results at the vegetation monitoring sites V7, V8, V9 and V10, on the surface of the Content waste rock dump were recorded in 2010 and are provided in Table 3. Data show that the Content waste rock dump fell below the recommended success criteria of 75% of the appropriate analogue areas for ground cover. However a significant portion of this failure is a result of inadvertent sampling during the low point in the vegetative production cycle which compromised the ability to identify all grass species. However, rock and litter are major components of the cover system on the Golden Butterfly and Content waste rock dumps. Rock cover is considered an effective cover system component for preventing soil erosion.

An additional component to ground cover monitoring, and a criterion for successful rehabilitation, is species diversity, which can be a measure of biodiversity. There are two optional success criteria for species diversity. The landform must either exhibit: 1) greater than three non exotic species with greater than 2% relative cover, or 2) 50% of the number of non exotic species with greater than 2% relative cover from the appropriate analogue area. The Content waste rock dump exceeded both of these optional success criteria based on the analogue areas. Further, it was determined that soil stability results were closely tied to the vegetation cover results. All evaluated slopes of the Content Waste Dump passed the soil stability standard. It is considered from these results that the vegetation performance on the Content waste rock dump is effective.

It is proposed that domesticated stock be permanently excluded from the western section of ML 5248 (i.e. Content and Lady Isabella mining areas) to minimise the impact of grazing on the revegetation performance in this area. Further details of the grazing management measures for the Project are provided in the Grazing Management Plan (Attachment B).

It is considered from the on site surface waters, receiving waters and vegetation monitoring results provided above that the cover system of the Content waste rock dump is effective, except for the western batter. The proposed reclamation works for the Content waste rock dump are scheduled during the yearly dry season period when site access and working conditions are suitable. However, the exact timing of the proposed works is dependent upon the outcomes of the refinement of the Content Pit hydrological model. At completion of the proposed reclamation works (Section 3.1 of the Plan of Operations [Barrick, 2208a]), monitoring at the on site water, receiving water and vegetation monitoring sites identified above, will continue to assess the effectiveness of the proposed works.

As required by Condition C2 2 (c) of the EA a report on the effectiveness of the above works on the Content waste rock dump cover system will be finalised when the proposed reclamation works are completed and will include monitoring results from site SW5, SW6, and V7 to V10.

Operation and Maintenance of the Vegetation Cover and Final Cover Systems

If vegetation, erosion and water monitoring indicates poor final cover system performance, reclamation works will be conducted to maintain the integrity and effectiveness of the final cover systems and vegetation performance at the Project. As stated above a report on the effectiveness of the final cover systems will be finalised upon completion of the proposed reclamation works described in Section 3.1 of the Plan of Operations (Barrick, 2011).

2.4 DRAINAGE DESIGN

A Water Management Strategy (WMS) has been prepared in accordance with Condition F7.1 of the EA. The WMS includes details of the drainage management strategies for the Project and is included as Appendix D of the Plan of Operations (Barrick, 2011). A summary of the WMS is provided below.

Water Management Strategy Summary

The WMS provides a drainage review of the Project, including the general relief, surface hydrology and hydrogeology.

Drainage management strategies have been prepared for the final landforms on ML 5248 where required. The proposed strategies will include:

- excavating a subsurface trench at the western foot of the Content waste rock dump and installing a collector pipe to drain any contaminated seepage to the Content Pit (Figure 3);
- capping the trench with a clay layer to exclude any surface runoff;
- excavating the salted area to the west of the Content waste rock dump, sampling and characterising the excavated and residual material, placing the excavated material in the Content Pit, back filling the excavated area and re contouring to shed all surface runoff to the west of ML 5248; and

A monitoring program of the surface water and groundwater monitoring sites will be conducted in accordance with the Rehabilitation Monitoring Program (Attachment A). The results of the monitoring program will be included in the annual review of the WMS which will assist in assessing the effectiveness of the proposed drainage management strategies.

Operation and Maintenance of Surface Water Management System

Should surface water monitoring indicate poor performance of the surface water management system, further reclamation works will be conducted. A description of the proposed drainage management plan for the Project is provided in the WMS (Appendix D of the Plan of Operations [Barrick, 2011]).

2.5 EROSION AND SEDIMENT CONTROL

An Erosion and Sediment Control Plan (ESCP) has been prepared in accordance with Condition F5 1 of the EA. The ESCP details the erosion protection and sediment control measures implemented at the Project and is included as Appendix E of the Plan of Operations (Barrick, 2008a). A summary of the ESCP is provided below.

Erosion and Sediment Control Plan Summary

The ESCP provides a review of the status and sources of erosion and sediment on the Project. The principles that underpin the control measures are provided to justify the proposed erosion protection and sediment control works.

The proposed erosion protection and sediment control measures for the final landforms on ML 5248. will include:

- excavating the Sediment Dam (i.e. SW5) in the north west corner of ML 5248, sampling and characterising the excavated and residual material, placing the excavated material in the Content Pit and constructing a shallow sediment dam to capture any sediment transport off ML 5248; and
- maintenance works on existing drainage structures in the event of major damage due to extreme storm events (e.g. cyclones).

A monitoring program of the vegetation monitoring sites will be conducted in accordance with the Rehabilitation Monitoring Program (Attachment A). The results of the monitoring program will assist in assessing the effectiveness of the proposed erosion and sediment control measures and if necessary, the ESCP will be updated where required.

2.6 MATERIALS BALANCE

A materials investigation was conducted by Woodward Clyde (1996) at the Golden Butterfly and Content waste rock dumps and near surrounds during the reclamation works of 1996/1997. The materials characteristics from this investigation are identified in Section 4.

In addition to this investigation and in accordance with EA Condition C2 2 (i) a materials balance, including low permeability encapsulation media, has been prepared for the proposed reclamation works scheduled for the Content waste rock dump as described in Section 3.1 of the Plan of Operations (Barrick, 2011). The materials balance, including low permeability encapsulation media, for the proposed works is provided in Table 5.

Table 4: Materials Balance

Material Requirements/Sources	Volume (m^3)
Material Requirements	
Content hardstand area	
Rock mulch and soil	10,000
Sand	450
Clay	45
Material Sources	
Golden Butterfly waste rock dump - east haul ramp	
Rock mulch	6,000
External sources	
Rock mulch and soil	5,000
Sand	450
Clay	45

Note: m^3 = cubed metres

3 GEOTECHNICAL ASSESSMENT

There is no documentation available to indicate that any historical geotechnical investigations have been completed. A geotechnical investigation of the various landforms at the Croydon site was conducted by Allan Watson Associates in November 2009 based on the following scope of work:

- Data review of available information relating to the Project site and associated landforms.
- Site visit and geotechnical assessment, comprising a confirmation of general geological setting and a detailed visual inspection of each landform to identify key geotechnical issues /constraints.
- Geotechnical interpretation and analysis to further characterise the mining landforms and to isolate any geotechnical issues of significance.

The focus of this scope of work has been to inform a Project risk assessment conducted by Barrick, in compliance with the requirements of the EA No. MIN100401906.

3.1 MINING RELATED LANDFORMS

The mining related landforms on ML 5248 comprise waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads /tracks) surrounding the open pits and waste rock dumps. These landforms are located on Figure 2 and include the following:

- Golden Butterfly pit.
- Golden Butterfly North pit.
- Golden Butterfly waste rock dump.
- Content pit.
- Content waste rock dump.
- Lady Isabella pit.
- Hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps.
- Stormwater diversion bunds and sediment /stormwater dams adjacent to the Content and Golden Butterfly waste rock dumps.
- Roads and tracks.

No processing infrastructure (e.g. plant areas or tailings storage facility) was located within ML 5248. Furthermore, historic mine workings (e.g. shafts and mullock heaps are located near to the site but outside ML 5248.

3.2 SUMMARY OF GEOTECHNICAL ASSESSMENT

The geotechnical assessment identified areas of geotechnical significance. A summary of these areas is as follows:

- There is potential for a slip failure within the sandstone on the south western face of the Golden Butterfly North pit that would also include the overlying fill. Given the sub horizontal bedding of the sandstone, which precludes a block type failure, such a failure would likely occur by a circular failure mechanism within the mass of the pit wall. The circular failure mechanism could be initiated through saturation of tension cracking observed within the surface of the fill profile which would act as a surcharge to the pit wall. The adjacent Croydon Railway and surcharge from the abandonment bund could also be potential mechanisms for failure.
- The southern pit wall of the Golden Butterfly pit is surcharged by an area of fill material, with evidence of tension cracking within the surface of the fill profile. Whilst it is considered that the cracking occurred as a result of settlement immediately following placement, and not an indication of imminent failure, instability could occur with excessive water ingress within the fill material with the fractured surface being confined to the fill profile.

- Undercutting of the less competent alluvium below a ferricrete profile is possible on the north western face of the Content pit, being initiated by water level drawdown in the pit.
- Shear foliation noted in the granite in the south western face of the Lady Isabella pit may allow shallow translational or planar failures into the pit void. The scale of such a failure would be limited. No specific mechanism would exist to initiate such movement.
- With the exception of the potential slip failure of the south western face of the Golden Butterfly North pit, it is considered that a higher level of investigation is not warranted for the areas of geotechnical significance.

Given the potential consequence of a failure of the south western face of the Golden Butterfly North pit affecting the Croydon Railway, it is considered that additional investigations into this area of geotechnical significance are required. A slope stability has therefore been conducted and is and discussed in the following section.

3.3 GOLDEN BUTTERFLY NORTH PIT STABILITY ASSESSMENT

The stability analysis was completed using the Slope/W computer package, which uses limit equilibrium theory to solve for the factor of safety of earth and rock slopes. The model calculates a factor of safety for a modeled two dimensional section, satisfying both moment and force equilibrium. This software is widely used in the assessment of stability of landforms such as the Golden Butterfly North pit wall.

In the absence of a detailed intrusive investigation program (eg drilling and sampling of subsurface materials), no opportunity for geotechnical testing of pit wall material to identify strength parameters was available. Notwithstanding, an inspection of rock mass and structure was made at the south western pit face as part of the geotechnical assessment. Given the sub horizontal bedding of the Coffin Hill Member sandstone in the walls, with bedding struck into the face, any failure would occur through the rock mass rather than via structural lineation. Compressive strength of the sandstone rock, based on rock quality observed in the pit face has been estimated to be 10 to 50mPa. It has also been estimated that effective strength properties for intact rock, tested in direct shear, would be in the order of:

Friction Angle (ϕ') 40 to 60 degrees
Effective Cohesion (c') up to 100 kPa

For the purpose of this assessment, the following unit weighting for fill and insitu sandstone were adopted:

Sandstone 21.0kN/m3
Fill 17.0kN/m3

No strength parameters for the fill profile were considered as it is considered that any localized failure within this material would be of low consequence (i.e. would not affect the Croydon Railway). All theoretical failure circles were therefore forced into the sandstone unit.

The stability model assumed that the sandstone profile was dry (i.e. assuming groundwater coincided with pit water level), although assumed that the tension crack was saturated as void recharge to the pit face. The overall assessment methodology adopted for the stability assessment overestimates the potential for pit wall failure and is therefore considered to be conservative.

The typical range of the calculated strength parameters for the sandstone mass based on the analysis was as follows:

Friction Angle (ϕ') 45 degrees
Effective Cohesion (c') 60 kPa

This combination of strength parameters are within the estimated range of strength properties as outlined above and are at the lower bound for strength properties of intact rock. The sensitivity of the model to the applied line load representing the train (i.e. 10kN/m) was carried out. Line loads up to 30kN/m were applied with no change to the FoS for a failure encompassing the Croydon Railway. It is considered based on this analysis that the Golden Butterfly North pit wall (excluding minor failures which may occur within the granitic spoil) is stable and that failure of the pit face encompassing the railway line based on the assumed parameters has a FoS greater than 1.5.

4 GEOCHEMICAL ASSESSMENT

Woodward Clyde (1996) investigated the acid producing potential of various rock types within the waste rock dumps and surrounding areas (i.e. former hardstand and ore stockpile areas and drainage channels) including key mine related landforms and infrastructure areas (HLA Enviroscience s, 2001a). The Woodward Clyde (1996) investigation included the excavation of 49 test pits from the locations identified in Table 6. Materials recovered from each pit were geologically logged, and tested for pH and EC in the field. Representative samples of each identifiable waste rock unit were collected for laboratory analysis. Analysis for total sulphur and acid neutralising capacity was carried out on these samples for estimation of the maximum potential acidity and net acid producing potential. The characteristics of the materials are provided in Table 6.

Table 5: Materials Characteristics

Location	Materials Characteristics	Potential for Acid Production
Golden Butterfly Waste Rock Dump	• Surface soil layer of clay and red sand overlying grey granite waste. • White granite materials were encountered beneath the surface soils in some areas.	• Indeterminate • Indeterminate
Content Waste Rock Dump	• Brown sandy topsoil layer overlying grey granite waste. • Thin layers of red gravelly clay were encountered in some areas. • Grey granite was found on the dump surface in a number of locations.	• Potentially Acid Producing Grey Granite • Indeterminate • Potentially Acid Producing Grey Granite
Haul Road	• Mixture of granite, sand and red gravelly clay. • The mixed waste material was considered to be potentially acid producing, however due to the high level of compaction of the haul road, the materials were effectively encapsulated.	• Potentially Acid Producing Grey Granite • Potentially Acid Producing Grey Granite
Stockpile Area	• Surficial red sand/ sandstone overlying grey granite, similar to that found in Golden Butterfly waste rock dump.	• Potentially Acid Producing Grey Granite
Western Side of Content Pit	• Grey granite waste similar to Content waste rock dump.	• Potentially Acid Producing Grey Granite
Drainage Channel	• Red clay to brown sandy clay.	• Indeterminate
North of Golden Butterfly Pit	• Non acid producing natural soils.	• Non Acid Producing

Source: Woodward Clyde (1996)

The investigation resulted in the re profiling and capping of the Golden Butterfly and Content waste rock dumps and the removal of all potentially acid generating material from the Golden Butterfly and Content stockpile hardstand areas and the Slaughteryard Creek drainage channel. These works were conducted in 1996. No further geochemical work is considered necessary for the Project.

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5 HYDROLOGICAL AND HYDROGEOLOGICAL ASSESSMENTS

5.1 HYDROLOGICAL ASSESSMENT

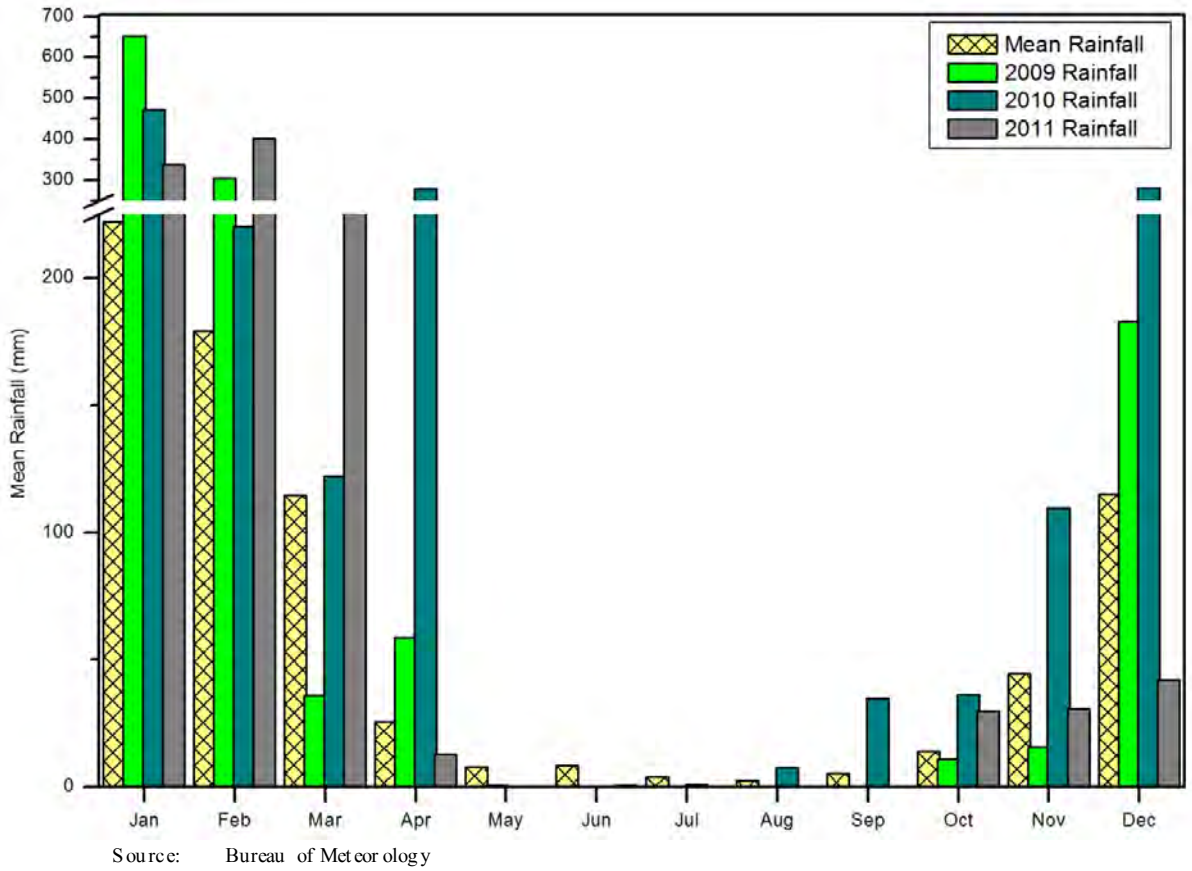
This section provides a description of the existing hydrological environment at the Project. The water management requirements and proposed drainage remediation works for the Project have been prepared and are included in the WMS (Appendix D of the Plan of Operations [Barrick, 2011]). The water quality from the surface water monitoring sites is analysed to provide an indication of the rehabilitation performance at the Project.

5.1.1 Existing Hydrological Environment

Rainfall

The Project experiences highly seasonal rainfall with an average annual rainfall of 747.9 mm (Table 7). This rainfall pattern is illustrated in Figure 4.

Figure 4: Average Monthly Rainfall Totals for Croydon Township



Source: Bureau of Meteorology

Flow Regime

The highly seasonal nature of rainfall means that all local creeks are ephemeral. The south eastern section ML 5248 (i.e. the Golden Butterfly mining area) is within the upper catchment of Slaughteryard Creek and the north western section of ML 5248 (i.e. the Content and Lady Isabella mining areas) lie within the Belmore Creek catchment.

There is no hydrological flow gauging records for ML 5248, however it is considered that surface water runoff in local creeks and drainage lines ceases relatively soon after storm events. Gradients are very low on much of ML 5248 which means that sheet flow is the dominant hydrological process during the short wet season.

Table 6: Croydon Township Weather Station Rainfall Data

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	
Mean rainfall (mm)	223	181	115.7	25.5	7.8	8.5	3.9	2.7	5.5	14	44.6	116.3	747.9	1889 2011
Highest rainfall (mm)	860.5	601.4	591.4	279.8	129.3	139.2	83.4	44.2	92.7	145	384.7	312	1565.8	
Date	1974	1964	1936	2010	1920	1990	2006	1924	1943	1975	1973	1942	2010	
Lowest rainfall (mm)	49.4	5.3	0	0	0	0	0	0	0	0	0	0.5	225.4	
Date	2003	1926	1988	2008	2011	2010	2011	2011	2011	2008	2003	1934	1952	
Decile 1 rainfall (mm)	73.2	43.5	16.5	0	0	0	0	0	0	0	5.8	36.2	438.6	
Decile 5 (median) rainfall (mm)	200.8	170.6	93.7	9.9	0.4	0.4	0	0	0	4.6	27.6	103.6	715.7	
Decile 9 rainfall (mm)	397	304.2	239.3	63.6	22.9	21.1	11.1	8.9	20	37	95.5	232.5	1038	
Highest daily rainfall (mm)	381	367.8	245.9	155.2	63.5	91	35	39.6	77.5	63.5	151.1	153	381	
Date	29 JAN 1908	05 FEB 1964	12 MAR 1936	06 APR 2010	07 MAY 1956	05 JUN 1990	15 JUL 2006	29 AUG 1924	04 SEP 1943	15 OCT 1964	27 NOV 1973	20 DEC 1976	29 JAN 1908	
Mean number of days of rain	12.8	12.3	8.3	2.1	1	1	0.6	0.4	0.6	1.8	4.5	8.3	53.7	
Mean number of days of rain ≥ 1 mm	11.9	11.3	7.3	1.8	0.8	0.8	0.5	0.3	0.5	1.4	3.8	7.6	48	
Mean number of days of rain ≥ 10 mm	6	5.5	3.3	0.6	0.3	0.2	0.1	0.1	0.2	0.5	1.3	3.4	21.5	
Mean number of days of rain ≥ 25 mm	2.8	2.2	1.4	0.3	0.1	0.1	0	0	0.1	0.1	0.5	1.4	9	
Monthly rainfall (mm)	338.8	401.6	241.6	13.2	0	0.6	0	0	0	30	36.4	42.2	1104.4	2011
Highest daily rainfall (mm)	77	142.4	53.2	12.4	0	0.6	0	0	0	17.8	25.8	14.8	77	
Number of days of rain	16	18	21	3	0	1	0	0	0	4	5	9	77	
Number of days of rain ≥ 1 mm	16	15	20	1	0	0	0	0	0	2	4	6	64	
Number of days of rain ≥ 10 mm	11	8	6	1	0	0	0	0	0	2	1	1	30	
Number of days of rain ≥ 25 mm	5	5	2	0	0	0	0	0	0	0	1	0	13	

Note: Data sourced from www.bom.gov.au (Croydon Station No 29012)

On-site Water Storages

The on site water storages on ML 5248 include the following (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Lady Isabella Pit;
- Content Pit;
- Golden Butterfly waste rock dump toe drain (i.e. SW3a);
- Stock water dam (i.e. SW4); and
- Sediment dam (i.e. SW5).

A summary of the most recent open pit water quality and surface water quality data (2000 to 2011) is provided in Table 8 and Table 9

Monitoring

In addition to the open pit and on site surface water monitoring sites identified above, the surface water monitoring program is inclusive of the following receiving water monitoring sites (Figure 2):

- SW1 (lower Slaughteryard Creek);
- SW2 (Slaughteryard west tributary at the boundary of ML 5248);
- SW3 (Slaughteryard Creek upstream of the Golden Butterfly waste rock dump);
- SW6 (Belmore Creek borrow pit/stock dam);
- SW3b (Reference site for Slaughteryard Creek); and
- SW7 (Reference site for Belmore Creek).

A summary of the most recent receiving water quality data (2000 to 2011) is provided in Table 9. No biological monitoring has been conducted at the Project. Given that no waste water treatment system is operating at the Project, it is considered that the monitoring of biological parameters in surface water is not required.

The monitoring program for the open pit waters, on site water storages and receiving waters is provided in the Rehabilitation Monitoring Program (Attachment A).

Open Pit Water Balance and Storage Capacity

An investigation conducted by HLA Enviroscience (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping. The consecutive unprecedented rainfall totals experienced since 2008/2009 support this conclusion in regards to the Golden Butterfly and Golden Butterfly North Pits. However, the overtopping and discharge from the Content Pit during early 2011 obviously shows that the conceptual hydrogeological model in terms of the Content Pit and Lady Isabella Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation.

Water Demand

As the Project is decommissioned/closed water would only be required for reclamation works. Water for these works would be sourced from the Golden Butterfly North Pit.

Table 7: Pit Lake Water Quality 2000-2011

Parameter	Sample Site							
	Golden Butterfly		Golden Butterfly North		Content		Lady Isabella	
	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	2.3 2.8	2.5	5.8 7.7	6.8	3.3 4.3	3.8	3.4 4.6	3.7
EC (µS/cm)	2910 12000	5971	60 370	270	737 1800	1135	491 1300	891
SO_4 (mg/L)	1910 8000	5130	11 92	69	300 780	483	180 610	372
Cu (mg/L)	3.3 24	14.1	<0.005 <0.05	<0.05*	0.048 0.28	0.12	0.13 1.4	0.69
Pb (mg/L)	<0.002 <0.005	<0.005*	<0.001 <0.002	<0.002*	<0.001 <0.002	<0.002*	0.002 0.007	0.003
Ni (mg/L)	1.56 8.5	5.10	<0.004 <0.05	<0.05*	0.087 0.32	0.18	0.14 0.77	0.39
Al (mg/L)	122 700	436	0.025 0.73	0.20	1.31 7.0	3.1	2.98 20	9.8
Zn (mg/L)	2.4 36	19.2	<0.005 0.05	0.011	0.23 1.1	0.58	0.82 5.8	2.98
Co (mg/L)	1.24 7.3	3.5	<0.005 <0.05	<0.05*	0.09 0.29	0.14	0.109 0.53	0.25
Cd (mg/L)	0.055 0.34	0.19	<0.0001 0.0002	<0.0002*	0.0021 0.023	0.006	0.013 0.19	0.08
Fe (mg/L)	240 450	356	<0.05 0.18	0.06*	0.69 1.5	0.95	<0.05 0.66	0.23*
Mn (mg/L)	56 110	79	<0.05 0.17	<0.05*	3.7 5.2	4.4	3.3 6.3	4.7
As (mg/L)	0.34 1.3	0.71	<0.005 0.01	<0.005*	<0.005 0.058	0.015	<0.003 0.013	0.004

Notes : * indicates median, below detection results have been replaced with half the relevant detection limit to calculate averages.

Table 8: Water Quality Summary of Surface Water Monitoring Sites 2000- 2011

Parameter	Sample Site													
	SW1		SW2		SW3		SW3b		SW4		SW5		SW6	
	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	6.2 9.2	7.20	5.7 9.1	6.78	6.2 8.00	6.96	5.3 6.76	6.16	6.4 9.3	7.45	3.5 6.75	4.3	5.3 9.0	7.4
EC (ȣS/cm)	77 610	245	64 301	144	38 450	116	17 97	54	38 770	159	32 1400	473	24 480	105
S04 (mg/L)	12 100	44	18 96	42	9 140	25.3	5 23	12.4	8 150	32	6 810	210	<1 43	12.6
Cu (mg/L)	0.004 0.063	0.019	<0.001 – 0.022	0.01	0.001 0.05	0.02	0.001 0.03	0.01	0.002 0.020	0.008	<0.001 2.5	0.38	0.001 0.158	0.018
Pb (mg/L)	<0.001 0.004	0.002*	0.001 0.01	<0.002*	<0.002 0.004	<0.002*	<0 .002 0.004	<0.002*	0.001 0.012	0.004	<0.002 0.006	<0.002*	<0.002 0.047	0.006*
Ni (mg/L)	<0.002 0.003	0.002	<0.001 – 0.011	0.004	<0.001 0.03	0.02	<0.001 0.03	0.01	<0.001 0.025	0.010	<0.001 1.0	0.20	<0.001 0.025	0.017
Al (mg/L)	0.06 2.7	0.55	0.01 18	1.08	<0.05 3.5	0.41	<0.01 0.62	0.12	0.03 11.0	0.93	0.11 77	9.8	0.025 350	9.1
Zn (mg/L)	0.008 0.03	0.018	<0.005 – 0.07	0.04	0.003 0.17	0.02	0.01 0.03	0.01	<0.005 0.110	0.020	<0.005 6.0	0.95	<0.005 0.073	0.019
Co (mg/L)	<0.005 <0.05	<0.05*	<0.001 0.003	0.002	<0.001 0.03	0.3	<0.001 0.03	0.01	<0.001 <0.05	<0.05*	<0.001 1.0	0.21	<0.001 0.025	0.020
Cd (mg/L)	<0.0002 0.0002 5	<0.0002*	<0.0001 0.0002	0.0001	<0.0001 0.0003	0.0001	<0.0001 0.0003	0.0001	<0.0001 0.0002	0.0001	<0.0001 0.24	0.036	<0.0001 0.0004	0.0001
Fe (mg/L)	0.33 2.7	1.19	0.27 1.2	0.69	0.73 5.2	2.05	0.33 1.2	0.77	0.42 5.1	1.30	0.08 0.39	0.24	0.57 13	2.6
Mn (mg/L)	<0.05 0.24	<0.05*	<0.05 0.014	0.08*	<0.05 1.9	<0.05*	<0.05 0 .07	<0.05*	<0.05 0 .14	<0.05*	0.31 10	3.69	<0.05 0.14	<0.05*
As (mg/L)	<0.005 0.033	0.010	<0.001 – 0.055	0.02	0.002 0.07	0.01	<0.001 0.018	0.004	0.003 0.04	0.01	0.002 0.02	0.004	<0.001 0.011	0.003

Notes : * indicates median, below detection results have been replaced with half the relevant detection limit to calculate averages .

Water Management Requirements

In accordance with Condition F7 1 of the EA a WMS is required. The WMS is provided as Appendix D in the Plan of Operations (Barrick, 2011). The WMS provides a drainage review of the Project, including the general relief, surface hydrology and hydrogeology. Drainage management strategies have been prepared for the final landforms on ML 5248. A brief description of the proposed drainage management strategies is provided in Section 2.4.

5.2 HYDROGEOLOGICAL ASSESSMENT

This section provides a description of the existing groundwater environment at the Project and provides a brief description of the conceptual hydrogeological model that was developed for the Project during the preparation of the Environmental Management Plan (Barrick, 2008b). The conceptual hydrogeological model was based on available hydrogeological and groundwater quality information.

5.2.1 Existing Groundwater Environment

It is expected that the area covered by ML 5248 is a 'hardrock' geological terrain with groundwater hosted in the upper weathered rock horizon and deeper fractured rock aquifers associated with the mineral deposit. This is supported by the limited use of groundwater in the surrounding region for stock watering. The aquifers are therefore not considered a potential resource. Groundwater quality is expected to reflect the mineralised nature of the country rock and bore yields are likely to be highly erratic due to the expected lack of hydrogeological interconnectivity between fractures. Regional groundwater levels are believed to be some 15 m below ground surface and any groundwater exploration would have to target geological structures.

The only known use of groundwater in the surrounding area is the decommissioned town borefield located some 2 km to the south west of ML 5248. The town borefield, which exploited an unconfined alluvial aquifer located along Slaughteryard Creek and deeper sedimentary bedrock aquifers, was decommissioned in 1995 when Lake Belmore was constructed as the permanent town water supply. Anecdotal evidence (Croydon Shire Council Engineer, pers. comm., 2008) indicates that many of the initial bores were dry and yields in the equipped bores rapidly decreased from an initial 1.3 litres per second (L/s) to 0.2 L/s at the time of decommissioning. Groundwater quality in this aquifer was fresh but several bores and the shallow wells had a high iron content. At the time unsuccessful attempts were made to implement a local artificial recharge scheme within the creek sands. Currently only two shallow wide diameter wells remain functional as a potential backup water supply for the town oval.

Fractured Rock Aquifers

Groundwater monitoring and pit lake recovery trends support the hypothesis that the deeper fractured rock aquifers are highly variable in water quality and have limited connectivity. Figure 5 shows the conceptualised hydrogeology in the Golden Butterfly Pit area. Groundwater levels on either side of the pit differ by up to 5 m and water qualities differ significantly (i.e. Bores BH1 and BH2) (Figure 6 and Table 9). It is suggested, based on the groundwater quality data (Table 9, Table 10, Table 11) that a major geological contact exists between bores GBMB2 and GBMB3 (Figure 5). This is borne out by the geology and the different water quality found in Golden Butterfly North Pit (Table 7). A summary of the groundwater quality from 2000 to 2011 is provided in Table 9, Table 10, and Table 11.

All four pits (i.e. Golden Butterfly, Golden Butterfly North, Content and Lady Isabella) now contain pit lakes largely as a result of groundwater inflow at depth from expected rock aquifers. The differing pit water qualities reflect country rock geology and varying mineralisation within the ore deposit through which the groundwater is moving prior to entering the pits. A summary of the water quality from 2000 to 2011 of the four open pits is provided in Table 7.

A hydrogeological study by HLA Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit (due to short wet season and high evaporation during most of the year) and that even in the wettest years there is no risk of the pit lakes overtopping. A simple water balance indicates that the pit lakes are expected to act as groundwater sinks and have limited capacity to influence groundwater quality much beyond the immediate footprint of the pit.

This hypothesis is supported by water quality monitoring results with a change in water quality occurring with increased distance from the Golden Butterfly Pit (shown in Table 9, Table 10, and Table 11). Despite these conclusions from the conceptual hydrogeological model the unprecedented rainfall totals experienced since 2008/2009 raised concerns about the model's robustness.

The 2008/2009 and 2009/2010 wet seasons resulted in extraordinary rainfall totals (Figure 4). In recognition of the possibility of a discharge from the Content Pit, Barrick had undertaken short term remediation works involving the transfer from water from the Content Pit to the Golden Butterfly Pit to minimise the risk of the Content Pit overtopping during the 2010/2011 wet season. The water level of the Content Pit was decreased by approximately four (4) meters during November and December 2010 (with a subsequent increase of one (1) meter in the Golden Butterfly Pit). Nevertheless, on the 29th March 2011 the Content Pit began discharging water which continued until the 13th April 2011 when no flow was observed to be entering receiving streams. This event obviously shows that the conceptual hydrogeological model in terms of the Content Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation.

A possible addition to the hydrogeological model for the Content Pit is the inclusion of a hydraulic connection with the Lady Isabella Pit. Figure 7 presents an aerial photograph of the area around the Content Pit overlaid with a contour map. The Lady Isabella Pit when full is approximately five meters higher in elevation that the Content Pit discharge level. This elevation difference provides a hydraulic driving force which with the relative close proximity of the Lady Isabella Pit to the Content Pit and possible connecting facture zones and or fault lines enabling water flow.

Unconfined Alluvial Aquifer – Slaughteryard Creek

The Slaughteryard Creek unconfined alluvial aquifer previously exploited by the original town water supply borefield is located off ML 5248 and some 2 km from the Golden Butterfly Pit (Figure 5). Although there are no bore logs for the town borefield, it is believed that it utilised the shallow unconfined alluvial aquifer associated with Slaughteryard Creek. It is expected that the unconfined alluvial aquifer is locally recharged by surface water flow within the creek. As previously stated the surface water recharge component that can be attributed to the Golden Butterfly Pit Lake is most unlikely. This has been confirmed by groundwater monitoring over the past ten years (Table 10, Table 11 and Table 12).

Groundwater Management Requirements

In addition to the groundwater monitoring network additional hydrogeological investigations are required by Condition F4 6 of the EA. A hydrogeological investigation/assessment was conducted in 2009 (Barrick, 2010) with the aim to confirm the conceptual hydrogeological model. In accordance with EA Condition F4 6 the hydrogeological investigation/assessment included:

- Obtaining additional geological information, regional groundwater use and bore water levels.
- Analysing groundwater quality data from the decommissioned town water supply bores.
- Surveying pit lake water levels and erection of water level gauges.
- Pit water level fluctuations and behaviour.

The 2009 hydrogeological investigation/assessment (Barrick, 2010) concluded the following:

- Groundwater is not considered a significant water resource within the mining lease and does not support or recharge any surface water drainage system. Some groundwater contamination has occurred below sections of the Content waste rock dump and around the mine pits. This contamination is highly localised and of no environmental concern, except along the western toe of Content Waste Rock Dump where remedial drainage measures are planned.

- There is no direct hydrogeological link between the Golden Butterfly Pit Lake and the Town Borefield or Lakes homestead bore and no possibility of this alluvial aquifer being contaminated by pit lake seepage water.
- The mine pits which have been considered hydrogeological sinks have until recently been slowly filling with rain and groundwater seepage. The two southern pits, namely, Golden Butterfly and Golden Butterfly North remain groundwater sinks and are likely to always be sinks if all stormwater runoff is diverted away from the surrounding area. Content and Lady Isabella Pits on the other hand have now filled with water to the extent that pit lake levels reflect local groundwater levels and hence currently represent hydrogeological flow through cells.
- The water quality in the pit lakes has improved over the past 20 years, and it is only Golden Butterfly Pit that currently has a true acid mine drainage problem. Access to this pit lake must be restricted at all times. The current water quality in the remaining pit lakes does not exclude their use for irrigation in the case of Golden Butterfly North and dust suppression (road construction) for Content and Lady Isabella. There is however an ongoing safety concern and issue that natural evapo concentration will continue in all pit lakes, particularly during low rainfall cycles. As such these facilities should not be considered as potential stock water supplies and all access restricted to avoid any unnecessary safety liabilities.
- Current water balance modelling and field observations suggests that the proposed surface drainage plan for the Golden Butterfly Pit area needs to be fully implemented before the next wet season. The relatively simple earth works proposed could significantly reduce seepage and groundwater recharge to the mine pits. It is also suggested that drainage measures be put in place to provide for potential managed discharge (spillage) from Content Pit lake. This is a precautionary measure that needs to be taken as this pit lake will at some stage briefly overtop and the excess water needs to be directed in a control manner to discharge into the adjacent Belmore Creek. Water quality is not considered an issue, should such a spill occur, particularly as it would only occur during extreme flood conditions.

All recommendations for earthworks and other physical changes to improve drainage measures and restrict access to the various pit lakes were implemented during 2009/ 2010.

In order to provide additional information to assist in refining the conceptual hydrological model, a series of water level monitoring stations have been installed during November 2011 in each of the pit lakes at Croydon (Figure 8). Each of these stations is fitted with a pressure sensor transducer connected to a data logger with solar powered battery supply. Additionally, in the event of a further discharge from the Content Pit, a measuring flume has been installed in the v drain which will direct any outflow from the Content Pit.

Operation and Maintenance of Groundwater Monitoring Network

The groundwater monitoring network for the Project includes the groundwater monitoring sites identified in Section 8 and is described in the Rehabilitation Monitoring Program (Attachment A).

The groundwater monitoring bores will be inspected during each monitoring event and maintenance would be conducted as required.

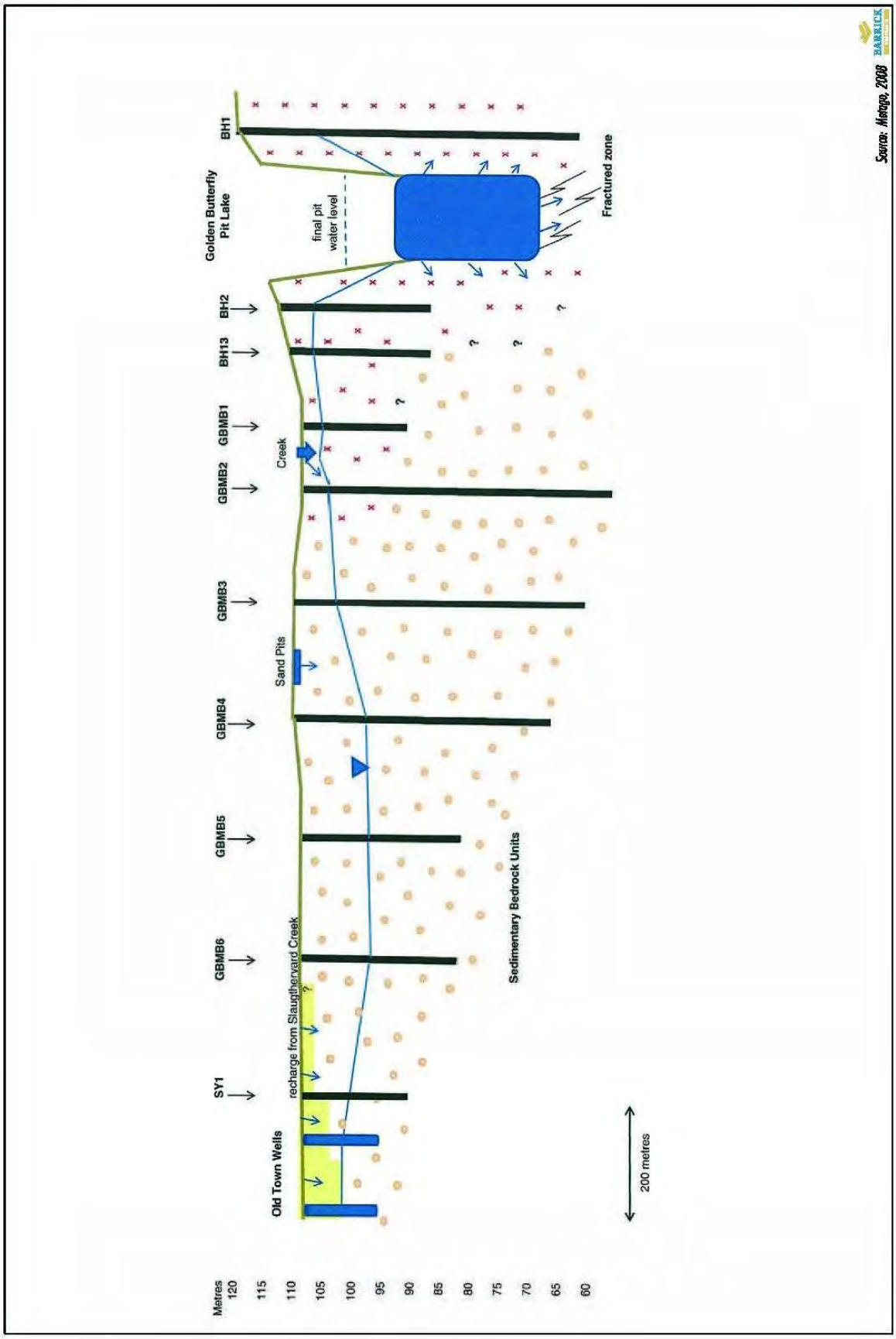


Figure 5: Conceptual Hydrogeological Model

Table 9: Groundwater Quality – Confined Fractured Rock Aquifer 1995 - 2009

Parameter	Sample Site																	
	BH1		BH2		BH3		BH4		BH5		BH6		BH7		GBMB1		GBMB2	
	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median
pH (pH units)	6.1 7.9 (42)	7.2 7.2	3.3 6.5 (41)	3.7 3.6	5.5 7.7 (35)	6.41 6.4	6.9 8.6	7.4	7.3 7.8 (13)	7.5 7.5	6.9 7.5	7.15	6.4 7.1	6.8	6.4 7	6.7	6.9 7.7	7.3
EC (µS/cm)	985 2260 (42)	1298 1300	740 1300 (41)	1016 980	110 3000 (35)	604 340	4800 7200	5611	4900 6800 (13)	5550 5600	480 2200	933	6400 8700	7472	160 760	591	2200 2700	2491
SO_4 (mg/L)	310 1160 (42)	471 460	260 850 (40)	442 435	20 990 (35)	172 100	1200 1800	1522	1400 2000 (13)	1733 1800	59 530	172	1400 2600	1950	36 190	120	630 790	703
Cu (mg/L)	<0.001 0.05 (16)	0.008 0.005	0.002 0.05 (15)	0.011 0.005	0.001 0.025 (13)	0.009 0.005	<0.001 <0.05	<0.01	<0.001 0.03 (13)	0.007 0.005	0.009 0.02	0.01	<0.003 0.03	<0.01	0.001 0.01	<0.01	<0.001 <0.05	<0.01
Pb (mg/L)	<0.001 0.35 (13)	0.031 0.001	<0.001 0.15 (13)	0.051 0.046	<0.001 0.072 (11)	0.013 0.001	<0.001 0.006	<0.002	<0.001 0.24 (11)	0.023 0.001	<0.002 0.056	0.009	<0.001 0.35	<0.002	<0.002 0.003	<0.002	<0.002 0.02	0.002
Ni (mg/L)	0.002 0.025 (16)	0.016 0.025	0.025 0.09 (15)	0.056 0.05	<0.001 0.025 (10)	0.014 0.0145	<0.002 <0.05	<0.05	<0.001 0.025 (13)	0.016 0.025	0.002 <0.05	<0.05	0.004 <0.05	<0.05	0.02 <0.05	<0.05	<0.002 <0.05	<0.05
Al (mg/L)	0.02 0.25 (15)	0.045 0.025	0.16 2.7 (14)	1.54 1.65	0.07 2.1 (10)	0.49 0.33	<0.05 0.37	<0.05	<0.01 0.29 (13)	0.049 0.025	0.14 6.8	2.35	<0.05 0.16	<0.05	<0.05 0.092	<0.05	<0.05 0.21	<0.05
Zn (mg/L)	0.01 0.18 (16)	0.053 0.038	0.043 1.06 (15)	0.40 0.36	<0.005 2.9 (13)	0.24 0.015	0.008 0.04	0.017	0.0025 0.032 (13)	0.0127 0.012	0.005 0.055	0.021	0.029 0.15	0.072	0.012 0.047	0.024	0.011 0.056	0.028
Co (mg/L)	<0.001 0.025 (11)	0.016 0.025	0.018 0.045 (11)	0.018 0.025	<0.001 0.025 (9)	0.015 0.025	<0.005 <0.05	<0.05	<0.001 <0.05	<0.05	<0.005 <0.05	<0.05	<0.005 0.07	<0.05	<0.05 <0.05	<0.05	<0.005 <0.05	<0.05
Cd (mg/L)	<0.0001 0.0025 (16)	0.0003 0.0001	<0.0001 0.0025 (15)	0.0007 0.0007	<0.0001 0.0009 (13)	0.0002 0.0001	<0.0001 0.0003	<0.0002	<0.0005 0.0004 (13)	<0.0005 0.0001	<0.0001 <0.0002	<0.0002	0.0002 0.002	0.00085	<0.0001 0.0067	0.0005	<0.0001 0.0003	<0.0002*
Fe (mg/L)	<0.05 3.2 (32)	0.436 0.1	0.025 27 (32)	4.54 1.3	0.025 1.75 (29)	0.33 0.25	<0.05 <0.05	<0.05	<0.05 0.09 (5)	<0.05	0.06 3.1	1.4	<0.05 0.27	<0.05	<0.05 0.08	<0.05	<0.05 <0.05	<0.05
Mn (mg/L)	<0.05 1.19 (8)	0.247 0.075	0.95 1.97 (8)	1.23 1.1	0.0025 0.025 (4)	0.019 0.025	<0.05 <0.05	<0.05	<0.05 0.06 (7)	0.034 0.025	<0.05 0.68	0.06	<0.05 1.9	<0.05	0.26 1.4	0.83	0.67 1.2	0.90
As (mg/L)	0.01 0.022 (16)	0.014 0.014	<0.001 0.09 (15)	0.008 0.025	<0.003 0.03 (13)	0.010 0.009	<0.005 0.003	<0.005	<0.05 0.009 (13)	0.012 0.007	0.013 0.048	0.026	<0.005 0.007	<0.005	0.007 0.034	0.02	<0.003 0.023	<0.005

* Below detection limit results have been substituted with a value of half of the detection limit

Table 10: Groundwater Quality – Unconfined Alluvial Aquifer 2001 - 2009

Parameter	Sample Site							
	GBMB3		GBMB4		GBMB5		GBMB6	
	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	5.7 6.8	6.2	5.9 6.5	6.1	5.6 7.1	6.0	5.7 7.1	6.2
EC (µS/cm)	52 110	79.4	260 350	308	68 490	114	66 580	152
SO_4 (mg/L)	3 13	6.3	17 38	28.8	2 13	4.4	3 19	7.1
Cu (mg/L)	0.001 0.01	<0.01*	<0.001 <0.05	<0.01*	<0.001 0.01	<0.01*	<0.001 <0.05	<0.01*
Pb (mg/L)	0.002 0.018	0.008	<0.001 0.008	<0.002*	<0.001 0.004	<0.002*	<0.001 0.31	<0.002*
Ni (mg/L)	<0.002 <0.05	<0.05*	<0.002 <0.05	<0.05*	<0.002 <0.05	<0.05*	<0.002 <0.05	<0.05*
Al (mg/L)	0.07 4.8	0.99	<0.05 0.29	<0.05*	<0.05 0.05	<0.05*	<0.05 0.69	<0.05*
Zn (mg/L)	0.017 0.11	0.052	0.006 0.18	0.043	0.01 .015	0.08	<0.005 0.092	0.025*
Co (mg/L)	<0.005 <0.05	<0.05*	<0.005 <0.05	<0.05*	<0.005 <0.05	<0.05*	<0.005 <0.05	<0.05*
Cd (mg/L)	<0.0002 <0.0002	<0.0002*	<0.0001 0.0018	<0.0002*	<0.0001 <0.0002	<0.0002*	<0.0001 <0.0002	<0.0002*
Fe (mg/L)	0.53 3	1.8	<0.05 6.6	0.18*	<0.05 <0.05	<0.05	<0.05 0.39	<0.05*
Mn (mg/L)	<0.05 0.15	0.05*	<0.05 .07	<0.05*	<0.05 0.26	<0.05*	<0.05 .037	<0.05*
As (mg/L)	0.003 0.012	<0.005*	<0.003 0.007	<0.005*	<0.003 0.091	<0.005*	<0.005 0.15	0.005

* indicates Median.

Table 11: Groundwater monitoring results 2010 – 2011

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH1	22/08/2011	8	1390	4	497	0.04	0.014	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.023
	20/09/2011	7.62	1410	3.7	476	<0.01	0.01	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.013
BH2	20/11/2010	3.69	940	0.8	374	0.99	0.001	<0.05	0.0001	<0.010	0.017	0.003	<0.0001	0.027	<0.01	0.204
	22/08/2011	3.7	934	1.4	383	0.96	<0.001	<0.05	0.0001	<0.001	0.016	0.01	<0.0001	0.026	<0.01	0.171
	20/09/2011	3.69	989	1.2	380	1.05	0.001	<0.05	0.0004	<0.001	0.019	0.015	<0.0001	0.034	<0.01	0.183
BH3	20/11/2010	8	746	3.6	148	0.43	0.01	<0.05	<0.0001	<0.010	<0.001	0.003	<0.0001	<0.001	<0.01	0.031
	23/08/2011	7.08	454	2.9	92	0.17	0.008	<0.05	<0.0001	<0.001	0.003	0.003	<0.0001	0.002	<0.01	0.007
	20/09/2011	7.09	499	3	95	0.23	0.031	<0.05	<0.0001	<0.001	0.006	0.002	<0.0001	0.002	<0.01	0.007
BH5	20/11/2010	8.37	5500	6.6	1930	<0.01	0.005	<0.05	0.0003	<0.010	<0.001	0.004	<0.0001	<0.001	<0.01	0.02
	23/08/2011	7.59	5600	7.7	2000	0.02	0.005	<0.05	0.0005	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.01
	20/09/2011	7.05	6490	4.4	2050	<0.01	0.006	<0.05	0.0022	<0.001	<0.001	0.001	<0.0001	0.005	<0.01	0.065
BH6	20/11/2010	8.3	642	8.3	67	0.29	0.047	<0.05	<0.0001	<0.010	<0.001	0.016	<0.0001	0.003	<0.01	<0.005
BH7	20/11/2010	8	5290	6.3	1540	0.02	0.008	<0.05	0.0032	<0.010	0.005	0.051	<0.0001	0.026	<0.01	0.241
	23/08/2011	7.12	5120	7.4	1540	0.03	0.004	<0.05	0.0002	<0.001	0.013	0.001	<0.0001	0.012	<0.01	0.031
	20/09/2011	6.81	5000	6.9	1470	0.02	0.013	<0.05	0.0002	<0.001	0.014	0.001	<0.0001	0.013	<0.01	0.052
BH8	20/11/2010	7.5	118	0.5	13	0.04	0.018	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	0.001	<0.01	0.056
	22/08/2011	5.31	110	<0.1	12	0.02	0.003	<0.05	<0.0001	<0.001	0.001	0.005	<0.0001	0.002	<0.01	0.045
	20/09/2011	5.39	118	0.1	12	0.02	0.002	<0.05	<0.0001	<0.001	0.002	0.002	<0.0001	0.002	<0.01	0.02
BH9	20/11/2010	6.56	104	<0.1	<1	0.29	<0.001	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	<0.001	<0.01	0.027
	22/08/2011	5.39	99	<0.1	1	0.03	<0.001	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.013
	20/09/2011	5.45	98	<0.1	1	0.02	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
BH10	20/11/2010	7.92	2670	2.4	1280	<0.01	0.02	<0.05	<0.0001	<0.010	0.02	0.002	<0.0001	0.006	<0.01	0.035
	22/08/2011	7.36	2700	2.9	1260	<0.01	0.012	<0.05	<0.0001	<0.001	0.019	0.001	<0.0001	0.005	<0.01	0.03
	20/09/2011	7.16	2680	2.9	1190	<0.01	0.004	<0.05	0.0001	<0.001	0.007	0.001	<0.0001	0.008	<0.01	0.078
BH11	20/11/2010	8.1	370	2.4	51	<0.01	0.054	<0.05	<0.0001	<0.010	<0.001	0.002	<0.0001	0.002	<0.01	0.043
	22/08/2011	7.47	358	2.9	51	0.01	0.058	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.005
	20/09/2011	7.13	353	2.9	49	<0.01	0.054	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	0.001	<0.01	0.008
EA Trigger Level		6.0 to 7.5	250			0.055	0.013	0.37	0.0002	0.001	0.0014	0.0014	0.0006	0.011	0.011	0.008
EA Contaminant Limit		5 to 9	5970	2	1000	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

Table 11 (Continued): Groundwater monitoring results 2010 – 2011

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH12	20/11/2010	8.44	1400	4.2	186	<0.01	0.024	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	<0.001	<0.01	0.025
	22/08/2011	7.69	1380	4.9	182	<0.01	0.019	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.022
	20/09/2011	7.4	1390	4.6	173	<0.01	0.017	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
SY1	20/11/2010	7.01	51	<0.1	<1	0.04	0.002	<0.05	<0.0001	<0.010	0.001	<0.001	<0.0001	<0.001	<0.01	0.04
	23/08/2011	6.02	60	<0.1	<1	<0.01	0.003	<0.05	<0.0001	<0.001	0.003	<0.001	<0.0001	0.001	<0.01	0.009
GBMB1	20/11/2010	7.91	533	1.7	110	<0.01	0.012	<0.05	<0.0001	<0.010	<0.001	0.002	<0.0001	<0.001	<0.01	0.035
	23/08/2011	7.62	498	1.7	81	0.03	0.037	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
	20/09/2011	6.67	694	2.2	165	0.01	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
GBMB3	23/08/2011	6.25	103	<0.1	<1	0.07	0.016	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	<0.001	<0.01	0.006
	20/09/2011	5.84	61	<0.1	<1	0.21	0.016	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.001	<0.01	0.014
GBMB6	23/08/2011	6.9	247	0.2	1	<0.01	0.096	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.002	<0.01	<0.005
	20/09/2011	6.2	158	0.2	2	<0.01	0.087	<0.05	<0.0001	<0.001	0.001	<0.001	<0.0001	0.002	<0.01	<0.005
EA Trigger Level		6.0 to 7.5	250			0.055	0.013	0.37	0.0002	0.001	0.0014	0.0014	0.0006	0.011	0.011	0.008
EA Contaminant Limit		5 to 9	5970	2	1000	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

Table 12: Groundwater levels in monitoring bores

Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)	Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)
BH1	117	1/03/2008	13.90	103.10	BH6	114	29/03/2010	1.70	112.30
BH1	117	2/04/2009	8.71	108.29	BH6	114	11/07/2010	3.20	110.80
BH1	117	10/08/2009	13.85	103.15	BH6	114	18/10/2010	4.35	109.65
BH1	117	29/03/2010	12.50	104.50	BH6	114	20/11/2010	4.25	109.75
BH1	117	11/07/2010	15.00	102.00	BH6	114	29/03/2011	2.00	112.00
BH1	117	13/08/2010	15.44	101.56	BH6	114	22/08/2011	3.20	110.80
BH1	117	18/10/2010	16.05	100.95					
BH1	117	20/11/2010	16.17	100.83	BH7	116	1/03/2008	4.70	111.30
BH1	117	29/03/2011	11.50	105.50	BH7	116	2/04/2009	3.35	112.65
BH1	117	22/08/2011	13.00	104.00	BH7	116	10/08/2009	3.35	112.65
					BH7	116	29/03/2010	4.60	111.40
BH2	112	1/03/2008	4.70	107.30	BH7	116	11/07/2010	4.60	111.40
BH2	112	2/04/2009	6.17	105.83	BH7	116	18/10/2010	4.65	111.35
BH2	112	10/08/2009	7.14	104.86	BH7	116	20/11/2010	4.60	111.40
BH2	112	29/03/2010	4.90	107.10	BH7	116	29/03/2011	4.10	111.90
BH2	112	11/07/2010	5.30	106.70	BH7	116	22/08/2011	4.30	111.70
BH2	112	13/08/2010	5.41	106.59					
BH2	112	18/10/2010	5.75	106.25	BH8	123.92	1/10/2008	17.12	106.80
BH2	112	20/11/2010	5.84	106.16	BH8	123.92	2/04/2009	12.20	111.72
BH2	112	29/03/2011	3.75	108.25	BH8	123.92	10/08/2009	16.70	107.22
BH2	112	22/08/2011	4.55	107.45	BH8	123.92	29/03/2010	13.55	110.37
					BH8	123.92	10/07/2010	12.50	111.42
BH3	113	1/03/2008	1.10	111.90	BH8	123.92	13/08/2010	12.50	111.42
BH3	113	2/04/2009	0.05	112.95	BH8	123.92	18/10/2010	12.60	111.32
BH3	113	10/08/2009	1.53	111.47	BH8	123.92	20/11/2010	12.57	111.35
BH3	113	29/03/2010	1.45	111.55	BH8	123.92	29/03/2011	8.75	115.17
BH3	113	11/07/2010	3.95	109.05	BH8	123.92	22/08/2011	9.28	114.64
BH3	113	18/10/2010	4.35	108.65					
BH3	113	20/11/2010	4.39	108.61	BH9	122.29	1/10/2008	12.42	109.87
BH3	113	29/03/2011	1.25	111.75	BH9	122.29	2/04/2009	7.40	114.89
BH3	113	22/08/2011	2.82	110.18	BH9	122.29	10/08/2009	9.66	112.63
					BH9	122.29	29/03/2010	8.70	113.59
BH4	113	29/03/2010	4.60	108.40	BH9	122.29	10/07/2010	8.60	113.69
BH4	113	11/07/2010	4.50	108.50	BH9	122.29	13/08/2010	8.85	113.44
BH4	113	18/10/2010	4.80	108.20	BH9	122.29	18/10/2010	9.15	113.14
BH4	113	20/11/2010	4.85	108.15	BH9	122.29	20/11/2010	9.23	113.06
BH4	113	29/03/2011	4.60	108.40	BH9	122.29	29/03/2011	6.50	115.79
BH4	113	22/08/2011	4.70	108.30	BH9	122.29	22/08/2011	7.22	115.07
BH5	114	1/03/2008	5.40	108.60	BH10	103.95	1/10/2008	10.44	93.51
BH5	114	2/04/2009	2.82	111.18	BH10	103.95	2/04/2009	7.98	95.97
BH5	114	10/08/2009	3.89	110.11	BH10	103.95	10/08/2009	7.80	96.15
BH5	114	29/03/2010	4.90	109.10	BH10	103.95	28/03/2010	7.70	96.25
BH5	114	11/07/2010	4.80	109.20	BH10	103.95	11/07/2010	7.50	96.45
BH5	114	18/10/2010	5.10	108.90	BH10	103.95	18/10/2010	7.64	96.31
BH5	114	20/11/2010	5.09	108.91	BH10	103.95	20/11/2010	7.62	96.33
BH5	114	29/03/2011	2.90	111.10	BH10	103.95	29/03/2011	7.30	96.65
BH5	114	22/08/2011	4.48	109.52	BH10	103.95	22/08/2011	7.19	96.76

Table 13 Continued: Groundwater levels in monitoring bores

Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)	Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)
BH11	104. 13	1/10/2008	7.60	96. 53	SY1	107. 48	1/10/2008	10. 62	96. 86
BH11	104. 13	2/04/2009	5.51	98. 62	SY1	107. 48	2/04/2009	8.09	99. 39
BH11	104. 13	10/08/2009	4.73	99. 40	SY1	107. 48	10/08/2009	10. 47	97. 01
BH11	104. 13	28/03/2010	4.26	99. 87	SY1	107. 48	29/03/2010	7.10	100. 38
BH11	104. 13	11/07/2010	3.75	100. 38	SY1	107. 48	11/07/2010	6.75	100. 73
BH11	104. 13	18/10/2010	3.70	100. 43	SY1	107. 48	20/11/2010	8.10	99. 38
BH11	104. 13	20/11/2010	3.75	100. 38	SY1	107. 48	29/03/2011	5.25	102. 23
BH11	104. 13	29/03/2011	2.25	101. 88	SY1	107. 48	22/08/2011	6.00	101. 48
BH11	104. 13	22/08/2011	2.75	101. 38					
BH12	102. 08	1/10/2008	7.46	94. 62					
BH12	102. 08	2/04/2009	7.22	94. 86					
BH12	102. 08	10/08/2009	7.02	95. 06					
BH12	102. 08	28/03/2010	6.90	95. 18					
BH12	102. 08	11/07/2010	6.82	95. 26					
BH12	102. 08	18/10/2010	6.87	95. 21					
BH12	102. 08	20/11/2010	6.83	95. 25					
BH12	102. 08	29/03/2011	6.50	95. 58					
BH12	102. 08	22/08/2011	6.42	95. 66					
GBMB1	109	1/03/2008	3.60	105. 40					
GBMB1	109	2/04/2009	1.09	107. 91					
GBMB1	109	10/08/2009	1.97	107. 03					
GBMB1	109	29/03/2010	3.00	106. 00					
GBMB1	109	11/07/2010	3.15	105. 85					
GBMB1	109	18/10/2010	3.50	105. 50					
GBMB1	109	20/11/2010	3.35	105. 65					
GBMB1	109	29/03/2011	1.90	107. 10					
GBMB1	109	22/08/2011	1.98	107. 02					
GBMB3	113	1/03/2008	7.30	105. 70					
GBMB3	113	2/04/2009	2.48	110. 52					
GBMB3	113	10/08/2009	4.18	108. 82					
GBMB3	113	29/03/2010	2.80	110. 20					
GBMB3	113	11/07/2010	3.55	109. 45					
GBMB3	113	18/10/2010	3.70	109. 30					
GBMB3	113	20/11/2010	3.80	109. 20					
GBMB3	113	29/03/2011	2.75	110. 25					
GBMB3	113	22/08/2011	3.90	109. 10					
GBMB6	113	1/03/2008	11. 70	101. 30					
GBMB6	113	2/04/2009	10. 73	102. 27					
GBMB6	113	10/08/2009	13. 14	99. 86					
GBMB6	113	29/03/2010	10. 05	102. 95					
GBMB6	113	11/07/2010	9.55	103. 45					
GBMB6	113	18/10/2010	9.85	103. 15					
GBMB6	113	20/11/2010	10. 20	102. 80					
GBMB6	113	29/03/2011	7.10	105. 90					
GBMB6	113	22/08/2011	8.00	105. 00					

Figure 6: Golden Butterfly Pit Monitoring Bore Water Levels

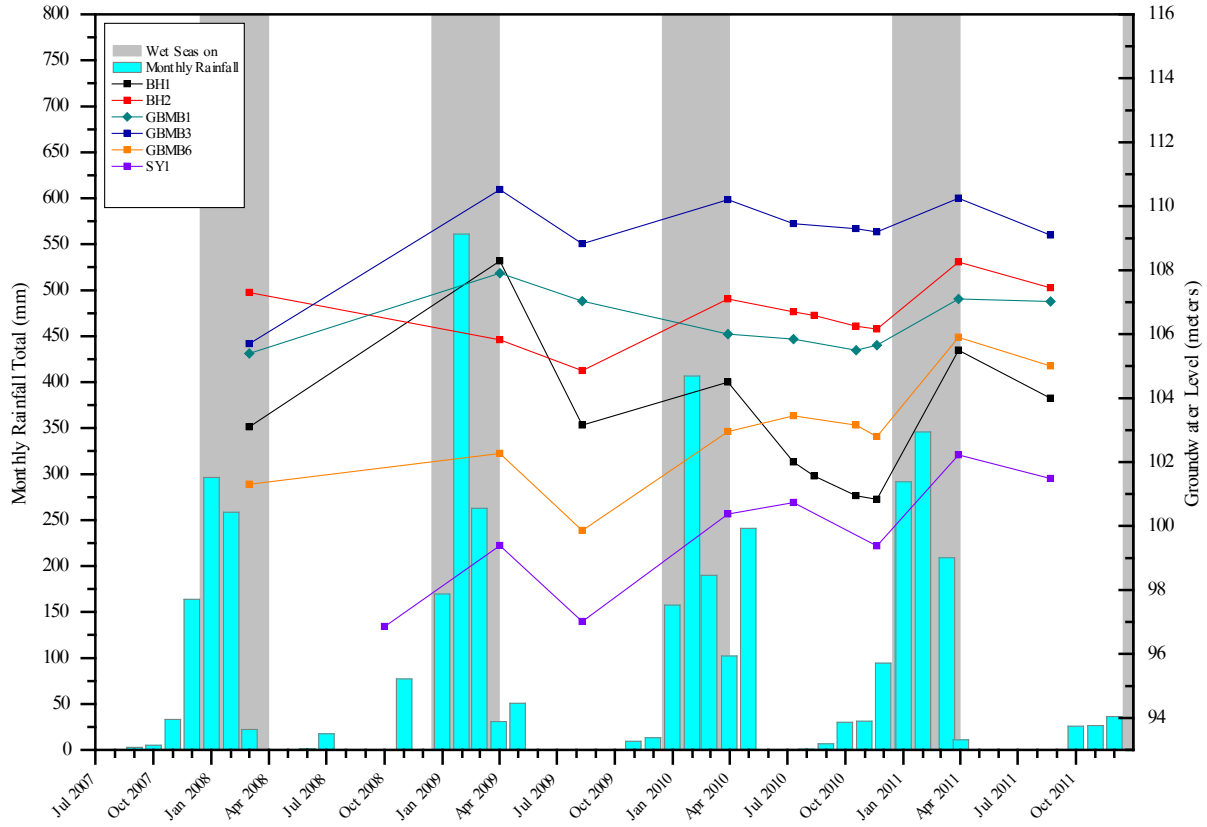


Figure 7: Content Pit local area contour map

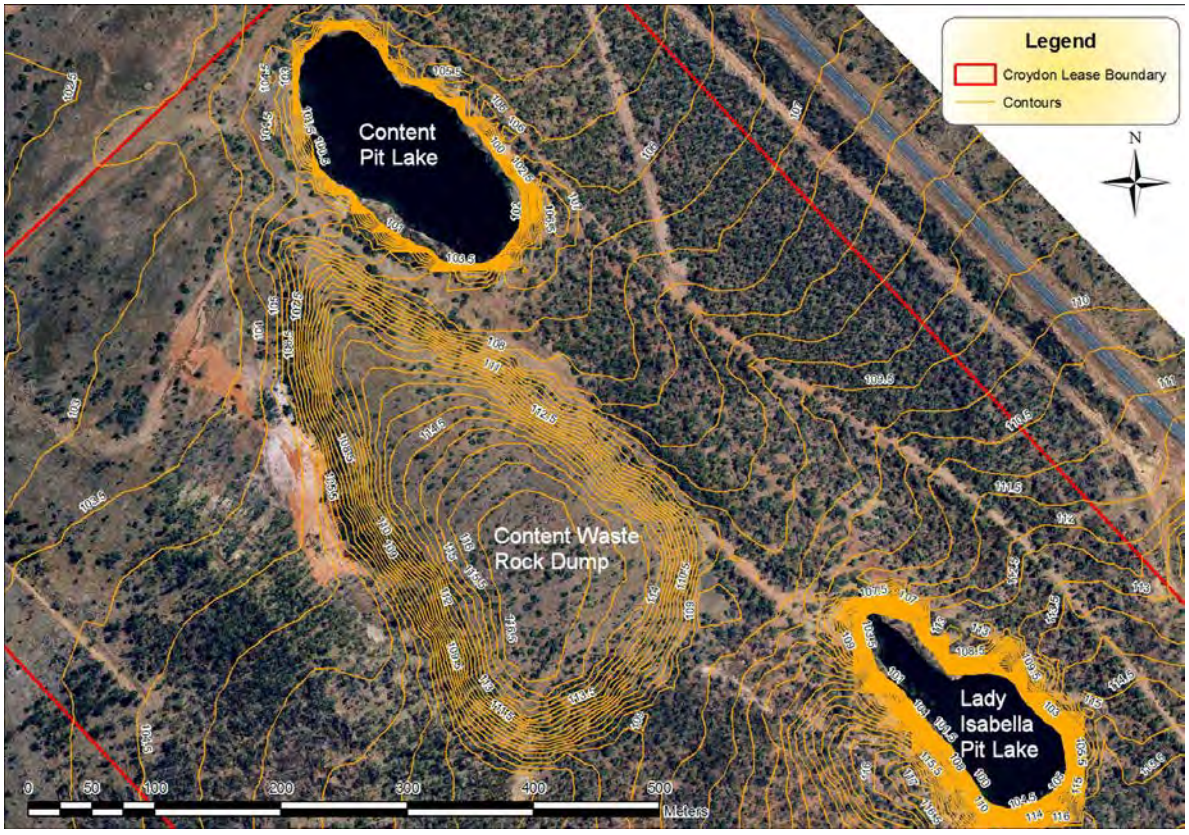


Table 13: Croydon Pit Lake Levels

	Content Pit		Golden Butterfly Pit		Lady Isabella Pit		Golden Butterfly North Pit	
	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate
10th July 2010	102.53	1.54	102.07	12.57	106.93	3.13	112.01	9.71
13th Aug 2010	102.35	1.36	102.0	12.5	106.75	2.95	111.8	9.5
27th Aug 2010	102.30	1.40	101.97	12.47	na	na	na	na
18th Oct 2010	102.10	1.60	na	na	106.53	3.17	111.44	9.86
19th Nov 2010	101.98	1.72	101.86	12.64	106.37	3.33	111.27	10.03
7th Dec 2010	98.98	4.72	103.36	11.14	106.48	3.23	na	na
29th Dec 2010	99.305	4.395	103.56	10.94	na	na	na	na
23rd Feb 2011	103.7	0	na	na	109.7	0.0	na	na
23rd Aug 2011	103.24	0.47	106.31[a]	8.19	108.26[a]	1.44	113.31	9.40
20th Oct 2011	102.89	0.81	104.91[a]	9.59	107.90[a] 108.13[b]	1.57	112.64	10.07
6th Dec 2011	102.65[d]	1.05	104.75[d]	9.75	107.96[c] 107.82[d]	1.74	na	na
22nd Dec 2011	102.57[d]	1.13	104.74	9.76	107.76[d]	1.94	113.78[d]	8.92

a. Using Dumpy Level
b. Compared to last gauge board reading (8th Dec 2010)
c. Using gauge board reading
d. Using survey equipment
e. Reference RL's: Content Pit 103.7m; Golden Butterfly Pit 114.5m; Lady Isabella Pit 109.7m; Golden Butterfly North Pit 122.7m

Lady Isabella Pit

Golden Butterfly North Pit

Golden Butterfly Pit

Content Pit

Figure 8: Croydon Pit Lake water level monitoring stations

6 REHABILITATION MONITORING PROGRAM

A Rehabilitation Monitoring Program has been prepared in accordance with Condition C2 2 (n) of the EA and is included as Attachment A.

The Rehabilitation Monitoring Program includes the description of:

- surface water monitoring;
- groundwater monitoring;
- vegetation monitoring;
- erosion monitoring; and
- final cover system monitoring.

The current Rehabilitation Monitoring Program is focused on rehabilitation performance monitoring and is a refinement of the program that has been in place since 1996. The emphasis is on water and vegetation monitoring and will continue until sufficient data is available to confirm rehabilitation trends satisfy the completion criteria identified in Section 8. In the event rehabilitation monitoring indicates ineffective final cover systems and/or poor vegetation performance, additional reclamation works will be conducted.

Experimental and Statistical Design

A Rehabilitation Monitoring Program has been prepared for the Project and is provided as Attachment A. The Rehabilitation Monitoring Program includes three analogue monitoring sites and 12 rehabilitation monitoring sites (Figure 2). The parameters identified in the Rehabilitation Monitoring Program are collected at both the analogue monitoring sites and the rehabilitation monitoring sites. Comparisons between the data from the analogue monitoring sites and the rehabilitation monitoring sites will be made with the objective of:

- determining if there is significant statistical difference between the analogue monitoring sites and rehabilitation monitoring sites; and/or
- establishing relevant trends from the rehabilitation monitoring site data which establish that these sites demonstrate similar characteristics to the analogue monitoring sites.

In the event that the data indicates no significant difference between the analogue monitoring sites and rehabilitation monitoring sites and/or a trend toward the analogue monitoring site values, it will be considered that the rehabilitation monitoring sites are characteristic of analogue monitoring sites. If the data indicates that there is a significant difference between the analogue monitoring sites and rehabilitation monitoring sites and/or there is no evident trend of rehabilitation monitoring site data toward the analogue monitoring site values, an investigation will be conducted to determine the likely cause of the difference and/or trend (e.g. bushfire has occurred at one monitoring site and not the other). If the investigation indicates the likely cause of the difference and/or trend is likely to be due to rehabilitation site characteristics, additional rehabilitation works will be conducted, amelioration measures will be implemented and/or more time will be allowed for the revegetation performance to improve.

7 GRAZING MANAGEMENT PLAN

A Grazing Management Plan for the Project has been prepared in accordance with Condition C2 2(o) of the EA and is provided as Attachment B.

8 COMPLETION CRITERIA

Measurable completion criteria will provide the ability to monitor the performance of the rehabilitation. The measurable completion criteria for the final landforms, revegetation, surface water and groundwater are outlined below.

8.1 FINAL LANDFORMS

The completion criteria for the final landforms at the Project are outlined in Table 11.

Table 14: Final Landforms Completion Criteria

Rehabilitation Type	Completion Criteria
Final Landforms	• Post mining landforms will be rehabilitated in accordance with rehabilitation objectives defined in Schedule C – Table 1 of the EA which is provided in Table 2. The post mining landforms will: • be stable now and in the foreseeable future; • have a low probability of subsidence, rock falls and/ or slope slippage ; and • have comparable management requirements similar to the non mined land surrounding the Project by demonstrating that the site can sustain a low intensity grazing / disturbed native habitat landuse. The parameters measured will include : • no observable subsidence, rock falls and/ or slope slippage ; • incidence of erosion; and • results from geotechnical investigation (Section 3).

8.2 REVEGETATION

The completion criteria for the revegetated areas at the Project are outlined in Table 12.

Table 15: Revegetation Completion Criteria

Rehabilitation Type	Completion Criteria
Revegetation	• Establish a self sustaining natural vegetation cover on all post mining landforms. • Species diversity is comparable to the surrounding areas of the Project. • Species abundance is comparable to the surrounding areas of the Project. • The abundance of weeds is minimal. • Species composition is comparable to the surrounding areas of the Project. • Projective cover is comparable to the surrounding areas of the Project: Groundcover is adequate to support the intended post mining landuse and is self sustaining. Tree cover is adequate to support the intended post mining landuse and is self sustaining. • Dry matter production is comparable to the surrounding areas of the Project. Nutrient cycling is occurring. Leaf litter is assisting in limiting erosion on the soil/spoil surface. • Stocking rates maintain self sustaining vegetation cover at the Project.

In order to maintain the revegetation performance and satisfy the revegetation completion criteria described above, domesticated stock will be excluded from the western section of ML 5248 (i.e. Content and Lady Isabella mining areas). Controlled low intensity grazing of domesticated stock during the dry season will occur on the eastern section of ML 5248 (i.e. Golden Butterfly mining area) as described in the Grazing Management Plan (Attachment B).

8.3 SURFACE WATER

The completion criteria for surface water, including receiving waters and on site storages, at the Project are outlined in Table 17 to Table 21.

Table 16: Surface Water Completion Criteria

Rehabilitation Type	Completion Criteria
Receiving Waters	• The water quality at the receiving water monitoring locations defined in Schedule F – Table 1 of the EA (Table 14) will be in accordance with contaminant limits specified in Schedule F – Table 3 of the EA (Table 15).
On site Storages	• Any contaminated seepage water will be contained on site within the open pits. • Any on site storages, defined in Schedule F – Table 7 of the EA (Table 16), containing water that exceeds the contaminant limits defined in Schedule F – Table 8 of the EA (Table 17), will be fenced to exclude access by livestock and minimise access by native fauna.

Table 17: Schedule F – Table 1 of EA MIN100401906 Receiving Water Monitoring Sites

Monitoring point	Easting MGA (GDA 94)	Northing MGA (GDA 94)
SW 1 Lower Slaughteryard Creek	630350	7986405
SW 2 Slaughteryard West Tributary at the ML boundary	630197	7987640
SW 3 Slaughteryard Creek upstream of the Golden Butterfly waste rock dump	TBA[2]	TBA[2]
SW 6 Belmore Creek borrow pit / stock dam	627908	7989454
Reference Site[1]		
SW 3b Reference point for Slaughteryard creek	613208	7988220
SW 7 Reference point for Belmore Creek	TBA[2]	TBA[2]

[1] Reference sites must:
(a) be from the same bio geographic and climatic region; and
(b) have similar geology, soil types and topography; and
(c) contain a range of habitats similar to those at the test sites; and
(d) have a similar flow regime; and
(e) not be so close to the test sites that any disturbance at the test site also results in a change at the reference site.

[2] TBA – Location co ordinates to be provided to the Administering Authority by 30 September 2008.

Table 18: Schedule F – Table 2 of EA MIN100401906 Receiving Water Contaminant Limits

Parameter	Unit	Test Value	Contaminant Limit[2]
pH	pH unit	Range	Greater than 5, less than 9
EC	µS/cm	Maximum	5970 [1]
Sulphate	mg/L	Maximum	1000 [1]
Fluoride	mg/L	Maximum	2 [1]
Aluminium [2]	mg/L	Maximum	5 [1]
Arsenic [2]	mg/L	Maximum	0.5 [1]
Boron [2]	mg/L	Maximum	5 [1]
Cadmium [2]	mg/L	Maximum	0.01 [1]
Chromium [2]	mg/L	Maximum	1 [1]
Cobalt [2]	mg/L	Maximum	1 [1]
Copper [2]	mg/L	Maximum	1 [1]
Mercury [2]	mg/L	Maximum	0.002 [1]
Nickel [2]	mg/L	Maximum	1 [1]
Selenium [2]	mg/L	Maximum	0.02 [1]
Zinc [2]	mg/L	Maximum	20 [1]

[1] Contaminant limit based on Australian and New Zealand Environment and Conservation Council (ANZECC) (2000) stock water quality guidelines.

[2] Analysis for soluble metal concentrations only, not totals.

Table 19: Schedule F – Table 7 of EA MIN100401906 On-site Storage Monitoring Sites

Monitoring Point	Easting MGA (GDA 94)	Northing MGA (GDA 94)
Golden Butterfly Pit (base of ramp)	631140	7987525
Golden Butterfly North Pit (base of ramp)	630545	7987921
Lady Isabella Pit (base of ramp)	629473	7990023
Content Pit (base of ramp)	629048	7990435
SW 3a Golden Butterfly waste rock dump toe drain	630913	7988253
SW 4 Stock water dam	631049	7987892
SW 5 Sediment dam at lease boundary	628691	7990012

Table 20: Schedule F – Table 8 of EA MIN100401906 On-site Storage Monitoring Sites

Parameter	Unit	Test Value	Contaminant Limit
pH	pH unit	Range	Greater than 4, less than 9[1]
EC	µS/cm	Maximum	5970 [2]
Turbidity	TDS	Maximum	4000 [2]
Sulphate	mg/L	Maximum	1000 [2]
Fluoride	mg/L	Maximum	2[2]
Aluminium[3]	mg/L	Maximum	5[2]
Arsenic[3]	mg/L	Maximum	0.5[2]
Boron[3]	mg/L	Maximum	5[2]
Cadmium[3]	mg/L	Maximum	0.01[2]
Chromium[3]	mg/L	Maximum	1[2]
Cobalt[3]	mg/L	Maximum	1[2]
Copper[3]	mg/L	Maximum	1[2]
Mercury[3]	mg/L	Maximum	0.002[2]
Nickel[3]	mg/L	Maximum	1[2]
Selenium[3]	mg/L	Maximum	0.02[2]
Zinc[3]	mg/L	Maximum	20[2]

1 Page 4.2 15 of ANZECC (2000) "Soil and animal health will not generally be affected by water with pH in the range of 4–9".

2 Contaminant limit based on ANZECC (2000) stock water quality guidelines.

3 Analysis for soluble metal concentrations only, not totals.
TDS = total dissolved solids

8.4 GROUNDWATER

The completion criteria for groundwater at the Project are outlined in Table 22 to Table 24.

Table 21: Groundwater Completion Criteria

Rehabilitation Type	Completion Criteria
Groundwater	• The water quality at the groundwater monitoring locations identified in Schedule F – Table 9 of the EA (Table 19) will be in accordance with contaminant limits specified in Schedule F – Table 11 of the EA (Table 20). • Confirmation of the conceptual hydrogeological model described in Section 5.2.

Table 22: Schedule F – Table 9 of EA MIN100410906 Groundwater Monitoring Sites

Monitoring Point	Easting MGA (GDA94)	Northing MGA (GDA94)	Surface RL[1] (m)	Monitoring Frequency
BH1 west of Golden Butterfly Pit	631270	7987673	TBA[2]	Annually during the dry season
BH2 east of Golden Butterfly Pit	630985	7987444	TBA[2]	Annually during the dry season
BH3 east of Golden Butterfly Waste Rock Dump	TBA[2]	TBA[2]	TBA[2]	Annually during the dry season
BH5 east of Golden Butterfly Waste Rock Dump	630987	7988051	TBA[2]	Annually during the dry season
BH7 east of Golden Butterfly Waste Rock Dump	631000	7988150	TBA[2]	Annually during the dry season
BH8 (east of Golden Butterfly Waste Rock Dump)	TBA[3]	TBA[3]	TBA[3]	Annually during the dry season
BH9 east of Golden Butterfly Waste Rock Dump	TBA[3]	TBA[3]	TBA[3]	Annually during the dry season
BH10 west of Content Waste Rock Dump	TBA[3]	TBA[3]	TBA[3]	Annually during the dry season
BH11 west of Content Waste Rock Dump	TBA[3]	TBA[3]	TBA[3]	Annually during the dry season
BH12 west of Content Waste Rock Dump at lease boundary	TBA[3]	TBA[3]	TBA[3]	Annually during the dry season
GBMB1 Slaughteryard Creek	630894	7987274	TBA[2]	Annually during the dry season
GBMB3 Slaughteryard Creek	630685	7987087	TBA[2]	Annually during the dry season
GBMB6 Slaughteryard Creek	630257	7986656	TBA[2]	Annually during the dry season
SY1 Slaughteryard Creek	TBA[3]	TBA[3]	TBA[3]	Annually during the dry season

[1] Relative Level (RL) measurement to be taken from top of bore casing.

[2] TBA to be provided by 30 September 2008.

[3] Co ordinates and elevation to be determined once the proposed bores have been constructed.

Table 23: Schedule F – Table 11 of EA MIN100410906 Groundwater Contaminant Limits

Parameter	Unit	Test Value	Contaminant Limit
pH	pH unit	Range	Greater than 5, less than 9
EC	µS/cm	Maximum	5970 [1]
Turbidity	TDS	Maximum	4000 [1]
Sulphate	mg/L	Maximum	1000 [1]
Fluoride	mg/L	Maximum	2 [1]
Aluminium [2]	mg/L	Maximum	5 [1]
Arsenic [2]	mg/L	Maximum	0.5 [1]
Boron [2]	mg/L	Maximum	5 [1]
Cadmium [2]	mg/L	Maximum	0.01 [1]
Chromium [2]	mg/L	Maximum	1 [1]
Cobalt [2]	mg/L	Maximum	1 [1]
Copper [2]	mg/L	Maximum	1 [1]
Mercury [2]	mg/L	Maximum	0.002 [1]
Nickel [2]	mg/L	Maximum	1 [1]
Selenium [2]	mg/L	Maximum	0.02 [1]
Zinc [2]	mg/L	Maximum	20 [1]

[1] Contaminant limit based on ANZECC (2000) stock water quality guidelines.

[2] Analysis for soluble metal concentrations only, not totals.

9 RESEARCH PROGRAM

Research programs and/or trials will be commissioned in instances where baseline environmental surveys and/or on going monitoring indicate the need for additional specific studies. No specific research programs have been proposed. Where additional research activities are considered appropriate, the timing and nature, including associated milestones, of the research programs will be provided to the EPA.

10 REVIEW

EA Condition A2 4 is of additional relevance to this PMLP and is provided below:

> *(A2-4) Any management or monitoring plans, systems or programs required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm as often as necessary but at least every two years and amended promptly if required.*

In accordance with Condition A2 4 of the EA this PMLP will be reviewed for effectiveness at least every two years and amended promptly when required.

11 REFERENCES

Australian and New Zealand Environment and Conservation Council (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*

Barrick Gold of Australia (2008a) *Croydon Gold Mine – Plan of Operations.*

Barrick Gold of Australia (2008b) *Croydon Gold Mine Project – Environmental Management Plan.*

Barrick Gold of Australia (2010) *Croydon Gold Mine Project – Hydrological Investigation*, June 2010.

Barrick Gold of Australia (2011) *Croydon Mine – 2010 Revegetation Efforts Monitoring, Evaluation and Recommendations*, November 2011.

Barrick Gold of Australia (2011) *Croydon Gold Mine – Plan of Operations.*

Commonwealth Bureau of Meteorology (2008) *Climate Averages for Australian Sites – Averages for Croydon Township.*
Internet site: http://www.bom.gov.au/climate/averages/tables/cw_029012.shtml
Date retrieved: 22 September 2008.

Department of Minerals and Energy (1998) *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland.*

Fawcett, M. (2001) *Rehabilitation works undertaken at Croydon in 1996 and 1997*. Letter report prepared by Fawcett Mine Rehabilitation Services Pty Ltd for Goldfields Limited, May 2001.

HLA Enviroscience s (2001a) *Draft Final Rehabilitation Report – Croydon Gold Mine*. Report prepared for Goldfields Ltd, November 2001.

HLA Enviroscience s (2001b) *Water Level Analysis of Golden Butterfly Pit – Croydon Gold Mine*. Report prepared for Goldfields Ltd, May 2001.

Landline Consulting (2007) *Croydon ML 5248 Monitoring Report 2006*. Report prepared for Barrick Gold of Australia, April 2007.

Woodward Clyde (1996) *Croydon Gold Mine – (Amended) Decommissioning Plan for ML 5248.* Report prepared for Pancontinental Mining Limited.

ATTACHMENT A
REHABILITATION MONITORING PROGRAM

CROYDON GOLD MINE

REHABILITATION MONITORING PROGRAM

DECEMBER 2011

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1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Barrick holds Environmental Authority No. MIN100401906 (EA) for the Project.

This Rehabilitation Monitoring Program (RMP) has been prepared in accordance with EA Condition C2 2:

> *C2-2 The Post Mine Land Use Plan must be included in the Plan of Operations and updated with each subsequent Plan of Operations, describing how the rehabilitation objectives in Schedule C – Table 1 will be achieved. The Post Mine Land Use Plan must include:*
> *…*
> *(n)* ***rehabilitation monitoring program****, including the monitoring of:*
> *(i) surface water quality;*
> *(ii) groundwater quality;*
> *(iii) erosion rates;*
> *(iv) integrity and effectiveness of final cover systems; and*
> *(v) health and resilience of vegetative cover.*

Other EA conditions of relevance to this RMP are provided below:

> *C3-1 The holder of the environmental authority must conduct a Rehabilitation Monitoring Program on at least a yearly basis, which must include sufficient spatial and temporal replication to enable scientifically justifiable conclusions as established under the rehabilitation program or other methodology to the satisfaction of the Administering Authority.*
>
> *C3-2 The rehabilitation monitoring program must be developed by 1 October 2008 and be implemented by a person nominated by the environmental authority holder possessing appropriate qualifications and experience in the field of rehabilitation management.*
>
> *C3-3 Verification of rehabilitation success is to be determined by comparison with the criteria documented in the Post Mine Land Use Plan required under Condition C2-1.*

The above conditions are also addressed where relevant in this RMP.

In accordance with EA Condition C2 2 this RMP will be included in the Croydon Gold Mine Plan of Operations.

The remainder of this RMP is structured as follows:

Section 2: Provides a description of the Project.

Section 3: Presents an overview of rehabilitation monitoring at the Project.

Section 4: Details the surface water monitoring program.

Section 5: Illustrates the stream sediment monitoring program.

Section 6: Presents the groundwater monitoring program.

Section 7: Describes the rehabilitation monitoring program.

Section 8: Details monitoring of erosion and the final cover systems at the Project.

Section 9: Describes the review process for this RMP.

Section 10: Lists the references cited in this RMP.

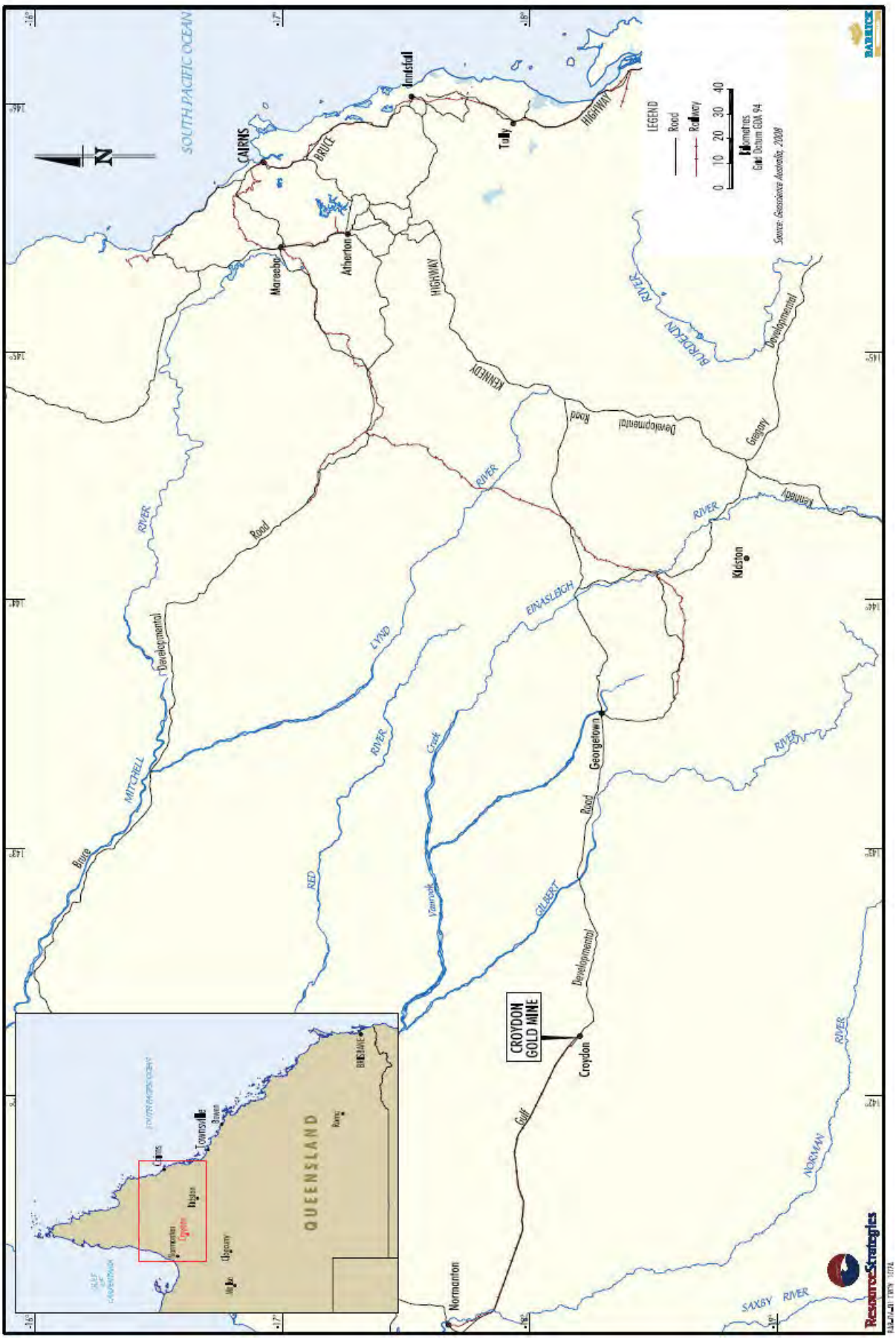

Figure 1: Regional Location

2 BACKGROUND

Extensive gold mining at the Project commenced in the late 1880s for approximately 30 years, before recommencing in 1987. Operational mining ceased in 1990 and the Project was decommissioned by late 1993 (Barrick, 2008). Reclamation performance was audited in 1996/97 and significant additional reclamation works were undertaken in 1996 and 1997 (Barrick, 2008).

The mining related landforms on ML 5248 comprise of waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps.

Specifically they include (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Golden Butterfly waste rock dump;
- Content Pit;
- Content waste rock dump;
- Lady Isabella Pit;
- abandonment bunds across the access ramps of the four open pits;
- hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps;
- water diversion bunds and sediment dams adjacent to the Content and Golden Butterfly waste
- rock dumps; and
- roads and tracks.

Schematic diagrams of the final landforms, inclusive of drainage features, are provided in Figure 3 of the Post Mine Landuse Plan (Appendix A of the Plan of Operations [Barrick, 2008a]).

The final landform concept is to achieve a stable post mining landform that is able to meet the identified post mining landuse and rehabilitation objectives. The post mining land descriptions and rehabilitation objectives are specified in Schedule C – Table 1 of the EA, which is reproduced in Table 2.

3 OVERVIEW OF PROJECT REHABILITATION MONITORING

Monitoring of surface water, groundwater, vegetation and soil fertility at the Project has been conducted since 1997. Annual rehabilitation monitoring results are available from 1997 to 2001 and from 2004 to present. Vegetation, soil fertility and erosion monitoring has occurred at vegetation monitoring transects on the Golden Butterfly and Content waste rock dumps and at analogue transects between these two waste rock dumps (Figure 2).

Surface water monitoring has occurred at monitoring sites in the receiving waters of Slaughteryard Creek and Belmore Creek, as well as at the base of the access ramp to the four open pit on site storages of Golden Butterfly Pit, Golden Butterfly North Pit, Lady Isabella Pit and Content Pit (Figure 2).

Groundwater monitoring has occurred at BH1 and BH2 adjacent to the Golden Butterfly Pit, BH3, BH5 and BH7 on the eastern side of the Golden Butterfly waste rock dump and at bores GBMB1, GBMG3 and GBMB6 parallel to Slaughteryard Creek (Figure 2).

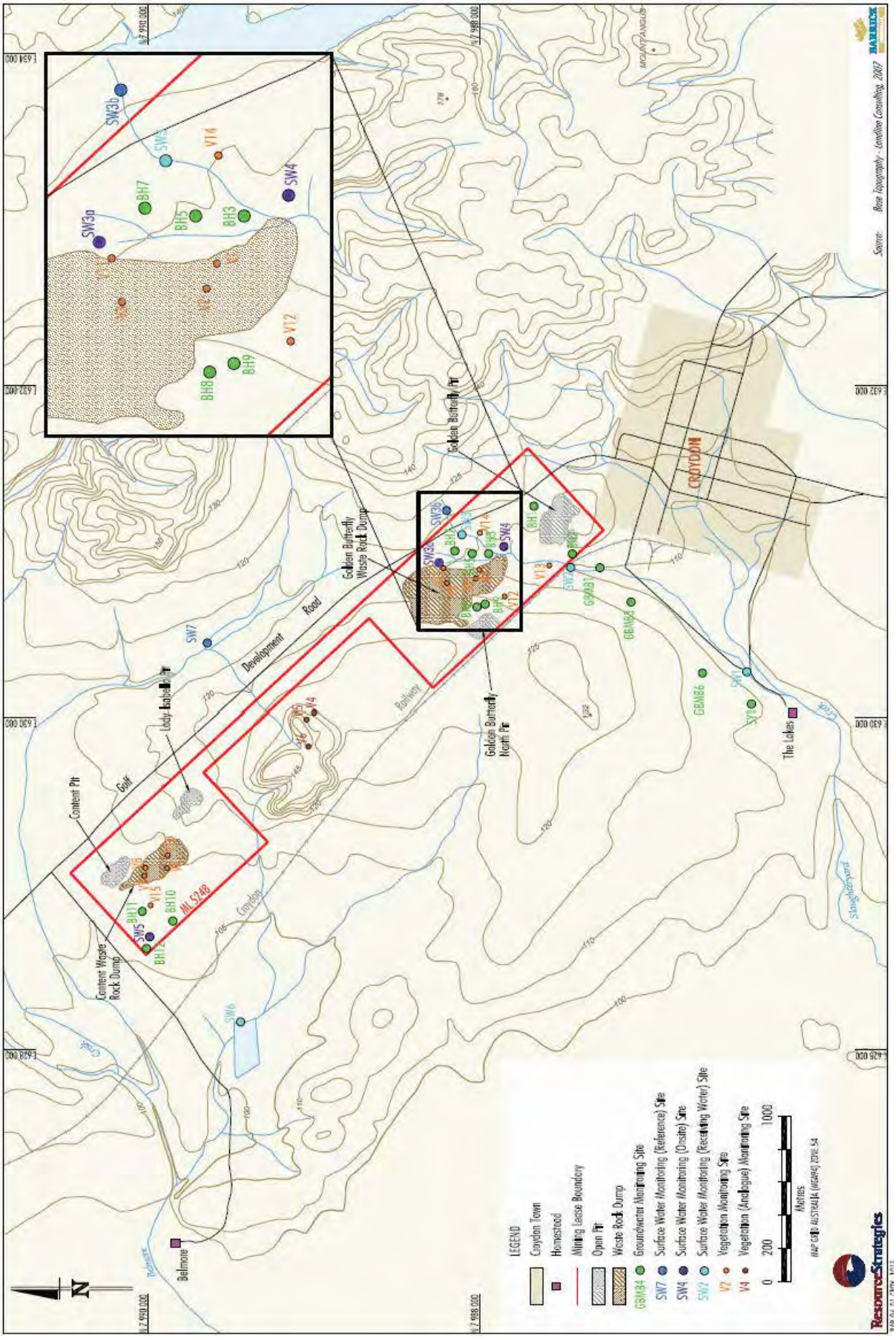

Figure 2: Site Location and Location of Environmental Monitoring Stations

4 SURFACE WATER MONITORING

Surface water monitoring will be conducted at the Project in accordance with EA No. MIN100401906. A description of the surface water monitoring program is provided in Sections 4.1 and 4.2.

The surface water monitoring program described below is based on the existing monitoring program currently implemented at the Project.

4.1 RECIEVING WATERS

In accordance with EA Condition F1 3 receiving waters monitoring will be conducted at the locations defined in Schedule F – Table 1 of the EA for the parameters identified in Schedule F – Tables 2 and 3 of the EA. The frequency of monitoring will be conducted in accordance with EA Condition F1 3. A summary of the receiving waters monitoring for the Project is provided in Table 1.

Table 1: Receiving Water Monitoring Programme

Monitoring Location (refer Figure 2)	Frequency	Parameters
SW1 Lower Slaughteryard Creek	For routine monitoring: • Twice yearly once during wet season (January – March) & once during dry season (July – September). Event based sampling of discharge event[1] or flow events[2]: • One representative sample must be taken of a discharge event or flow event. • Where a discharge event or a flow event has a duration of 24 hours or greater, samples must be taken	pH EC Turbidity Sulphate Fluoride Aluminium Arsenic Boron Cadmium Chromium (CrVI) Cobalt Copper Mercury (inorganic) Nickel Selenium (total) Zinc
SW 2 Slaughteryard Creek West Tributary at the ML boundary		
SW 3 Slaughteryard Creek upstream of the Golden Butterfly WRD		
SW 6 Belmore Creek borrow pit / stock dam		
Reference Sites		
SW3b Reference point for Slaughteryard Creek		
SW 7 Reference point for Belmore Creek		

1 Discharge event is an unauthorised surface water discharge from water storages or contaminated areas on the licensed place.
2 Flow event is a surface water flow in Slaughteryard Creek and/ or Belmore Creek that occurs as a result of rainfall.
Note: Where discharge events or flow event occur simultaneously only one set of samples are required to be taken.
No sample is required where there is insufficient flow during the dry season (July – September).

The sampling method for the receiving waters will comply with the latest edition of the Environment al Protection Agency's Water Quality Sampling Manual in accordance with EA Condition F1 2. As required by EA Condition F1 6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

4.2 ON-SITE STORAGES

In accordance with EA Condition F3 1 monitoring of the on site storages will be conducted at the locations defined in Schedule F – Table 7 for the parameters identified in Schedule F – Table 8. The frequency of monitoring will be conducted in accordance with EA Condition F3 1. A summary of the monitoring for the on site storages for the Project is provided in Table 2.

Table 2: On-site Storages Monitoring Programme

Monitoring Location (refer Figure 2)	Frequency	Parameters
Golden Butterfly Pit (base of ramp) Golden Butterfly North Pit (base of ramp) Lady Isabella Pit (base of ramp) Content Pit (base of ramp) SW3a Golden Butterfly WRD toe drain SW 4 Stock water dam SW 5 Sediment Dam at lease boundary	For routine monitoring: • Twice yearly once during wet season (January – March) & once during dry season (July – September). Event based sampling of discharge event[1] or flow events[2]: • One representative sample must be taken of a discharge event or flow event. • Where a discharge event or a flow event has a duration of 24 hours or greater, samples must be taken	pH EC Turbidity Sulphate Fluoride Aluminium Arsenic Boron Cadmium Chromium (CrVI) Cobalt Copper Mercury (inorganic) Nickel Selenium (total) Zinc

1 Discharge event is an unauthorised surface water discharge from an on site water storage.

Note:

Samples must be analysed for all parameters listed in Schedule F – Table 8.

Monitoring of the storage is to be conducted at the spillway.

No sample is required where there is insufficient water present in on site locations during the dry season (July – September).

The sampling method for the on site storages will comply with the latest edition of the Environmental Protection Agency's Water Quality Sampling Manual in accordance with EA Condition F1 2. As required by EA Condition F1 6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

5 STREAM SEDIMENT MONITORING

In accordance with EA Condition F2 1 stream sediment monitoring will be conducted at the locations and frequencies defined in Schedule F – Table 4 of the EA for the parameters identified in Schedule F – Table 5 and Table 6 of the EA. A summary of the stream sediment monitoring for the Project is provided in Table 3.

Table 3: Stream Sediment Monitoring Program

Monitoring Location (refer Figure 2)	Frequency	Parameters
SW1 Lower Slaughteryard Creek	Twice yearly in wet season (January – March) & dry season (July – September).	Aluminium Arsenic Boron Cadmium Chromium Cobalt Copper Mercury Nickel Selenium Zinc
SW2 Slaughteryard Creek West Tributary at the ML boundary		
SW3 Slaughteryard Creek upstream of the Golden Butterfly WRD		
SW6 Belmore Creek borrow pit / stock dam		
Reference Sites		
SW3b Reference point for Slaughteryard Creek		
SW7 Reference point for Belmore Creek		

The sampling method for stream sediment will comply with the Australian Standard 5667. 12 Guidance on Sampling of Bottom Sediments 1998 in accordance with EA Condition F2 4. As required by EA Condition F1 6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

6 GROUNDWATER MONITORING

Groundwater monitoring will be conducted at the Project in accordance with EA No. MIN100401906. A description of the groundwater monitoring program is provided below. The groundwater monitoring program described below is based on the existing monitoring program currently being used at the Project.

In accordance with EA Condition F4 1 groundwater monitoring will be conducted at the locations and frequencies defined in Schedule F – Table 9 of the EA for the parameters identified in Schedule F – Tables 10 and 11 of the EA. A summary of the groundwater monitoring for the Project is provided in Table 4.

Table 4: Groundwater Monitoring Program

Monitoring Location (refer Figure 2)	Frequency	Parameters
BH1 North of Golden Butterfly Pit	Annually during the dry season	pH EC Turbidity Sulphate Fluoride Aluminium Arsenic Boron Cadmium Chromium (CrVI) Cobalt Copper Mercury (inorganic) Nickel Selenium (total) Zinc
BH2 South west of Golden Butterfly Pit		
BH3 South east of Golden Butterfly Waste Rock Dump		
BH5 East of Golden Butterfly Pit Waste Rock Dump		
BH7 East of Golden Butterfly Waste Rock Dump		
BH8 West of Golden Butterfly Waste Rock Dump		
BH9 West of Golden Butterfly Waste Rock Dump		
BH10 West of Content Waste Rock Dump		
BH11 West of Content Waste Rock Dump		
BH12 West of Content Waste Rock Dump at lease boundary		
GBMB1 Slaughteryard Creek		
GBMB3 Slaughteryard Creek		
GBMB6 Slaughteryard Creek		
SY1 Slaughteryard Creek		

The sampling method for groundwaters will comply with the latest edition of the Environmental Protection Agency's Water Quality Sampling Manual in accordance with EA Condition F1 2. As required by EA Condition F1 6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

In accordance with EA Condition F4 4 annual groundwater reports analysing the groundwater chemistry and hydrogeological status of all groundwater bores and groundwater conditions will be prepared by November each year.

7 REHABILITATION MONITORING

A monitoring program will be implemented to assess the performance of rehabilitation at the Project. In accordance with EA Conditions C3 1 and C3 2, rehabilitation monitoring will be conducted on at least a yearly basis by a person nominated by Barrick possessing appropriate qualifications and experience in the field of rehabilitation management.

The monitoring program described below is based on the existing monitoring program currently being used at the Project. Section 7.1 describes the monitoring program, Section 7.2 discusses data analysis and assessment, and Section 7.3 outlines rehabilitation objectives and criteria.

7.1 MONITORING PROGRAM

7.1.1 Location of Monitoring Transects

Rehabilitation monitoring will be conducted at 12 vegetation transect sites (Figure 2). Each of the transect sites is 50 metres long. Four transect sites have been established on the Golden Butterfly waste rock dump, four transect sites have been established on the Content waste rock dump, and four transect sites will be established on areas of general disturbance (Figure 2).

In addition, three transect sites have been established as analogue sites. These analogue transect sites are located to the south of ML 5248 between the Golden Butterfly and Content waste rock dumps (Figure 2).

7.1.2 Monitoring Parameters

Vegetation

The following vegetation parameters will be monitored at each of the transect sites:

- tree density;
- tree height;
- tree species composition;
- pasture biomass;
- pasture cover;
- pasture species composition;
- weed abundance; and
- dry matter production.

In addition to the above, a photographic record will be taken of each transect. The health and resilience of the vegetation cover at the Project will be determined by the performance of the vegetation parameters identified above.

Soils

Soil samples will be taken to a depth of ten centimetres at five metre intervals along the transect sites. Large debris and stone will be extracted from the soil samples before they are sent to a commercial laboratory for analysis for the following parameters:

- pH (1:5 soil:H2O);
- EC (1:5 soil:H2O);
- nitrate;
- extractable phosphorus;
- organic carbon;
- total nitrogen and total carbon;
- cation exchange capacity (CEC);
- exchangeable cations (calcium, magnesium, potassium, sodium and aluminium); and
- DTPA extractable copper, zinc, iron and manganese.

7.2 DATA ANALYSIS AND ASSESSMENT

The rehabilitation monitoring results obtained from annual monitoring will be reviewed by a person possessing appropriate qualifications and experience in the field of rehabilitation management to track rehabilitation progress against the analogue sites and the rehabilitation objectives and criteria discussed in Section 7.3.

The monitoring programs outlined in this RMP will allow sufficient spatial and temporal replication to enable scientifically justifiable conclusions to be established.

7.3 REHABILITATION OBJECTIVES AND CRITERIA

7.3.1 Rehabilitation Objectives

The rehabilitation objectives for the Project are prescribed in Condition C1 1 of the EA in Schedule C – Table 1 which is reproduced in Table 5. This condition requires ML 5248 (except for the open pits) to be rehabilitated to a post mine landuse of low intensity grazing/disturbed native habitat. Condition C1 1 of the EA also requires ML 5248 (except for the open pits) to be rehabilitated to a land classification of Class VI or better (DME, 1995).

The open pits are required to be rehabilitated to a post mine landuse of "non beneficial land use" and to a land classification of Class VIII (DME, 1995) by Condition C1 1 of the EA.

Table 5: Schedule C – Table 1 of the EA MIN10401906

		Rehabilitation Objectives		
Landform (refer Schedule H – Map 1)	**Surface Area (ha)**	**Post-mine Land Description**	**Land Classification[1]**	**Analogue Site Identification**
Golden Butterfly North Pit	1.6	Non beneficial land use	Class VIII	Sites to be rehabilitated to a standard nominated in the rehabilitation program developed in accordance with Condition C2 1 based on analogue sites.
Golden Butterfly Pit	5.1	Non beneficial land use	Class VIII	
Lady Isabella Pit	1.7	Non beneficial land use	Class VIII	
Content Pit	2.1	Non beneficial land use	Class VIII	
Content Dump	6.3	L.I.G[2]/ disturbed native habitat	Class VI or better	
Golden Butterfly Dump	15.2	L.I.G[2]/ disturbed native habitat	Class VI or better	
Content Hardstand	2.0	L.I.G[2]/ disturbed native habitat	Class VI or better	
Golden Butterfly Hardstand	0.5	L.I.G[2]/ disturbed native habitat	Class VI or better	
Sediment Dams	1.5	L.I.G[2]/ disturbed native habitat	Class VI or better	
Roads / Tracks	3.5	L.I.G[2]/ disturbed native habitat	Class VI or better	

1 Technical guidelines for the Environmental Management of Exploration and Mining in Queensland (DME), 1995.
2 L.I.G. (Low Intensity Grazing) defined by criteria listed in Land Use Acceptance Criteria

7.3.2 Rehabilitation Criteria

The Post Mine Landuse Plan (PMLP) (Appendix A of the Plan of Operations [Barrick, 2008a]) has been prepared in accordance with Condition C2 1 of the EA. As required by EA Condition C2 2, the PMLP includes the following:

(g) proposed revegetation criteria including:

(i) species diversity, abundance and composition;

(ii) projective cover;

(iii) dry matter production; and

(iv) stocking rates to ensure self sustaining vegetation is maintained.

…

(h) measurable completion criteria for each rehabilitation indicator that enables determination of rehabilitation success for each disturbance type.

In accordance with Condition C3 3 of the EA (Section 1) the verification of rehabilitation success will be determined by the comparison with the measurable completion criteria documented in Section 8 of the PMLP (Appendix A of the Plan of Operations [Barrick, 2008a]).

8 EROSION AND FINAL COVER SYSTEM MONITORING

8.1 EROSION MONITORING

Erosion monitoring at the Project will consist of conducting an annual qualitative assessment at each of the vegetation monitoring transects listed in Section 7.1.1. In general accordance with the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME, 1995) this will include:

- field traverses to observe incidence of erosion;
- recording details of any incidence of erosion (e.g. rills and sheeting); and
- maintaining a photographic record for comparison.

In addition to the above, the following parameters will be monitored as part of the rehabilitation monitoring program at the vegetation monitoring transects to provide an indication of the potential for erosion at the Project:

- tree density;
- pasture biomass;
- pasture cover; and
- pasture species composition.

8.2 FINAL COVER SYSTEM MONITORING

The final cover system of the Content waste rock dump and the Golden Butterfly waste rock dump consists of a clay capping layer, a rock fill surface protection layer and topsoil layer, except for the western batter of the Content waste rock dump.

The performance of the final cover system at the Project is monitored indirectly via erosion, vegetation and water monitoring. These monitoring parameters provide an indirect indication of the integrity of the final cover system. Erosion and vegetation cover monitoring on the waste rock dumps will be monitored at the sites listed in Section 7.1.1 utilising the parameters identified in Section 8.1 for erosion monitoring and in Section 7.1.2 for vegetation cover monitoring.

Potential failure of the final cover system would possibly result in impacts on surface water and groundwater quality and vegetation cover performance. Accordingly, the integrity and effectiveness of the final cover systems at the Project are monitored indirectly via surface water, groundwater, vegetation and erosion monitoring (Sections 4, 6, 7 and 8).

9 REVIEW

EA Condition A2 4 is of additional relevance to this RMP and is provided below:

(A2-4) Any management or monitoring plans, systems or programs required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm as often as necessary but at least every two years and amended promptly if required.

In accordance with Condition A2 4 of the EA this RMP will be reviewed for effectiveness at least every two years and amended promptly when required.

10 REFERENCES

Barrick Gold of Australia (2008) *Croydon Gold Mine Project – Environmental Management Plan.*

Barrick Gold of Australia (2008a) *Croydon Gold Mine – Plan of Operations*.

Department of Minerals and Energy (1995) *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland,* Queensland Government.

ATTACHMENT B
GRAZING MANAGEMENT PLAN

CROYDON GOLD MINE

GRAZING MANAGEMENT PLAN

DECEMBER 2011

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1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Barrick holds Environmental Authority No. MIN100401906 (EA) for the Project.

This Grazing Management Plan (GMP) has been prepared in accordance with EA Condition C2 2:

> *C2-2 The Post Mine Land Use Plan must be included in the Plan of Operations and updated with each subsequent Plan of Operations, describing how the rehabilitation objectives in Schedule C – Table 1 will be achieved. The Post Mine Land Use Plan must include:*
> *…*
> *(o)* ***grazing management plan****.*

In accordance with EA Condition C2 2 this GMP will be included in the Croydon Gold Mine Plan of Operations.

The remainder of this GMP is structured as follows:

Section 2: Provides a background of the existing grazing practices and current vegetation cover at the Project.

Section 3: Identifies the objectives of this GMP.

Section 4: Provides details of how grazing will be managed at the Project.

Section 5: Outlines how grazing will be monitored at the Project.

Section 6: Describes the consultation process for this GMP.

Section 7: Describes the review process for this GMP.

Section 8: Lists the references cited in this GMP.

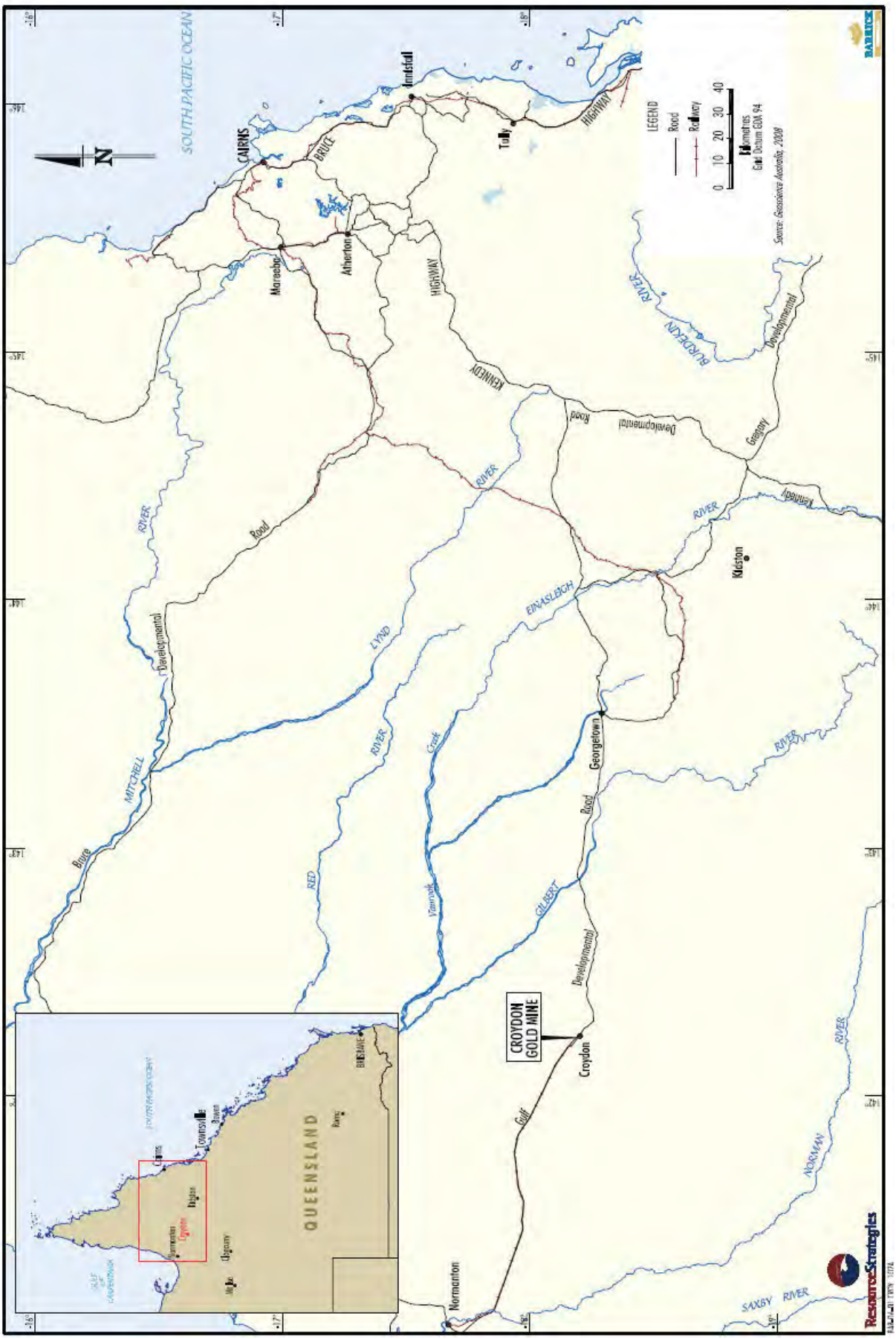

Figure 1: Regional Location

2 BACKGROUND

Existing Grazing Practices

Since the Project was decommissioned/ closed and final rehabilitation works were completed in 1996/ 1997 the eastern section of ML 5248 (i.e. area between the Golden Butterfly waste rock dump, Golden Butterfly Pit and Golden Butterfly North Pit) has been used by the Croydon Shire Council as a paddock for holding and grazing domesticated stock during the dry season (Figure 2). This eastern section of ML 5248 was previously a section of the Croydon Town Common which has traditionally been used for grazing of domesticated stock.

The western section of ML 5248 (i.e. area surrounding the Content waste rock dump, Content Pit and Lady Isabella Pit) is not currently fenced and domesticated stock graze this western section and surrounding areas (Figure 2).

Current Vegetative Cover

During the rehabilitation works conducted in 1996/1997 the rehabilitated areas at the Project were seeded with pasture species and trees and fertilised to stimulate growth (Landline Consulting, 2007). Fertilisation of the rehabilitated areas was repeated in 2004. As the Project experiences summer dominant rainfall, the productivity of native and improved pastures, coincides with the wet season (DNRW, 2008a). As a result higher levels of vegetation cover occur during the wet season and to a lesser extent during the dry.

The Golden Butterfly waste rock dump displays good potential for adequate and diverse plant communities (Barrick, 2011). However, illegal grazing is significantly impacting the landform in terms of vegetative cover and limiting the ability of the monitoring program to produce data to demonstrate achievement of success criteria. Despite this situation, the fact that the waste rock dump is a target for illegal grazing demonstrates substantial vegetative cover.

3 OBJECTIVES

The grazing management objectives on ML 5248 are to control grazing by implementing appropriate management measures that will:

- result in minimal impact on revegetation;
- encourage the development of a vigorous pasture and litter layer;
- enable the development of a tree layer that will be self sustaining and resistant to fire;
- reduce the potential for competitive advantage of weed growth; and
- assist with fire control.

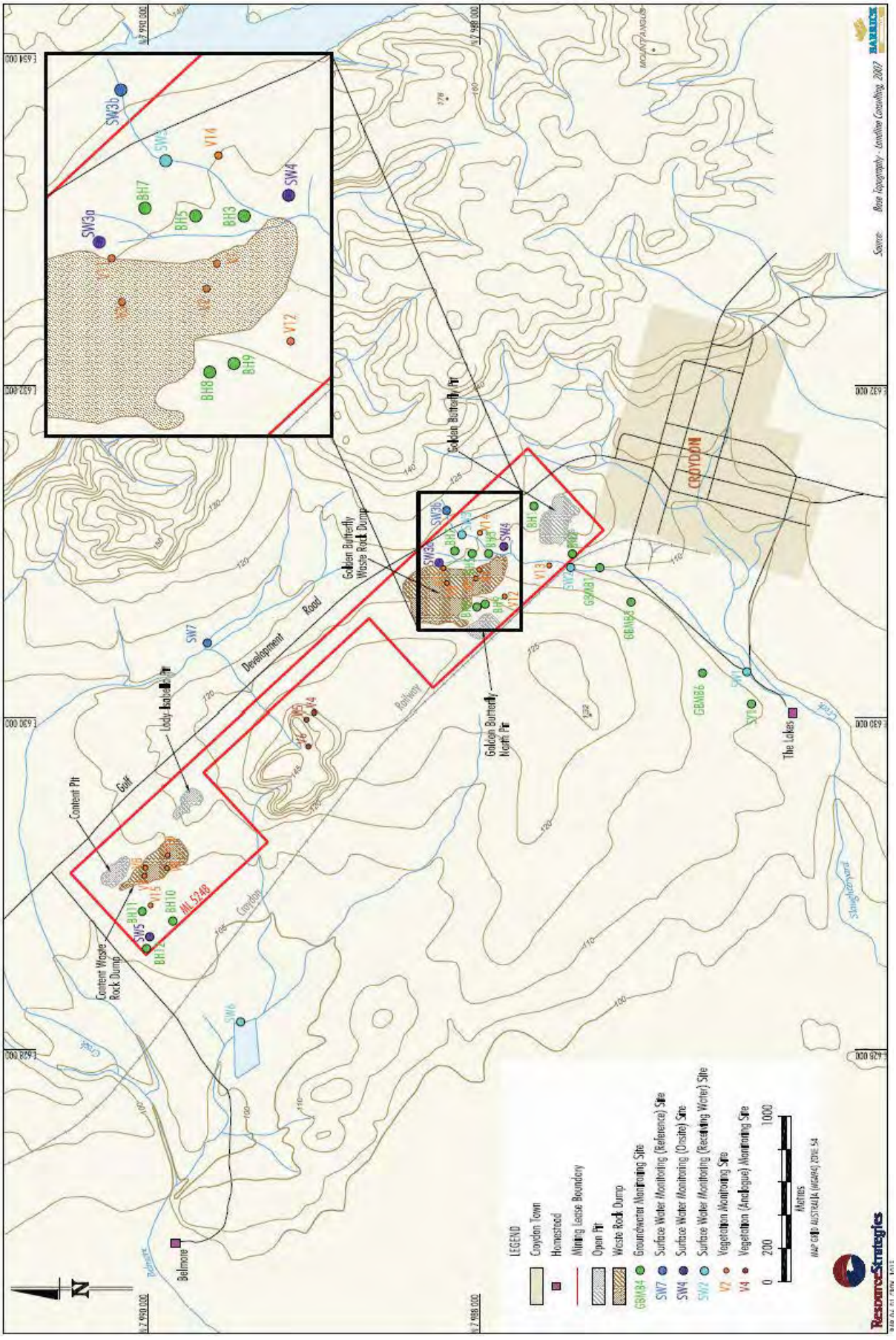

Figure 2: Site Location and Location of Environmental Monitoring Stations

4 MANAGEMENT OF GRAZING

Inappropriate stocking rates and overgrazing has the potential to inhibit rehabilitation performance at the Project. Pasture species seed during the late wet season therefore the impact of grazing is reduced if domesticated stock graze during the dry season only. However, excessive grazing in dry years can impact the survival of perennial pasture species, decreasing vegetative cover and exposing the surface soil to erosion and the introduction of weeds.

Stocking Rates

Ideal stocking rates match stock numbers to the available feed each year. It is considered that most native pastures will remain in good condition when no more than 30% of the summer growth is eaten (DNRW, 2008b). Groundcover yields during the mid dry season at the Project average approximately 30 to 50 kilograms per hectare (kg/ha) under current grazed conditions.

Low intensity grazing on the eastern section of ML 5248 (Figure 2) will assist with reducing fire hazards. Managing fuel loads through grazing assists with reducing the potential spread and intensity of any bushfires on ML 5248.

4.1 EASTERN SECTION OF ML 5248

The following grazing management measures will be implemented on the eastern section of ML 5248 (Figure 2):

- Low intensity grazing of domesticated stock will be conducted during the dry season.
- Supplementary feeding of domesticated stock will be provided by the owner of the domesticated stock during the dry season.
- Domesticated stock will be removed when vegetation monitoring indicates the vegetation cover cannot sustain further grazing without impacting on the revegetation performance (Section 5).
- Domesticated stock will be excluded during the wet season.
- Secure fencing will be maintained.

4.2 WESTERN SECTION OF ML 5248

Domesticated stock will be excluded from the western section of ML 5248 throughout the year (Figure 2). Secure fencing of the western section will be maintained.

5 MONITORING

As described in Section 4 domesticated stock will be removed from ML 5248 during excessively dry periods. The following vegetation parameters from the Rehabilitation Monitoring Program (RMP) (Section 7.1.2 of the RMP) will be monitored at the beginning of the dry season at the vegetation monitoring sites V1 to V3 and V11 to V14 (Figure 2) to assess the capacity of the vegetation cover to carry domesticated stock:

- pasture cover;
- pasture biomass; and
- pasture species composition.

To minimise the potential detrimental effects on the revegetation performance by overgrazing, domesticated stock will be excluded from the eastern section of ML 5248 if vegetation monitoring indicates:

- insufficient pasture cover and pasture biomass for the quantity of domesticated stock on the eastern section of ML 5248 as determined by visual observation of pasture cover and dry matter production monitoring (Section 7.1.2 of the RMP);
- incidence of erosion; and
- occurrence of weeds.

The Rehabilitation Monitoring Program is provided as Attachment A of Appendix A of the Plan of Operations (Barrick, 2008).

6 CONSULTATION

Contact with the Croydon Shire Council will be maintained throughout the year so:

- the eastern section of ML 5248 is not overgrazed (Sections 4 and 5); and
- that domesticated stock are excluded from the western section of ML 5248.

7 REVIEW

EA Condition A2 4 is of additional relevance to this RMP and is provided below:

(A2-4) Any management or monitoring plans, systems or programs required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm as often as necessary but at least every two years and amended promptly if required.

In accordance with Condition A2 4 of the EA this GMP will be reviewed for effectivenes s at least every two years and amended promptly when required.

8 REFERENCES

Barrick Gold of Australia (2008) *Croydon Gold Mine – Plan of Operations*.

Barrick Gold of Australia (2011) *Croydon Mine – 2010 Revegetation Efforts Monitoring, Evaluation and Recommendations*, November 2011.

Department of Natural Resources and Water (2008a) *Guide to the factors influencing carrying capacities of Queensland's rangelands*, Fact Sheet L 80, Queensland Government.

Department of Natural Resources and Water (2008b) *Managing for drought in grazing lands*, Fact Sheet L 90, Queensland Government.

Landline Consulting (2007) *Croydon ML 5248 Monitoring Report 2006*. Report prepared for Barrick Gold of Australia, April 2007.

Appendix B

EMERGENCY RESPONSE/CONTINGENCY PLAN

CROYDON GOLD MINE EMERGENCY

RESPONSE/CONTINENCY PLAN

JULY 2018

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1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low- grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Wilson Pty Ltd (Wilson) now holds the Environmental Authority No. EPML00950913 (EA) for the Project.

This Emergency Response/Contingency Plan (ER/CP) has been prepared in accordance with EA Condition A3-3:

> *(A3-3) An emergency response/contingency plan must be developed and implemented within the current plan of operations to manage the high risk categories identified in the risk assessment.*

Additional EA Conditions of relevance to this ER/CP are provided below:

> *(A3-1) The environmental authority holder must conduct a risk assessment for mining activities which conforms to the Australian Standard for Risk Management (AS/NZ 4360:2004) by 31 July 2009.*
>
> *(A3-2) The environmental authority holder must not implement risk control measures that contravenes or prevents the implementation of any condition of this environmental authority.*
>
> *(A4-1) The environmental authority holder must notify the administering authority by telephone or facsimile immediately after becoming aware of any emergency or incident resulting in, or having the potential to cause, environmental harm or any breach of condition of this environmental authority concerning releases of contaminants to the environment.*

In accordance with EA Condition A3-3 this ER/CP will be included in the Croydon Gold Mine Plan of Operations.

The remainder of this ER/CP is structured as follows:

Section 2: Provides details of the Emergency Response/Contingency Plan.

Section 3: Outlines the notification requirements involved in the ER/CP.

Section 4: Describes the review process for this ER/CP.

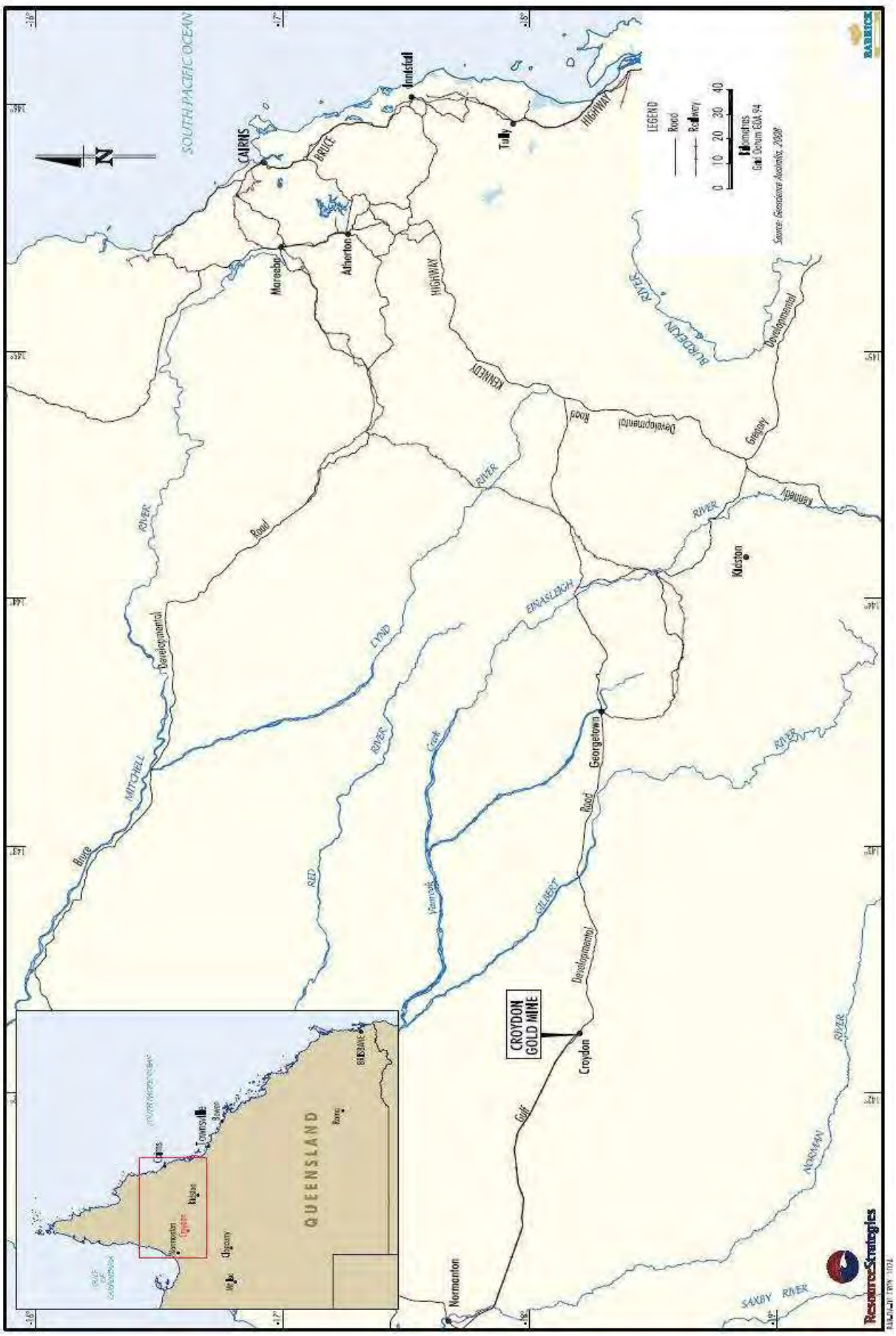

Figure 1: Regional Location

2 EMERGENCY RESPONSE/CONTINGENCY PLAN

This ER/CP provides general procedures to allow Wilson employees, contractors and visitors to respond safely and appropriately in emergency situations. As the Project is decommissioned/closed general emergency response procedures for the Project have been prepared. The general procedures included in this ER/CP are described in Table 1.

Table 1: General Emergency Procedures

Potential Hazards/ Incidents	Action
Fire	• Assess the situation – do not endanger yourself. • Notify the site supervisor. • Contact Emergency Services. • Determine if any hazardous materials are involved. • Use appropriate fire fighting equipment to minimise spread of the fire if safe to do so. • Standby in safe area for Emergency Services and provide relevant information.
Evacuation Procedure	• Ensure work place is safe. • Move to designated evacuation area/s. • Keep communication channels open. • Determine individuals unaccounted for.
Environmental Spills	• Determine hazardous substance/material. • Assess level of emergency. • Evacuate the area if necessary. • Notify the site supervisor. • Notify the EPA in accordance with Conditions A4-1, A4-2, A4-3 and A4-4 of the EA. • Determine containment action and necessary resources (e.g. containment bunding). • Contain, neutralise and dispose of material in appropriate manner.

In accordance with EA Condition A3-3 this ER/CP will be revised to include the high risk categories identified in the mining activities risk assessment required by EA Condition A3-1 (Section 1). The scope of the risk assessment will be to assess the potential risk of environmental harm from the Project. In accordance with Condition A3-2 of the EA no risk control measures identified from the risk assessment will be implemented that contravene or prevent the implementation of any condition of the EA.

3 NOTIFICATION

In accordance with EA Condition A4-1the administering authority will be notified by telephone or facsimile immediately after becoming aware of any emergency resulting in, or having the potential to cause, environmental harm or any breach of the environmental authority concerning release of contaminants to the environment.

Notification of the emergency to the administering authority will be in accordance with the EA Conditions A4-2, A4-3 and A4-4 provided below:

(A4-2) The notification in condition (A4-1) must include the following:

(a) the environmental authority number and name of holder;
(b) the name and telephone number of the designated contact person;
(c) the location of the emergency or incident;
(d) the date and time of the incident;
(e) the time the holder of the environmental authority became aware of the incident;
(f) the estimated quantity and type of any substances involved in the incident;
(g) a description of the nature and effects of the incident including environmental harm caused, threatened, or suspected to be caused by the incident;
(h) any sampling conducted or proposed, relevant to the emergency or incident; and
(i) immediate actions taken to prevent any further release and mitigate any environmental harm caused by the release.

(A4-3) Within fourteen (14) days following the initial notification of an emergency or incident, further written advice must be provided to the administering authority, including the following:

(a) results and interpretation of all samples taken and analysed (if available, if not yet available nominate a timeframe);
(b) outcomes of actions taken at the time to prevent or minimise environmental harm; and
(c) proposed actions to prevent a recurrence of the emergency or incidence.

(A4-4) As soon as practicable, but not more than six (6) weeks following the conduct of any environmental monitoring performed in relation to the emergency or incident, which results in the release of contaminants not in accordance, or reasonably expected to be not in accordance with the conditions of this environmental authority, written advice must be provided of the results of any such monitoring performed to the administering authority.

4 REVIEW

EA Condition A2-4 is of additional relevance to this ER/CP and is provided below:

(A2-4) Any management or monitoring plans, systems or programs required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm as often as necessary but at least every two years and amended promptly if required.

In accordance with Condition A2-4 of the EA this ER/CP will be reviewed for effectiveness at least every two years and amended promptly when required. In the event of further works being conducted at the Project, this ER/CP will be reviewed accordingly.

Appendix C

CULTURAL HERITAGE MANAGEMENT PLAN

CROYDON GOLD MINE

CULTURAL HERITAGE MANAGEMENT PROGRAM

JULY 2018

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1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low-grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Wilson Minerals Pty Ltd now holds the Environmental Authority No. EPML00950913 (EA) for the Project.

This Cultural Heritage Management Program (CHMP) has been prepared in accordance with EA Condition A9-1:

> *(A9-1) The holder of the environmental authority must develop and implement a Cultural Heritage Management Program covering European cultural heritage for all mining leases.*

In accordance with EA Condition A9-2 this CHMP will be included in the Croydon Gold Mine Plan of Operations.

The remainder of this CHMP is structured as follows:

Section 2: Outlines the existing European cultural heritage status of the Project.

Section 3: Provides details of the Cultural Heritage Management Program.

Section 4: Outlines European cultural heritage management measures.

Section 5: Describes the review process for this CHMP.

2 BACKGROUND

European Cultural Heritage

The Project contains a number of artefacts of mining heritage. The original Content Pit at the western boundary of ML 5248 (Figure 2) was operated from 1896 to 1917 and is listed in the Queensland Heritage Register. The locations of several mine shafts and adits have been recorded however are not listed on the Queensland Heritage Register.

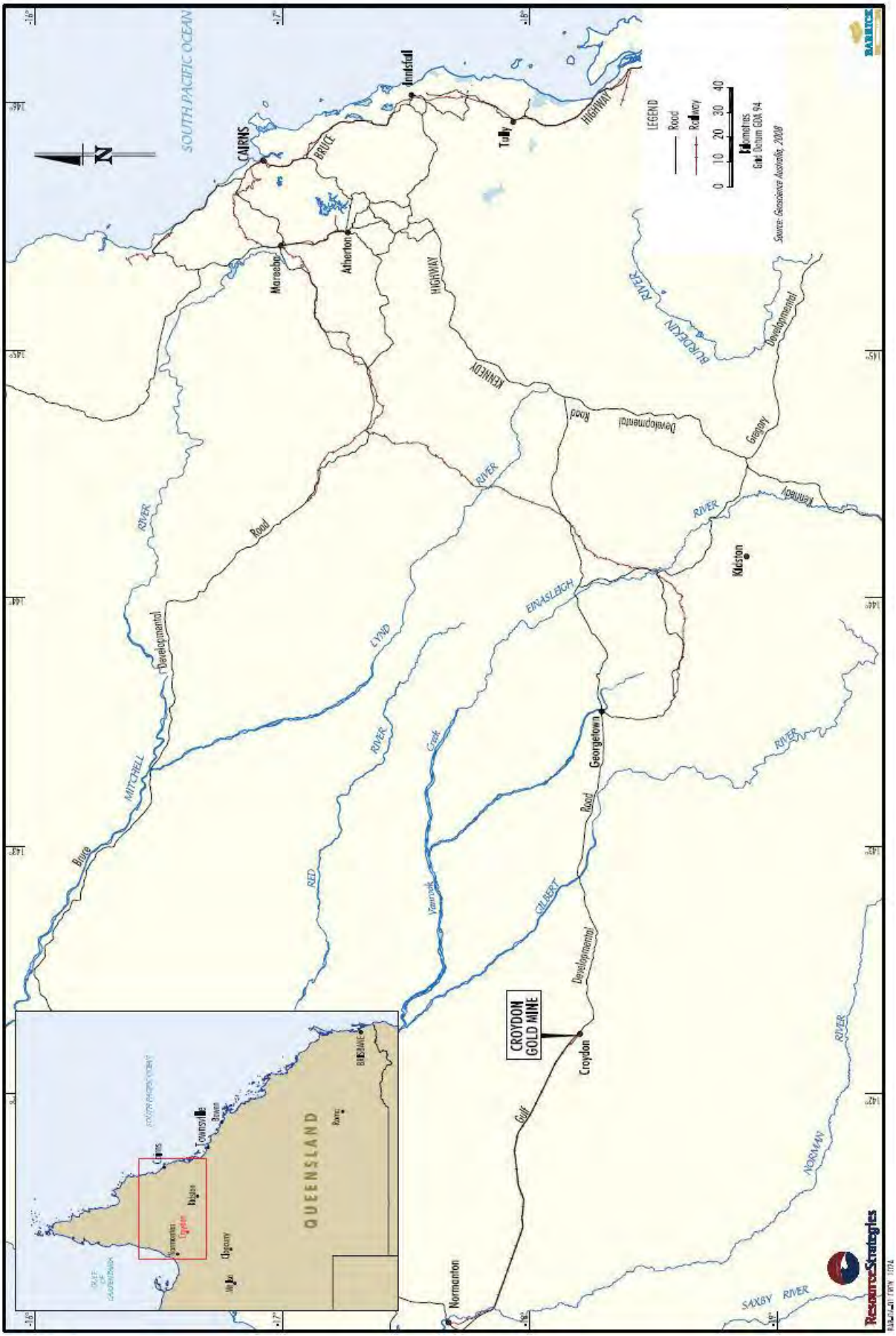

Figure 1: Regional Location

Figure 2: Site Locations

3 CULTURAL HERITAGE MANAGEMENT PROGRAM

This CHMP will provide details of the European cultural heritage artefacts remaining on ML 5248. In accordance with the Croydon Gold Mine Environmental Management Plan (Wilson, 2008) this CHMP will include:

Cooperation with the State Government and Croydon Shire Council to undertake any actions deemed necessary to protect significant cultural heritage items within the Mining Lease boundaries.

3.1 EUROPEAN CULTURAL HERTIAGE SURVEY

A European cultural heritage survey was conducted at the Croydon Gold Mine (CGM) on Mining Lease (ML) 5248 north of Croydon, North Queensland, on 4 and 5 June 2009, to identify any European cultural heritage features. This survey was preceded by a desk study of available historical information.

The original Content Mine area, at the western boundary of ML 5248, was operated from 1896 to 1917 and this area is listed in the Queensland Heritage Register (QHR) as a State Heritage Place under the *Queensland Heritage Act, 1992* (QH Act). The European cultural heritage features within the Content Mine area were surveyed in detail in 1996 (Lennon and Associates, 1996) and the layout of the area has generally remained the same.

The 2009 survey located a number of historical mine shafts and adits within ML 5248 that had not been previously recorded. These shafts are located around the QHR listed Content Mine area and the Lady Isabella area. Two of these shafts are considered of cultural heritage value and are included within the QHR boundary for the original Content Mine area. One of the shafts is a rare example of a sawn timber lined shaft and is of State significance to the Croydon District.

Except for the QHR listed Content Mine area and the machinery/plant/equipment and shafts within this area, no other sites or historic features on ML 5248 satisfy criterion A to H of the QH Act and do *'not contribute significantly to our understanding of the wider pattern and evolution of Queensland's history and heritage*' (QHC, 2006).

4 EUROPEAN CULTURAL HERITAGE MANAGEMENT

Given that no management measures are specified for the QHR listed Content Mine area under the QH Act, prior to the relinquishment of ML 5248 the following will be undertaken

- Installation of grates over the surface of the two timbered shafts and either install grates over the surface or in-fill the three remaining non-timbered shafts located within the QHR listed Content Mine area to mitigate the potential safety risks associated with open shafts. Installing grates over the surface of the timbered shafts or in-filling the open non-timbered shafts is not considered to impact the significance of the QHR listed Content Mine area.
- Given that the open shafts surrounding the mullock heaps within the Lady Isabella area located outside of ML 5248 and that Wilson can only conduct activities within the boundary of ML 5248, no management measures are proposed for these historic features. The responsibility to protect these historic features and/or the mitigation of the risks associated with the open shafts, lies with the land owner of this area.

Given that the results of this cultural heritage survey at the CGM indicate that no European cultural heritage features on ML 5248, other than those within the QHR listed Content Mine area, are considered to satisfy criterion A to H of the QH Act, no other management measures for the European cultural heritage features within ML 5248 identified in Section 5, are considered necessary other than those described for the QHR listed Content Mine area above.

5 REVIEW

EA Condition A2-4 is of additional relevance to this CHMP and is provided below:

(A2-4) Any management or monitoring plans, systems or programs required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm as often as necessary but at least every two years and amended promptly if required.

In accordance with Condition A2-4 of the EA this CHMP will be reviewed for effectiveness at least every two years and amended promptly when required. In the event of further works being conducted at the Project, this ER/CP will be reviewed accordingly.

6 REFERENCES

Barrick Gold of Australia (2008) *Croydon Gold Mine Environmental Management Plan.*

Barrick Gold of Australia (2009) *Croydon Gold Mine ML5248 Cultural Heritage Survey,* prepared by Jane Lennon and Associates Pty Ltd.

Appendix D

WATER MANAGEMENT STRATEGY

CROYDON GOLD MINE WATER

MANAGEMENT STRATEGY

JULY 2018

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1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low- grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Wilson Pty Ltd (Wilson) holds Environmental Authority No. EPML00950913 (EA) for the Project.

This Water Management Strategy (WMS) has been prepared in accordance with EA Condition F10-1:

> *F7-1 A water management strategy must be prepared for inclusion in the Plan of Operations. The strategy willinclude:*
>
> *(a) Data collection and identify existing data requirements.*
>
> *(b) Design and detail additional works as required.*
>
> *(c) Implement / construct additional works.*

In accordance with EA Condition F10-1 this WMS will be included in the Croydon Gold Mine Plan of Operations. This WMS has been prepared with the assistance of Metago Environmental Engineers.

The remainder of this WMS is structured as follows:

Section 2: Provides a review of the drainage for the Project.

Section 3: Describes the proposed drainage management plans for the post-mining final landforms.

Section 4: Identifies the monitoring program for this WMS.

Section 5: Outlines the water requirements for the Project.

Section 6: Describes the review process for this WMS.

Section 7: Lists the references cited in this WMS.

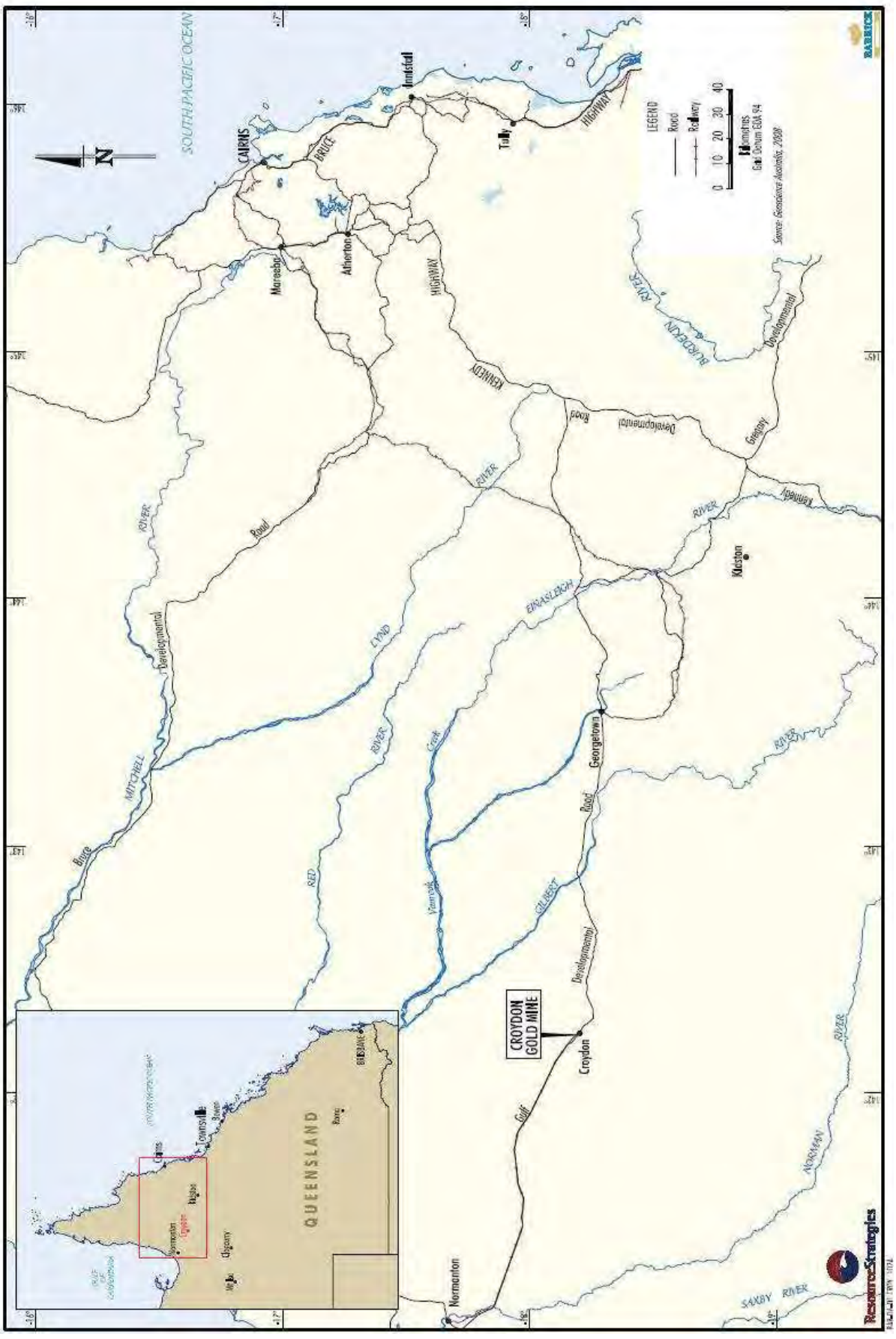

Figure 1: Regional Location

2 DRAINAGE REVIEW

2.1 POST-MINING FINAL LANDFORMS

The mining-related landforms on ML 5248 comprise of waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps.

Specifically they include (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Golden Butterfly waste rock dump;
- Content Pit;
- Content waste rock dump;
- Lady Isabella Pit;
- abandonment bunds across the access ramps of the four open pits;
- hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps;
- water diversion bunds and sediment dams adjacent to the Content and Golden Butterfly waste rock dumps; and
- roads and tracks.

Schematic diagrams of the final landforms, inclusive of drainage features, are provided in Figure 3. The final landform concept is to achieve a stable post-mining landform that is able to meet the identified post-mining landuse and rehabilitation objectives.

2.2 GENERAL RELIEF

The Project is located on the edge of the Gulf Country in Northern Queensland. There is little to no elevation difference across ML 5248 with the only significant natural landform a low (approximately 25 metre) hill located between the two mined areas (Figure 2). The south-eastern section of ML 5248 (i.e. the Golden Butterfly mining area) is within the upper catchment of Slaughteryard Creek and has a single shallow drainage line that flows from north to south across ML 5248.

The north-western section of ML 5248 (i.e. Content and Lady Isabella mining areas) lies within the Belmore Creek catchment with a very gentle slope (1:140) to the north-west with no defined drainage network. Sheetflow is the dominant hydrological runoff mechanism.

2.3 SURFACE HYDROLOGY

The Project receives highly seasonal rainfall and therefore all local creeks are ephemeral. The only permanent source of surface water (other than water within the open pits) is within the borrow pit located off ML 5248 on Belmore Creek to the west of the Content mining area (Figure 2). No hydrological flow gauging records exist for the ML 5248 area. However given the highly seasonal nature of rainfall in the area, it is expected that runoff in local creeks and drainage lines cease relatively soon after storm events.

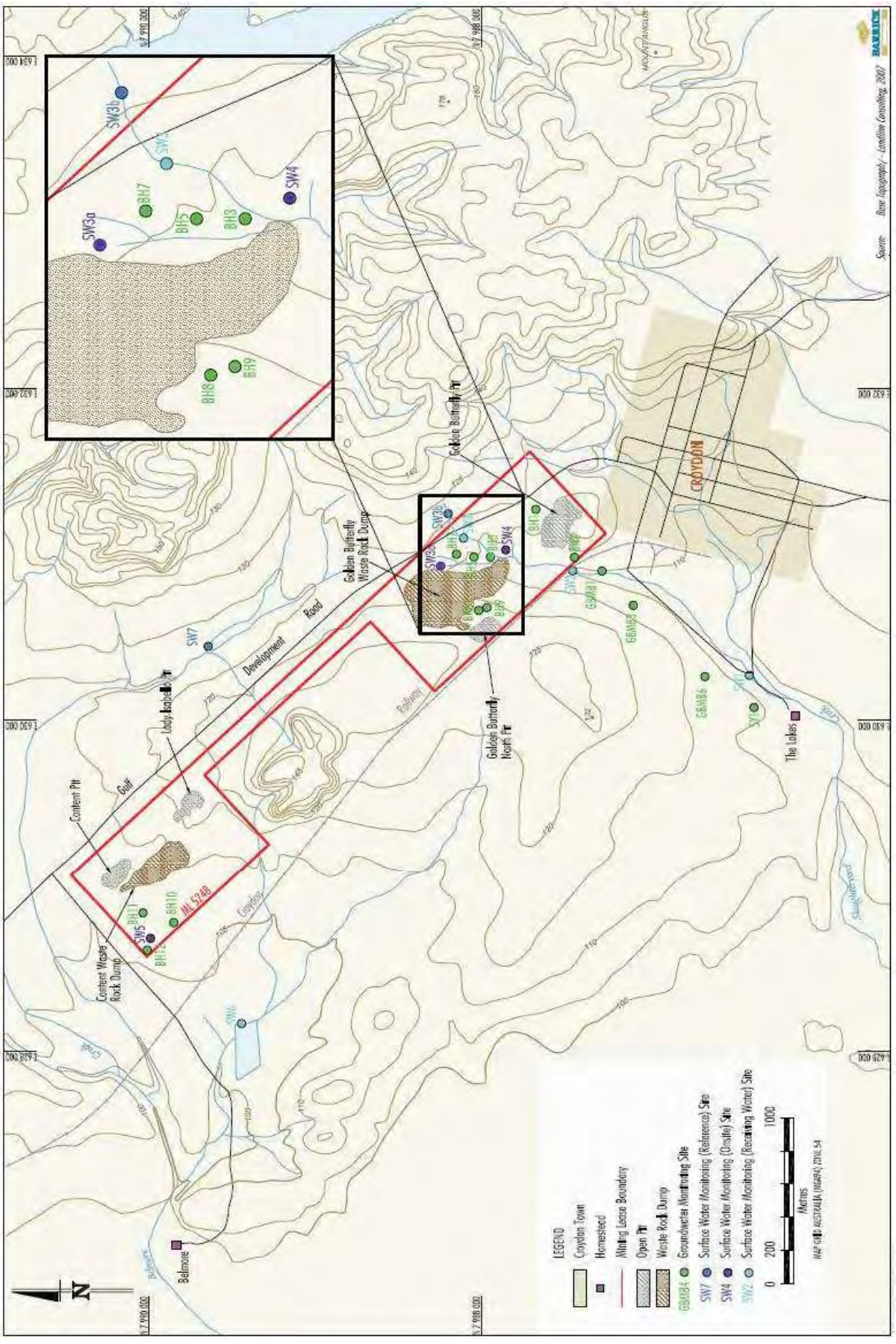

Figure 2: Surface Water and Groundwater Monitoring Sites

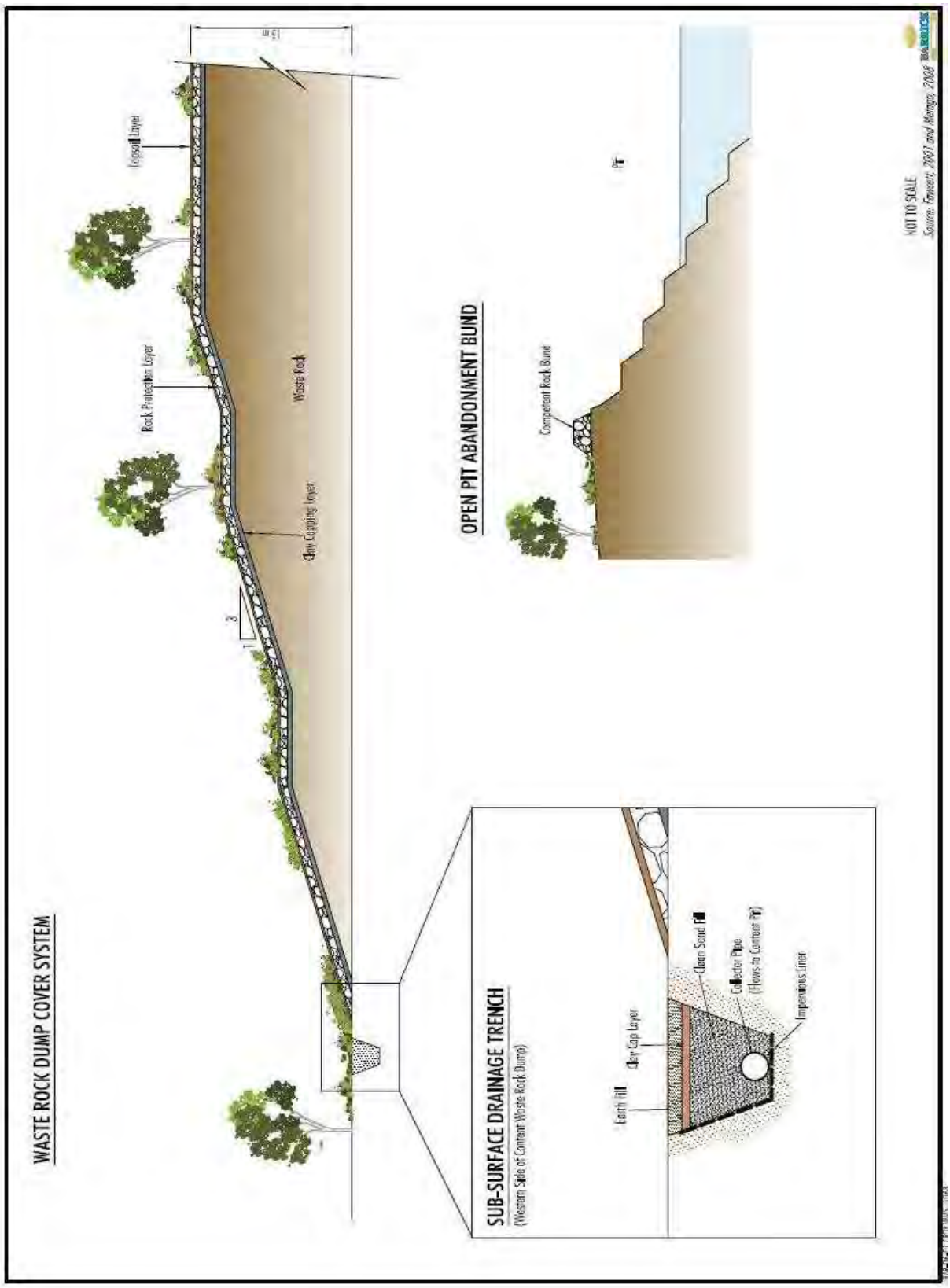

Figure 3: Waste Rock Dump Cover System and Open Pit Abandonment Bund Schematic Cross Sections

In the northern section of ML 5248 seasonal surface water runoff does contribute to the surface water storage in Belmore Creek borrow pit (SW6). In the southern section ML 5248 seasonal surface runoff probably provides some recharge to the shallow alluvial aquifer located along the lower section of Slaughteryard Creek (the original town borefield). However the western tributary that originates on the ML 5248 area constitutes a very small component of the overall Slaughteryard Creek catchment. Figure 4 identifies the surface water drainage flow on ML 5248. A summary of the most recent surface water quality data from 2000 to 2011 is provided in Attachment A.

All four mine pits now contain pit lakes. Pit lake water quality data for each pit lake is provided in Attachment A, with pit lake water quality time series graphs presented in Attachment B. The Golden Butterfly Pit Lake has low pH and raised levels of sulphate, aluminium, arsenic, cadmium, copper, nickel and zinc. Both the Content and Lady Isabella Pits have water quality that meets ANZECC (2000) stock water quality guidelines except for pH, which is below the lower limit, and in the case of Lady Isabella Pit cadmium concentration is also above ANZEEC (2000) stock water quality guidelines. Consequently, the Content and Lady Isabella pit lakes are considered potential stock water supplies. Reference to the time series graphs in Attachment B clearly show an improving trend in water quality versus time within these pits.

Water quality in Golden Butterfly North Pit Lake is considered of good quality and meets ANZECC (2000) livestock drinking water quality guidelines. The Golden Butterfly North Pit does receive a limited amount of surface runoff from the area to the immediate north-east. Water from this pit lake has in the recent past been used by the Croydon Shire Council for irrigation of town recreational areas.

An investigation conducted by HLA-Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping. The pits therefore represent groundwater sinks with limited capacity to influence groundwater quality much beyond the immediate footprint of the pit.

The consecutive unprecedented rainfall totals experienced since 2008/2009 support this conclusion in regards to the Golden Butterfly and Golden Butterfly North Pits. However, the overtopping and discharge from the Content Pit during early 2011 obviously shows that the conceptual hydrogeological model in terms of the Content Pit and Lady Isabella Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation. Section 6 details the hydrological data collection and modelling to be undertaken to provide a validated predictive representation of the Content Pit and Lady Isabella Pits to inform management options.

2.4 HYDROGEOLOGY

ML 5248 contains no springs or groundwater supported surface drainage features. Groundwater occurs in deep fractured rock aquifers, but is not utilised as a water resource on or adjacent to ML 5248. Any aquifers linked to the main mineralised zones might be expected to have raised levels of metals and sulphate. This assumption is supported by water quality analysis from the monitoring bores located in this area. It is likely that water quality will vary significantly between individual fractured rock aquifers, with limited hydrogeological linkage between aquifers. These aquifers would therefore not be considered as potential potable water supplies, irrespective of potential yields.

The original Croydon town borefield, decommissioned more than 12 years ago, is located within Slaughteryard Creek approximately one kilometre south-west of Golden Butterfly Pit. No bore logs or water quality data is available for these bores which are known to have been relatively shallow, exploiting both an unconfined alluvial aquifer and deeper fractured rock aquifers in the underlying sandstone units. Bore yields were never more than 1.25 litres per second (L/sec) and over time dropped to less than 0.25 L/sec resulting in their abandonment (Croydon Shire Council, pers. com., April, 2008).

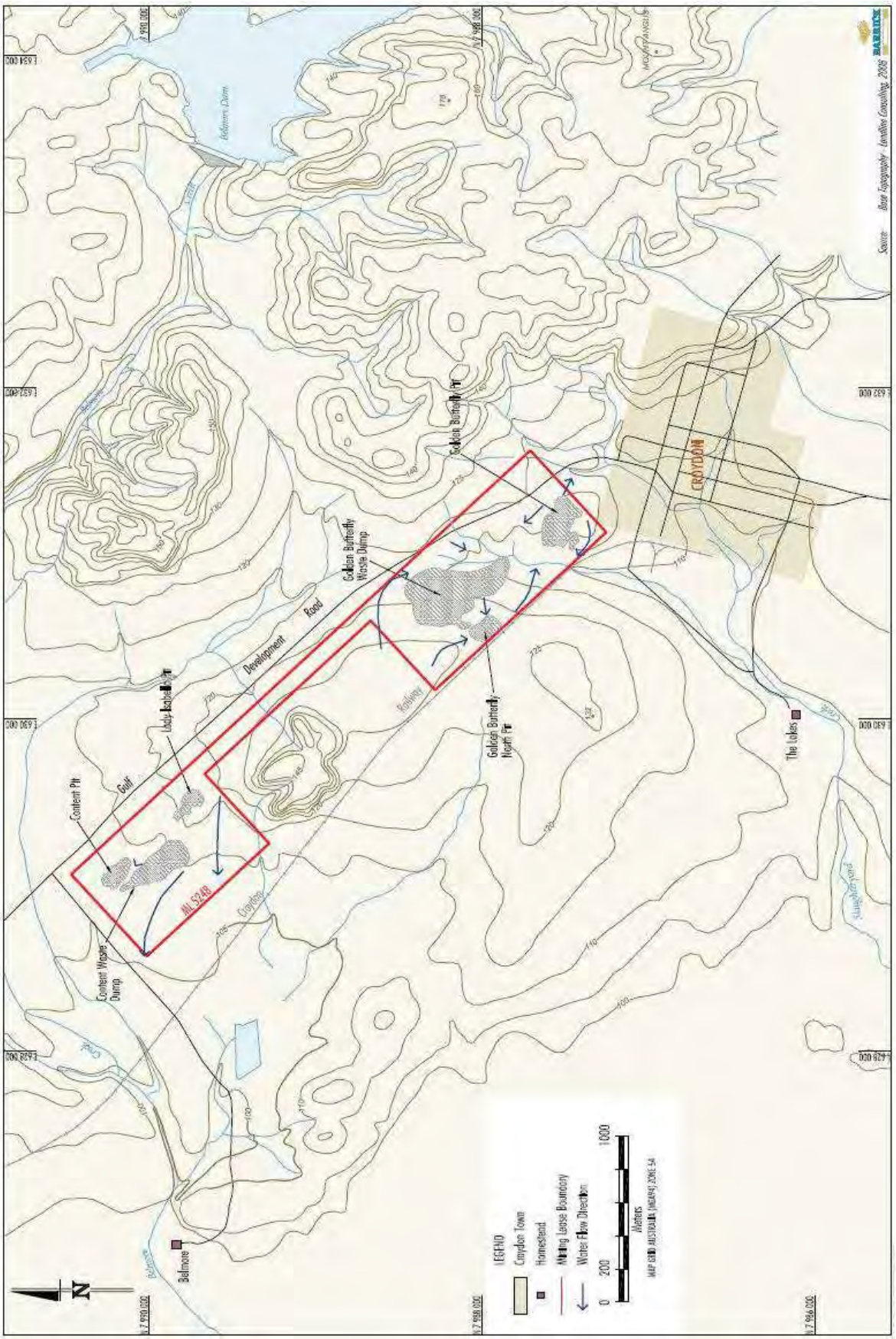

Figure 4: Site Drainage

An attempt was made at an artificial recharge scheme, but this was soon abandoned due to contamination as a result of acid mine drainage (AMD) from the Golden Butterfly waste rock dump and hardstand area. The source of AMD was removed during the 1996/1997 reclamation works and any contaminated soil within the creek removed (HLA-Envirosciences, 2001b).

Two shallow wells (1.2 metres diameter and 15 metres deep) located on the eastern side of the borefield are still used for irrigation of the town oval. The water quality is considered acceptable but has high iron content and requires lime dosing. A series of monitoring bores located between the old town borefield and ML 5248 have been monitored over 14 years and continue to show no influence (i.e. hydrogeological linkage) between Golden Butterfly Pit and the borefield. A summary of the most recent groundwater quality data from 2000 to 2011 is provided in Attachment A.

3 DRAINAGE MANAGEMENT PLAN

Drainage management strategies are proposed for all post-mining related landforms. It is considered these management strategies could impact drainage patterns within ML 5248.

3.1 GOLDEN BUTTERFLY WASTE ROCK DUMP

The Golden Butterfly waste rock dump was capped with an engineered cover system consisting of a clay capping layer, a rock fill surface protection layer and topsoil layer during the reclamation works conducted in 1996/1997. During periods of extreme rainfall any excess water from the waste rock dump surface is engineered to spill down rock lined drains that follow the original haul ramp to discharge to the western tributary of Slaughteryard Creek.

In addition an open seepage collection trench was excavated along the eastern toe of the waste rock dump. Water monitoring has been conducted at this trench for more than 14 years and no seepage or contaminant discharge has been observed. The trench also collects surface runoff from the natural catchment to the east of the waste rock dump and channels this water into the western tributary of Slaughteryard Creek. Additional details of the reclamation works conducted in 1996/1997 are provided in the Post Mine Landuse Plan (Appendix A of the Plan of Operations [Barrick, 2008a]).

Proposed Drainage Management Strategy

No further drainage management measures are considered necessary for the Golden Butterfly waste rock dump area. However, surface water and groundwater monitoring will be continued in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Barrick, 2008a]).

3.2 CONTENT WASTE ROCK DUMP

The Content waste rock dump was capped with an engineered cover system consisting of a clay capping layer and a rock fill surface protection layer during the reclamation works conducted in 1996/1997. At the time the rehabilitation and revegetation status of the waste rock dump western batter was considered adequate and no capping was constructed on this section of the waste rock dump (HLA-Envirosciences, 2001a).

The northern most section of the waste rock dump upper surface was not levelled to the same degree as the remainder of the dump. Subsequently some surface ponding has been noted to occur during extreme rainfall events. General erosion control works were conducted to the north-western part of the waste rock dump in 2009/2010. Several small gullies were beginning to form on the upper crest where water was concentrated in deep vehicle rut marks and localised depressions. Back fill material, sourced from the Golden Butterfly waste rock dump east haul ramp, was utilised to fill these localised depressions to reduce infiltration through the waste rock dump. No excavation was conducted on the top surface of the waste rock dump to avoid potential impacts to the integrity of the clay capping layer. Subsequent rainfall and surface runoff has not caused a recurrence and no further general erosion control works on the Content Waste Rock Dump are currently planned. Continual regular review will be undertaken to ascertain if potential problems are developing in order to schedule any necessary remedial action.

Proposed Drainage Management Strategy

No further drainage management measures are considered necessary for the Content waste rock dump area. However, surface water and groundwater monitoring will be continued in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Wilson, 2008a]).

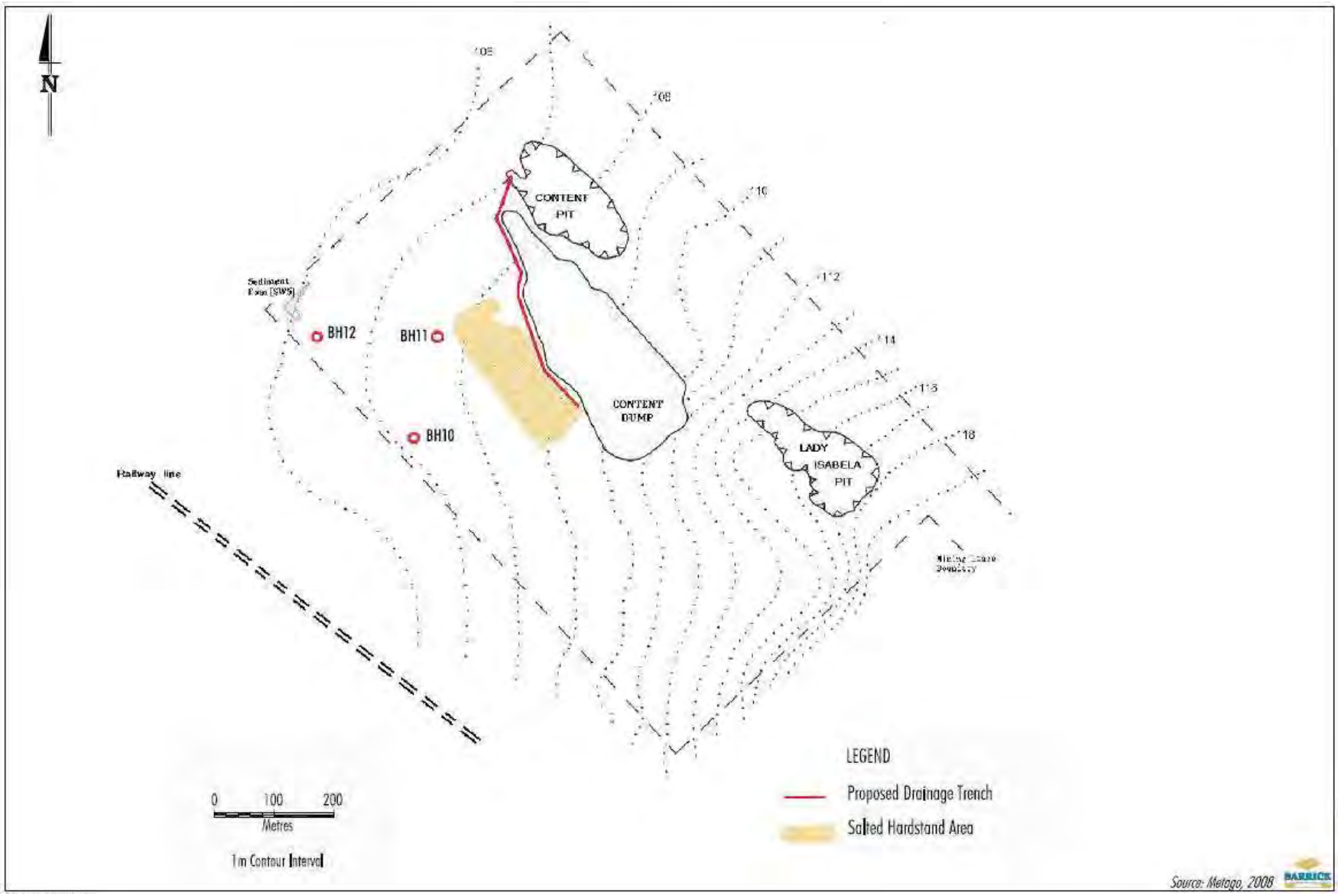

Figure 5: Proposed Reclamation Work on Content Waste Rock Dump

Three additional groundwater monitoring bores (BH10, BH11 and BH12) (Figure 5) were constructed to the west of Content waste rock dump to monitor the performance of the proposed works. Continual review of the groundwater hydrology to enable refining of the hydrogeological model may result in additional bores in the area of the Content waste rock dump to provide better resolution groundwater level data.

3.3 GOLDEN BUTTERFLY PIT

Water levels in the Golden Butterfly Pit Lake are slowly rising and are expected after several decades to reach equilibrium well below the upper pit crest (Wilson, 2008). A water balance conducted by HLAEnvirosciences (2001b) indicates that based on historic rainfall and evaporation data there is no risk of the Golden Butterfly Pit overtopping even during the wettest rainfall cycles. The consecutive unprecedented rainfall totals experienced since 2008/2009 support this conclusion in regards to the Golden Butterfly and Golden Butterfly North Pits.

The abandonment bund restricts any surface water discharge into the pit from surrounding areas. The pit represents a groundwater sink with limited capacity to influence groundwater quality much beyond the immediate footprint of the pit. The upper section of the access ramp to the pit has been engineered to restrict any vehicle access and the abandonment bund has been extended across the access ramp (Figure 3). The extension of the abandonment bund further reduces the amount of surface water reporting to the Golden Butterfly Pit. A water level gauging station has been installed so that pit water levels may be regularly monitored.

Proposed Drainage Management Strategy

Groundwater monitoring will be conducted in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Wilson, 2008a]).

3.4 GOLDEN BUTTERFLY NORTH PIT

The water quality in the Golden Butterfly North Pit is expected to remain fresh for some time however it is considered that the water will become brackish and even saline with time (i.e. 100s of years). The pit represents a groundwater sink with limited capacity to influence groundwater quality much beyond the immediate footprint of the void. Two bores (a deep and shallow bore) (BH8 and BH9) (Figure 2) have been drilled between the pit and Golden Butterfly waste rock dump and the Golden Butterfly North Pit to identify seepage which may be migrating towards the pit lake from the waste rock dump. Although the pit lake water quality is considered as a potential water resource, vehicle access to the pit has been restricted for safety reasons.

The upper section of the access ramp to the pit has been engineered to restrict vehicle access and the abandonment bund has been extended across the access ramp with a gate installed (Figure 3). The extension of the abandonment bund further reduces the amount of surface water reporting to the Golden Butterfly North Pit. A water level gauging station has been installed so that pit water levels may be monitored.

Proposed Drainage Management Strategy

Groundwater monitoring will be conducted in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Wilson, 2008a]).

3.5 CONTENT PIT

An investigation conducted by HLA-Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping.

The 2008/2009 and 2009/2010 wet seasons resulted in extraordinary rainfall totals. In recognition of the possibility of a discharge from the Content Pit, Wilson had undertaken short-term remediation works involving the transfer from water from the Content Pit to the Golden Butterfly Pit to minimise the risk of the Content Pit overtopping during the 2010/2011 wet season. The water level of the Content Pit was decreased by approximately four (4) meters during November and December 2010 (with a subsequent increase of one (1) meter in the Golden Butterfly Pit). Nevertheless, on the 29th March 2011 the Content Pit began discharging water which continued until the 13th April 2011 when no flow was observed to be entering receiving streams. This event obviously shows that the conceptual hydrogeological model in terms of the Content Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation.

A possible addition to the hydrogeological model for the Content Pit is the inclusion of a hydraulic connection with the Lady Isabella Pit. The Lady Isabella Pit when full is approximately five meters higher in elevation that the Content Pit discharge level. This elevation difference provides a hydraulic driving force which with the relative close proximity of the Lady Isabella Pit to the Content Pit and possible connecting facture zones and or fault lines enabling water flow. Section 6 details the hydrological data collection and modelling to be undertaken to provide a validated predictive representation of the Content Pit and Lady Isabella Pits to better inform management options.

The upper section of the access ramp to the pit has been engineered to restrict vehicle access and the abandonment bund has been extended across the access ramp with a gate installed (Figure 3). The extension of the abandonment bund further reduces the amount of surface water reporting to the Content Pit. Additional diversion drains were installed during 2009/2010 to ensure surface water flow in the vicinity of the Content Pit is maintained as much as possible to avoid ponding which may increase groundwater infiltration and possible input to the Content Pit lake.

Proposed Drainage Management Strategy

A water level gauging station was installed so that pit water levels may be monitored. Groundwater monitoring will be conducted in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Wilson, 2008a]).

3.6 LADY ISABELLA PIT

An investigation conducted by HLA-Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping.

The 2008/2009 and 2009/2010 wet seasons had extraordinary rainfall totals which resulted in the Lady Isabella Pit being full to capacity during early 2011, but with no overtopping and discharge observed. This event obviously shows that the conceptual hydrogeological model in terms of the Lady Isabella Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation.

A possible addition to the hydrogeological model for the Lady Isabella Pit is the inclusion of a hydraulic connection with the Content Pit. The Lady Isabella Pit when full is approximately five meters higher in elevation that the Content Pit discharge level. This elevation difference provides a hydraulic driving force which with the relative close proximity of the Lady Isabella Pit to the Content Pit and possible connecting facture zones and or fault lines enabling water flow. Section 6 details the hydrological data collection and modelling to be undertaken to provide a validated predictive representation of the Content Pit and Lady Isabella Pits to better inform management options.

Proposed Drainage Management Strategy

The upper section of the access ramp to the pit has been engineered to restrict vehicle access and the abandonment bund has been extended across the access ramp (Figure 3). The extension of the abandonment bund further reduces the amount of surface water reporting to the Lady Isabella Pit. A water level gauging station has been installed so that pit water levels may be monitored. Groundwater monitoring will be conducted in accordance with the groundwater monitoring program. Details are provided in the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Wilson, 2008a]).

3.7 STOCK WATERING DAM

The stock watering dam (i.e. SW4 surface water monitoring site) (Figure 2) is located to the north of Golden Butterfly Pit and captures runoff from the natural catchment to the immediate east of the mining area. Any spillage from this facility is directed into the western tributary of Slaughteryard Creek.

Proposed Drainage Management Strategy

No further drainage management measures are considered necessary for site SW4. However, surface water and groundwater monitoring will be continued in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Wilson, 2008a]).

4 MONITORING PROGRAM

All surface water and groundwater monitoring will be conducted in accordance with the Rehabilitation Monitoring Program which is provided in Attachment A of Appendix A of the Plan of Operations (Wilson, 2008a).

5 PROJECT WATER REQUIREMENTS

As the Project is decommissioned/closed no water is currently required on-site. In the event a water supply is required during the proposed reclamation works, water would be sourced from the Golden Butterfly North Pit.

6 HYDROLOGICAL MODELLING

Details of the existing conceptual and mathematical modelling of the hydrological environment of the Croydon site are provided in the Post Mine Landuse Plan (Wilson, 2011). An investigation conducted by HLA-Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping. The consecutive unprecedented rainfall totals experienced since 2008/2009 support this conclusion in regards to the Golden Butterfly and Golden Butterfly North Pits (see Figure 6). However, the overtopping of the Content Pit and the filling to capacity of the Lady Isabella Pit in 2011 obviously shows that the conceptual hydrogeological model in terms of these two pits, in view of the additional rainfall data currently available, inadequately describes the physical situation.

As previously discussed (Section 2.3) the Content Pit and Lady Isabella Pit show improving trends in pit lake water quality and are potential stock water supplies (see Attachment A and B for pit lake water quality summaries) whereas the Golden Butterfly Pit contains water of poor quality. Therefore, the existing hydrological model, confirmed by physical observation of pit lake levels, deals adequately with the pit lake that has a significant water quality issue. Nevertheless, the Content Pit and Lady Isabella Pit Lakes do not currently meet ANZECC (2000) stock water quality guidelines for pH (and in the case of Lady Isabella Pit for cadmium, which is marginally above the limit with a decreasing

trend). Therefore, a program of hydrological data collection and modelling will be undertaken to provide a validated predictive representation of the Content Pit and Lady Isabella Pits to better inform management options.

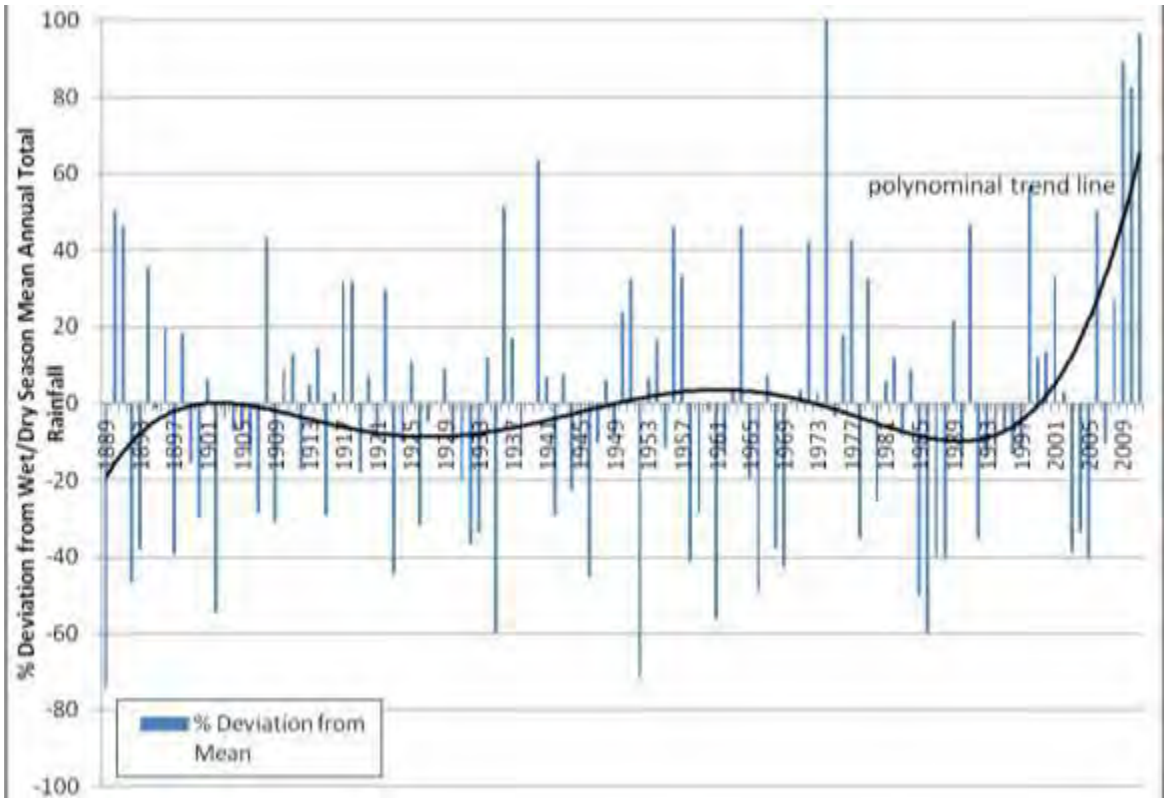

Figure 6: Croydon wet/dry season rainfall, %deviation from annual mean

The use of computer modelling has obvious benefits in providing information to form the basis of management decisions regarding water quantity and quality considering the complexities of the systems being considered. However, the level of abstraction required in order to provide this summary management information can also mask underlying knowledge gaps and or inaccurate assumptions. "The output from a model is only as good as the input data ... If the data are of low quality, the output will be poor no matter how sophisticated the model ... If the model's structure poorly approximates the operation of the real system, the output will always be poor no matter how good the input data." (Thompson, 1999).

In view of this, a data review of available information from the Croydon site was undertaken by Australasian Groundwater & Environmental Consultants Pty Ltd (AGE, 2011). The review concluded that direct rainfall alone does not explain the significant water level rises in the Content Pit and Lady Isabella Pit, and noted the following:

- A groundwater contribution must be occurring.
- Ponding of water, groundwater flow along the ore zone, or groundwater flow from the waste rock dumps, are considered unlikely causes of pit overflow.
- There is little subsurface and groundwater information available for the Content and Lady Isabella Pits areas
- The influence and presence of possible historic mine workings is currently unknown, but potentially significant; and
- The nature of the ferricrete layer needs better understanding due to influences on infiltration.

Therefore, in order to refine the existing conceptual hydrogeological model additional information beyond what has been identified during the initial data review is required, including:

- Characterisation of local geological structures (particularly the ferricrete layer);
- Characterisation of aquifer physical properties (e.g. permeability);
- Characterisation of local water levels and other groundwater investigations; and
- Location of historical mine shafts.

Such information collection, collation and interpretation is necessarily the preliminary step prior to selecting an appropriate computer modelling approach. The actual modelling (i.e. the computer code and output) will aim to identify any long term risk of pit overtopping and estimate likely frequencies and volumes of any such events. The final void water balance models for the various pits will utilise available contour data (for catchment area estimation) and open pit depth-volume data. Rainfall data would be developed from the available Bureau of Meteorology database. Key to the water balance model will be estimates of groundwater inflow/outflow provided by the initial groundwater investigation based upon the refined conceptual hydrogeological discussed previously. Model calibration will be based upon monitored pit void water levels.

In order to provide additional information to assist in refining the conceptual hydrological model, a series of water level monitoring stations have been installed during November 2011 in each of the pit lakes at Croydon. Each of these stations is fitted with a pressure sensor transducer connected to a data logger with solar powered battery supply. Additionally, in the event of a further discharge from the Content Pit, a measuring flume has been installed in the v-drain which will direct any outflow from the Content Pit. Further, a tipping bucket rain gauge with datalogger has been installed at the Content Pit. This will provide detailed rainfall intensity data to augment the Bureau of Meteorology data.

7 REVIEW

EA Condition F7-2 is of additional relevance to this WMS and is provided below:

> *F7-2 An annual review of the water management strategy must be submitted by November each year.*

In accordance with EA Condition F7-2 this WMS will be reviewed, and if necessary updated, annually. This review will be submitted to the EPA by November of each year.

8 REFERENCES

AGE (2011), *Croydon Gold Mine – Groundwater Studies for Pit Water Balance Stage 1 Data Review*, prepared for Wilson Gold of Australia.

Wilson Gold of Australia (2008) *Croydon Gold Mine Project – Environmental Management Plan. p*

Wilson Gold of Australia (2008a) *Croydon Gold Mine – Plan of Operations.*

Wilson Gold of Australia (2011) *Croydon Gold Mine – Post Mine Landuse Plan.*

Environmental Protection Agency (1998) *Draft Guidelines for the Assessment and Management of Contaminated Land*.

HLA-Envirosciences (2001a) *Draft Final Rehabilitation Report – Croydon Gold Mine*. Report prepared for Goldfields Limited, November, 2001.

HLA-Envirosciences (2001b) *Water Level Analysis of Golden Butterfly Pit – Croydon Gold Mine*. Report prepared for Goldfields Limited, May, 2001.

Thompson, S.A., (1999), p 318, *Hydrology for Water Management*, Balkema Publishers, Rotterdam.

ATTACHMENT A

WATER QUALITY SUMMARY TABLES

Table 1: Water Quality Summary of Surface Water Monitoring Sites 2000- 2014

Parameter	Sample Site													
	SW1		SW2		SW3		SW3b		SW4		SW5		SW6	
	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	6.2-9.2	7.20	5.7-9.1	6.78	6.2-8.00	6.96	5.3-6.76	6.16	6.4-9.3	7.45	3.5-6.75	4.3	5.3-9.0	7.4
EC (µS/cm)	77-610	245	64-301	144	38-450	116	17-97	54	38-770	159	32-1400	473	24-480	105
S04 (mg/L)	12-100	44	18-96	42	9-140	25.3	5-23	12.4	8-150	32	6-810	210	<1-43	12.6
Cu (mg/L)	0.004-0.063	0.019	<0.001 – 0.022	0.01	0.001-0.05	0.02	0.001-0.03	0.01	0.002-0.020	0.008	<0.001-2.5	0.38	0.001-0.158	0.018
Pb (mg/L)	<0.001-0.004	0.002*	0.001-0.01	<0.002*	<0.002-0.004	<0.002*	<0 .002-0.004	<0.002*	0.001-0.012	0.004	<0.002-0.006	<0.002*	<0.002-0.047	0.006*
Ni (mg/L)	<0.002-0.003	0.002	<0.001 – 0.011	0.004	<0.001-0.03	0.02	<0.001-0.03	0.01	<0.001-0.025	0.010	<0.001-1.0	0.20	<0.001-0.025	0.017
Al (mg/L)	0.06-2.7	0.55	0.01-18	1.08	<0.05-3.5	0.41	<0.01-0.62	0.12	0.03-11.0	0.93	0.11-77	9.8	0.025-350	9.1
Zn (mg/L)	0.008-0.03	0.018	<0.005 – 0.07	0.04	0.003-0.17	0.02	0.01-0.03	0.01	<0.005-0.110	0.020	<0.005-6.0	0.95	<0.005-0.073	0.019
Co (mg/L)	<0.005-<0.05	<0.05*	<0.001-0.003	0.002	<0.001-0.03	0.3	<0.001-0.03	0.01	<0.001-<0.05	<0.05*	<0.001-1.0	0.21	<0.001-0.025	0.020
Cd (mg/L)	<0.0002-0.00025	<0.0002*	<0.0001-0.0002	0.0001	<0.0001-0.0003	0.0001	<0.0001-0.0003	0.0001	<0.0001-0.0002	0.0001	<0.0001-0.24	0.036	<0.0001-0.0004	0.0001
Fe (mg/L)	0.33-2.7	1.19	0.27-1.2	0.69	0.73-5.2	2.05	0.33-1.2	0.77	0.42-5.1	1.30	0.08-0.39	0.24	0.57-13	2.6
Mn (mg/L)	<0.05-0.24	<0.05*	<0.05-0.014	0.08*	<0.05-1.9	<0.05*	<0.05-0 .07	<0.05*	<0.05-0 .14	<0.05*	0.31-10	3.69	<0.05-0.14	<0.05*
As (mg/L)	<0.005-0.033	0.010	<0.001 – 0.055	0.02	0.002-0.07	0.01	<0.001-0.018	0.004	0.003-0.04	0.01	0.002-0.02	0.004	<0.001-0.011	0.003

Notes: * indicates median, below detection results have been replaced with half the relevant detection limit to calculate averages.

Table 2: Pit Lake Water Quality 2000-2014

Parameter	Sample Site							
	Golden Butterfly		Golden Butterfly North		Content		Lady Isabella	
	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	2.3-2.8	2.5	5.8-7.7	6.8	3.3-4.3	3.8	3.4-4.6	3.7
EC (µS/cm)	2910-12000	5971	60-370	270	737-1800	1135	491-1300	891
SO_4 (mg/L)	1910-8000	5130	11-92	69	300-780	483	180-610	372
Cu (mg/L)	3.3-24	14.1	<0.005-<0.05	<0.05*	0.048-0.28	0.12	0.13-1.4	0.69
Pb (mg/L)	<0.002-<0.005	<0.005*	<0.001-<0.002	<0.002*	<0.001-<0.002	<0.002*	0.002-0.007	0.003
Ni (mg/L)	1.56-8.5	5.10	<0.004-<0.05	<0.05*	0.087-0.32	0.18	0.14-0.77	0.39
Al (mg/L)	122-700	436	0.025-0.73	0.20	1.31-7.0	3.1	2.98-20	9.8
Zn (mg/L)	2.4-36	19.2	<0.005-0.05	0.011	0.23-1.1	0.58	0.82-5.8	2.98
Co (mg/L)	1.24-7.3	3.5	<0.005-<0.05	<0.05*	0.09-0.29	0.14	0.109-0.53	0.25
Cd (mg/L)	0.055-0.34	0.19	<0.0001-0.0002	<0.0002*	0.0021-0.023	0.006	0.013-0.19	0.08
Fe (mg/L)	240-450	356	<0.05-0.18	0.06*	0.69-1.5	0.95	<0.05-0.66	0.23*
Mn (mg/L)	56-110	79	<0.05-0.17	<0.05*	3.7-5.2	4.4	3.3-6.3	4.7
As (mg/L)	0.34-1.3	0.71	<0.005-0.01	<0.005*	<0.005-0.058	0.015	<0.003-0.013	0.004

Notes: * indicates median, below detection results have been replaced with half the relevant detection limit to calculate averages.

Table 3: Groundwater Quality – Confined Fractured Rock Aquifer 1995 - 2009

Parameter	Sample Site																	
	BH1		BH2		BH3		BH4		BH5		BH6		BH7		GBMB1		GBMB2	
	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median
pH (pH units)	6.1-7.9 (42)	7.2 7.2	3.3-6.5 (41)	3.7 3.6	5.5-7.7 (35)	6.41 6.4	6.9-8.6	7.4	7.3-7.8 (13)	7.5 7.5	6.9-7.5	7.15	6.4-7.1	6.8	6.4-7	6.7	6.9-7.7	7.3
EC (µS/cm)	985-2260 (42)	1298 1300	740-1300 (41)	1016 980	110-3000 (35)	604 340	4800-7200	5611	4900-6800 (13)	5550 5600	480-2200	933	6400-8700	7472	160-760	591	2200-2700	2491
SO_4 (mg/L)	310-1160 (42)	471 460	260-850 (40)	442 435	20-990 (35)	172 100	1200-1800	1522	1400-2000 (13)	1733 1800	59-530	172	1400-2600	1950	36-190	120	630-790	703
Cu (mg/L)	<0.001-0.05 (16)	0.008 0.005	0.002-0.05 (15)	0.011 0.005	0.001-0.025 (13)	0.009 0.005	<0.001-<0.05	<0.01	<0.001-0.03 (13)	0.007 0.005	0.009-0.02	0.01	<0.003-0.03	<0.01	0.001-0.01	<0.01	<0.001-<0.05	<0.01
Pb (mg/L)	<0.001-0.35 (13)	0.031 0.001	<0.001-0.15 (13)	0.051 0.046	<0.001-0.072 (11)	0.013 0.001	<0.001-0.006	<0.002	<0.001-0.24 (11)	0.023 0.001	<0.002-0.056	0.009	<0.001-0.35	<0.002	<0.002-0.003	<0.002	<0.002-0.02	0.002
Ni (mg/L)	0.002-0.025 (16)	0.016 0.025	0.025-0.09 (15)	0.056 0.05	<0.001-0.025 (10)	0.014 0.0145	<0.002-<0.05	<0.05	<0.001-0.025 (13)	0.016 0.025	0.002-<0.05	<0.05	0.004-<0.05	<0.05	0.02-<0.05	<0.05	<0.002-<0.05	<0.05
Al (mg/L)	0.02-0.25 (15)	0.045 0.025	0.16-2.7 (14)	1.54 1.65	0.07-2.1 (10)	0.49 0.33	<0.05-0.37	<0.05	<0.01-0.29 (13)	0.049 0.025	0.14-6.8	2.35	<0.05-0.16	<0.05	<0.05-0.092	<0.05	<0.05-0.21	<0.05
Zn (mg/L)	0.01-0.18 (16)	0.053 0.038	0.043-1.06 (15)	0.40 0.36	<0.005 2.9 (13)	0.24 0.015	0.008-0.04	0.017	0.0025-0.032 (13)	0.0127 0.012	0.005-0.055	0.021	0.029-0.15	0.072	0.012-0.047	0.024	0.011-0.056	0.028
Co (mg/L)	<0.001-0.025 (11)	0.016 0.025	0.018-0.045 (11)	0.018 0.025	<0.001-0.025 (9)	0.015 0.025	<0.005-<0.05	<0.05	<0.001-<0.05	<0.05	<0.005-<0.05	<0.05	<0.005-0.07	<0.05	<0.05-<0.05	<0.05	<0.005-<0.05	<0.05
Cd (mg/L)	<0.0001-0.0025 (16)	0.0003 0.0001	<0.0001-0.0025 (15)	0.0007 0.0007	<0.0001-0.0009 (13)	0.0002 0.0001	<0.0001-0.0003	<0.0002	<0.0005-0.0004 (13)	<0.0005 0.0001	<0.0001-<0.0002	<0.0002	0.0002-0.002	0.00085	<0.0001-0.0067	0.0005	<0.0001-0.0003	<0.0002*
Fe (mg/L)	<0.05-3.2 (32)	0.436 0.1	0.025-27 (32)	4.54 1.3	0.025-1.75 (29)	0.33 0.25	<0.05-<0.05	<0.05	<0.05-0.09 (5)	<0.05	0.06-3.1	1.4	<0.05-0.27	<0.05	<0.05-0.08	<0.05	<0.05-<0.05	<0.05
Mn (mg/L)	<0.05-1.19 (8)	0.247 0.075	0.95-1.97 (8)	1.23 1.1	0.0025-0.025 (4)	0.019 0.025	<0.05-<0.05	<0.05	<0.05-0.06 (7)	0.034 0.025	<0.05-0.68	0.06	<0.05-1.9	<0.05	0.26-1.4	0.83	0.67-1.2	0.90
As (mg/L)	0.01-0.022 (16)	0.014 0.014	<0.001-0.09 (15)	0.008 0.025	<0.003-0.03 (13)	0.010 0.009	<0.005-0.003	<0.005	<0.05-0.009 (13)	0.012 0.007	0.013-0.048	0.026	<0.005-0.007	<0.005	0.007-0.034	0.02	<0.003-0.023	<0.005

* Below detection limit results have been substituted with a value of half of the detection limit

Table 4: Groundwater Quality – Unconfined Alluvial Aquifer 2001 - 2014

Parameter	Sample Site							
	GBMB3		GBMB4		GBMB5		GBMB6	
	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	5.7-6.8	6.2	5.9-6.5	6.1	5.6-7.1	6.0	5.7-7.1	6.2
EC (µS/cm)	52-110	79.4	260-350	308	68-490	114	66-580	152
SO_4 (mg/L)	3-13	6.3	17-38	28.8	2-13	4.4	3-19	7.1
Cu (mg/L)	0.001-0.01	<0.01*	<0.001-<0.05	<0.01*	<0.001-0.01	<0.01*	<0.001-<0.05	<0.01*
Pb (mg/L)	0.002-0.018	0.008	<0.001-0.008	<0.002*	<0.001-0.004	<0.002*	<0.001-0.31	<0.002*
Ni (mg/L)	<0.002-<0.05	<0.05*	<0.002-<0.05	<0.05*	<0.002-<0.05	<0.05*	<0.002-<0.05	<0.05*
Al (mg/L)	0.07-4.8	0.99	<0.05-0.29	<0.05*	<0.05-0.05	<0.05*	<0.05-0.69	<0.05*
Zn (mg/L)	0.017-0.11	0.052	0.006-0.18	0.043	0.01-.015	0.08	<0.005-0.092	0.025*
Co (mg/L)	<0.005-<0.05	<0.05*	<0.005-<0.05	<0.05*	<0.005-<0.05	<0.05*	<0.005-<0.05	<0.05*
Cd (mg/L)	<0.0002-<0.0002	<0.0002*	<0.0001-0.0018	<0.0002*	<0.0001-<0.0002	<0.0002*	<0.0001-<0.0002	<0.0002*
Fe (mg/L)	0.53-3	1.8	<0.05-6.6	0.18*	<0.05-<0.05	<0.05	<0.05-0.39	<0.05*
Mn (mg/L)	<0.05-0.15	0.05*	<0.05-.07	<0.05*	<0.05-0.26	<0.05*	<0.05-.037	<0.05*
As (mg/L)	0.003-0.012	<0.005*	<0.003-0.007	<0.005*	<0.003-0.091	<0.005*	<0.005-0.15	0.005

* indicates Median.

Table 5: Groundwater monitoring results 2010 – 2014

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH01	29/03/2010	7.94	1420	3.7	473	0.01	0.013	<0.05	<0.0001	<0.01	<0.001	0.004	<0.0001	<0.001	<0.01	0.049
BH01	22/08/2011	8	1390	4	497	0.04	0.014	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.023
BH01	20/09/2011	7.62	1410	3.7	476	<0.01	0.01	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.013
BH01	07/09/2012	7.55	1390	3.6	384	<0.01	0.013	<0.05	<0.0001	0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.011
BH01	24/06/2013	7.82	1420	3.9	485	<0.01	0.015	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.011
BH01	31/7/2014	7.58	1360	4.7	563	<0.01	0.015	<0.05	<0.0001	<0.001	<0.001	0.003	<0.0001	<0.001	<0.01	0.026
BH02	20/11/2010	3.69	940	0.8	374	0.99	0.001	<0.05	0.0001	<0.010	0.017	0.003	<0.0001	0.027	<0.01	0.204
BH02	22/08/2011	3.7	934	1.4	383	0.96	<0.001	<0.05	0.0001	<0.001	0.016	0.01	<0.0001	0.026	<0.01	0.171
BH02	20/09/2011	3.69	989	1.2	380	1.05	0.001	<0.05	0.0004	<0.001	0.019	0.015	<0.0001	0.034	<0.01	0.183
BH02	08/07/2012	3.67	982	1.3	362	1.06	0.001	<0.05	0.0002	0.002	0.016	0.014	<0.0001	0.027	<0.01	0.153
BH02	24/06/2013	3.73	995	1.2	353	1.46	<0.001	<0.05	0.0002	<0.001	0.017	0.021	<0.0001	0.029	<0.01	0.236
BH02	31/7/2014	4.04	931	1.5	415	1.45	0.004	<0.05	0.0001	<0.001	0.016	0.026	<0.0001	0.028	<0.01	0.198
BH03	20/11/2010	8	746	3.6	148	0.43	0.01	<0.05	<0.0001	<0.010	<0.001	0.003	<0.0001	<0.001	<0.01	0.031
BH03	23/08/2011	7.08	454	2.9	92	0.17	0.008	<0.05	<0.0001	<0.001	0.003	0.003	<0.0001	0.002	<0.01	0.007
BH03	20/09/2011	7.09	499	3	95	0.23	0.031	<0.05	<0.0001	<0.001	0.006	0.002	<0.0001	0.002	<0.01	0.007
BH03	08/07/2012	7.12	474	2.6	100	0.03	0.008	<0.05	<0.0001	0.002	<0.001	0.003	<0.0001	0.002	<0.01	<0.005
BH03	24/06/2013	6.97	317	2	70	3.04	0.009	<0.05	<0.0001	<0.001	<0.001	0.004	<0.0001	0.001	<0.01	0.005
BH03	31/7/2014	6.83	800	5.3	188	0.36	0.086	<0.05	<0.0001	<0.001	0.006	0.002	<0.0001	<0.001	<0.01	0.006
BH05	20/11/2010	8.37	5500	6.6	1930	<0.01	0.005	<0.05	0.0003	<0.010	<0.001	0.004	<0.0001	<0.001	<0.01	0.02
BH05	23/08/2011	7.59	5600	7.7	2000	0.02	0.005	<0.05	0.0005	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.01
BH05	20/09/2011	7.05	6490	4.4	2050	<0.01	0.006	<0.05	0.0022	<0.001	<0.001	0.001	<0.0001	0.005	<0.01	0.065
BH05	08/07/2012	7.42	5420	6.7	1980	<0.01	0.004	<0.05	0.0005	0.003	<0.001	<0.001	<0.0001	<0.001	<0.01	0.011
BH05	24/06/2013	7.4	5140	7	1780	<0.01	0.004	<0.05	0.0004	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.015
BH05	31/7/2014	7.43	5170	10.9	2080	<0.01	0.005	<0.05	0.0003	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.008
BH06	20/11/2010	8.3	642	8.3	67	0.29	0.047	<0.05	<0.0001	<0.010	<0.001	0.016	<0.0001	0.003	<0.01	<0.005
BH06	08/07/2012	7.42	568	9.2	64	0.03	0.013	<0.05	<0.0001	0.002	<0.001	0.015	<0.0001	0.001	<0.01	<0.005
BH06	24/06/2013	7.42	776	10.3	96	1.36	0.014	<0.05	<0.0001	<0.001	0.001	0.009	<0.0001	0.002	<0.01	0.01
BH06	31/7/2014	7.29	1500	15.2	320	3.14	0.018	<0.05	<0.0001	<0.001	0.002	0.005	<0.0001	0.003	<0.01	0.006
BH07	20/11/2010	8	5290	6.3	1540	0.02	0.008	<0.05	0.0032	<0.010	0.005	0.051	<0.0001	0.026	<0.01	0.241
BH07	23/08/2011	7.12	5120	7.4	1540	0.03	0.004	<0.05	0.0002	<0.001	0.013	0.001	<0.0001	0.012	<0.01	0.031

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH07	20/09/2011	6.81	5000	6.9	1470	0.02	0.013	<0.05	0.0002	<0.001	0.014	0.001	<0.0001	0.013	<0.01	0.052
BH07	08/07/2012	6.9	5070	7	1570	0.02	0.005	<0.05	0.0005	0.002	0.015	0.004	<0.0001	0.015	<0.01	0.038
BH07	24/06/2013	7.44	5250	10	1440	<0.01	0.049	<0.05	<0.0001	<0.001	0.004	<0.001	<0.0001	0.002	<0.01	0.01
BH07	31/7/2014	7.25	5360	12.8	1740	<0.01	0.017	<0.05	<0.0001	<0.001	0.003	0.002	<0.0001	0.002	<0.01	0.024
BH08	20/11/2010	7.5	118	0.5	13	0.04	0.018	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	0.001	<0.01	0.056
BH08	22/08/2011	5.31	110	<0.1	12	0.02	0.003	<0.05	<0.0001	<0.001	0.001	0.005	<0.0001	0.002	<0.01	0.045
BH08	20/09/2011	5.39	118	0.1	12	0.02	0.002	<0.05	<0.0001	<0.001	0.002	0.002	<0.0001	0.002	<0.01	0.02
BH08	08/07/2012	6.06	123	0.2	15	0.03	0.006	<0.05	0.0001	0.002	0.002	0.005	<0.0001	0.003	<0.01	0.029
BH08	24/06/2013	6.14	154	0.8	24	0.04	0.013	<0.05	0.0001	<0.001	<0.001	0.002	<0.0001	0.004	<0.01	0.04
BH08	31/7/2014	6.56	210	1.4	35	<0.01	0.022	<0.05	<0.0001	<0.001	<0.001	0.004	<0.0001	0.005	<0.01	0.04
BH09	20/11/2010	6.56	104	<0.1	<1	0.29	<0.001	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	<0.001	<0.01	0.027
BH09	22/08/2011	5.39	99	<0.1	1	0.03	<0.001	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.013
BH09	20/09/2011	5.45	98	<0.1	1	0.02	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
BH09	08/07/2012	5.27	113	<0.1	1	0.03	<0.001	<0.05	<0.0001	0.002	<0.001	0.003	<0.0001	<0.001	<0.01	0.008
BH09	24/06/2013	5.13	114	0.2	2	0.04	<0.001	<0.05	<0.0001	<0.001	<0.001	0.003	<0.0001	<0.001	<0.01	0.016
BH09	31/7/2014	5.64	107	<0.1	2	<0.01	0.002	<0.05	<0.0001	<0.001	<0.001	0.008	<0.0001	<0.001	<0.01	0.017
BH10	20/11/2010	7.92	2670	2.4	1280	<0.01	0.02	<0.05	<0.0001	<0.010	0.02	0.002	<0.0001	0.006	<0.01	0.035
BH10	22/08/2011	7.36	2700	2.9	1260	<0.01	0.012	<0.05	<0.0001	<0.001	0.019	0.001	<0.0001	0.005	<0.01	0.03
BH10	20/09/2011	7.16	2680	2.9	1190	<0.01	0.004	<0.05	0.0001	<0.001	0.007	0.001	<0.0001	0.008	<0.01	0.078
BH10	08/07/2012	7.15	2730	3	1290	<0.01	0.003	<0.05	<0.0001	0.002	0.014	0.002	<0.0001	0.005	<0.01	0.015
BH10	24/06/2013	7.28	2580	3.2	1250	<0.01	0.008	<0.05	<0.0001	<0.001	0.003	0.002	<0.0001	0.008	<0.01	0.043
BH10	31/7/2014	7.26	2530	3.7	1230	<0.01	0.047	<0.05	<0.0001	<0.001	0.015	0.002	<0.0001	0.007	<0.01	0.015
BH11	20/11/2010	8.1	370	2.4	51	<0.01	0.054	<0.05	<0.0001	<0.010	<0.001	0.002	<0.0001	0.002	<0.01	0.043
BH11	22/08/2011	7.47	358	2.9	51	0.01	0.058	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.005
BH11	20/09/2011	7.13	353	2.9	49	<0.01	0.054	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	0.001	<0.01	0.008
BH11	08/07/2012	7.04	429	3	49	0.01	0.059	<0.05	<0.0001	0.002	<0.001	0.005	<0.0001	0.001	<0.01	0.016
BH11	24/06/2013	7.62	331	3.2	54	<0.01	0.064	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.006
BH11	31/7/2014	7.37	343	3.8	53	<0.01	0.082	<0.05	<0.0001	<0.001	<0.001	0.004	<0.0001	<0.001	<0.01	0.008
BH12	20/11/2010	8.44	1400	4.2	186	<0.01	0.024	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	<0.001	<0.01	0.025
BH12	22/08/2011	7.69	1380	4.9	182	<0.01	0.019	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.022
BH12	20/09/2011	7.4	1390	4.6	173	<0.01	0.017	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH12	08/07/2012	7.39	1490	4.6	191	<0.01	0.019	<0.05	<0.0001	0.003	<0.001	0.002	<0.0001	<0.001	<0.01	0.008
BH12	24/06/2013	7.53	1450	4.6	174	0.01	0.017	<0.05	<0.0001	<0.001	<0.001	0.004	<0.0001	0.004	<0.01	0.014
BH12	31/7/2014	7.39	1540	5.2	200	<0.01	0.094	<0.05	<0.0001	<0.001	0.015	0.002	<0.0001	0.003	<0.01	0.009
SY1	20/11/2010	7.01	51	<0.1	<1	0.04	0.002	<0.05	<0.0001	<0.010	0.001	<0.001	<0.0001	<0.001	<0.01	0.04
SY1	23/08/2011	6.02	60	<0.1	<1	<0.01	0.003	<0.05	<0.0001	<0.001	0.003	<0.001	<0.0001	0.001	<0.01	0.009
SY1	20/09/2011	5.81	55	<0.1	<1	0.02	<0.001	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.001	<0.01	0.009
SY1	08/07/2012	5.63	64	<0.1	2	0.01	<0.001	<0.05	<0.0001	0.002	0.002	0.002	<0.0001	<0.001	<0.01	0.011
SY1	24/06/2013	5.7	58	0.2	1	0.01	<0.001	<0.05	<0.0001	<0.001	0.001	0.002	<0.0001	0.001	<0.01	0.02
SY1	31/7/2014	6.66	65	<0.1	2	<0.01	0.001	<0.05	<0.0001	<0.001	0.001	0.004	<0.0001	<0.001	<0.01	0.016
GBMB1	20/11/2010	7.91	533	1.7	110	<0.01	0.012	<0.05	<0.0001	<0.010	<0.001	0.002	<0.0001	<0.001	<0.01	0.035
GBMB1	23/08/2011	7.62	498	1.7	81	0.03	0.037	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
GBMB1	20/09/2011	6.67	694	2.2	165	0.01	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
GBMB1	08/07/2012	7.21	716	2.3	150	0.01	0.027	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.016
GBMB1	24/06/2013	7.2	632	2	133	0.02	0.015	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.013
GBMB1	31/7/2014	7.17	580	2.4	143	<0.01	0.019	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.014
GBMB3	11/07/2010	6.71	233	<0.1	1	0.15	0.009	<0.05	<0.0001	<0.010	<0.001	0.003	<0.0001	<0.001	<0.01	0.114
GBMB3	23/08/2011	6.25	103	<0.1	<1	0.07	0.016	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	<0.001	<0.01	0.006
GBMB3	20/09/2011	5.84	61	<0.1	<1	0.21	0.016	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.001	<0.01	0.014
GBMB3	08/07/2012	5.88	53	<0.1	<1	3.76	0.003	<0.05	<0.0001	0.002	0.001	<0.001	<0.0001	0.002	<0.01	0.5
GBMB3	24/06/2013	7.2	501	0.4	4	0.71	0.013	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	0.001	<0.01	0.02
GBMB3	31/7/2014	6.52	218	<0.1	1	2.2	0.038	<0.05	<0.0001	<0.001	0.007	0.001	<0.0001	0.004	<0.01	0.018
GBMB6	11/07/2010	6.21	138	0.1	2	<0.01	0.03	<0.05	<0.0001	<0.010	0.001	0.002	<0.0001	0.002	<0.01	0.143
GBMB6	23/08/2011	6.9	247	0.2	1	<0.01	0.096	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.002	<0.01	<0.005
GBMB6	20/09/2011	6.2	158	0.2	2	<0.01	0.087	<0.05	<0.0001	<0.001	0.001	<0.001	<0.0001	0.002	<0.01	<0.005
GBMB6	08/07/2012	6.9	276	0.3	<1	<0.01	0.093	<0.05	<0.0001	0.003	0.002	<0.001	<0.0001	0.003	<0.01	0.006
GBMB6	24/06/2013	7.19	498	0.6	1	<0.01	0.079	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.002	<0.01	0.005
GBMB6	31/7/2014	6.93	233	<0.1	<1	<0.01	0.116	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.002	<0.01	0.016
EA Trigger Level		6.0 to 7.5	250			0.055	0.013	0.37	0.0002	0.001	0.0014	0.0014	0.0006	0.011	0.011	0.008
EA Contaminant Limit		5 to 9	5970	2	1000	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

ATTACHMENT B WATER

QUALITY GRAPHS

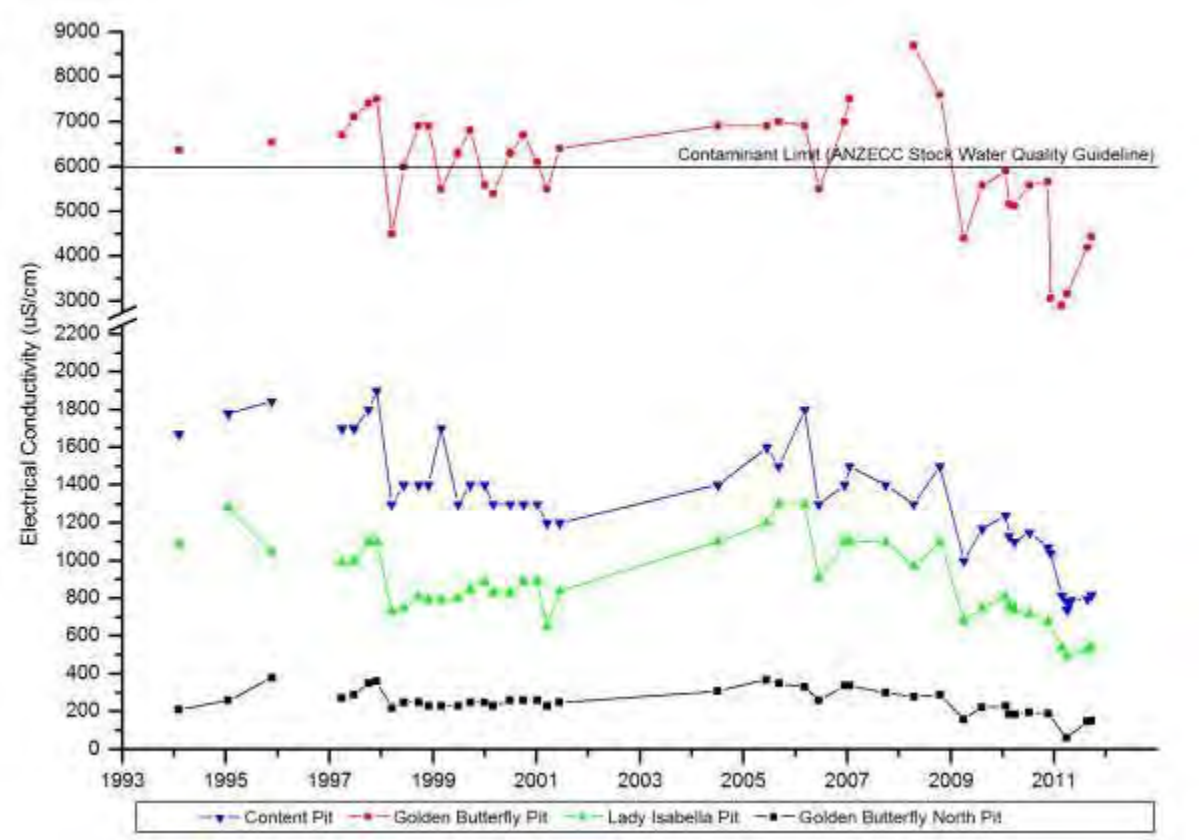

Figure 7: Croydon Pit Lake Electrical Conductivity Time Series Graph

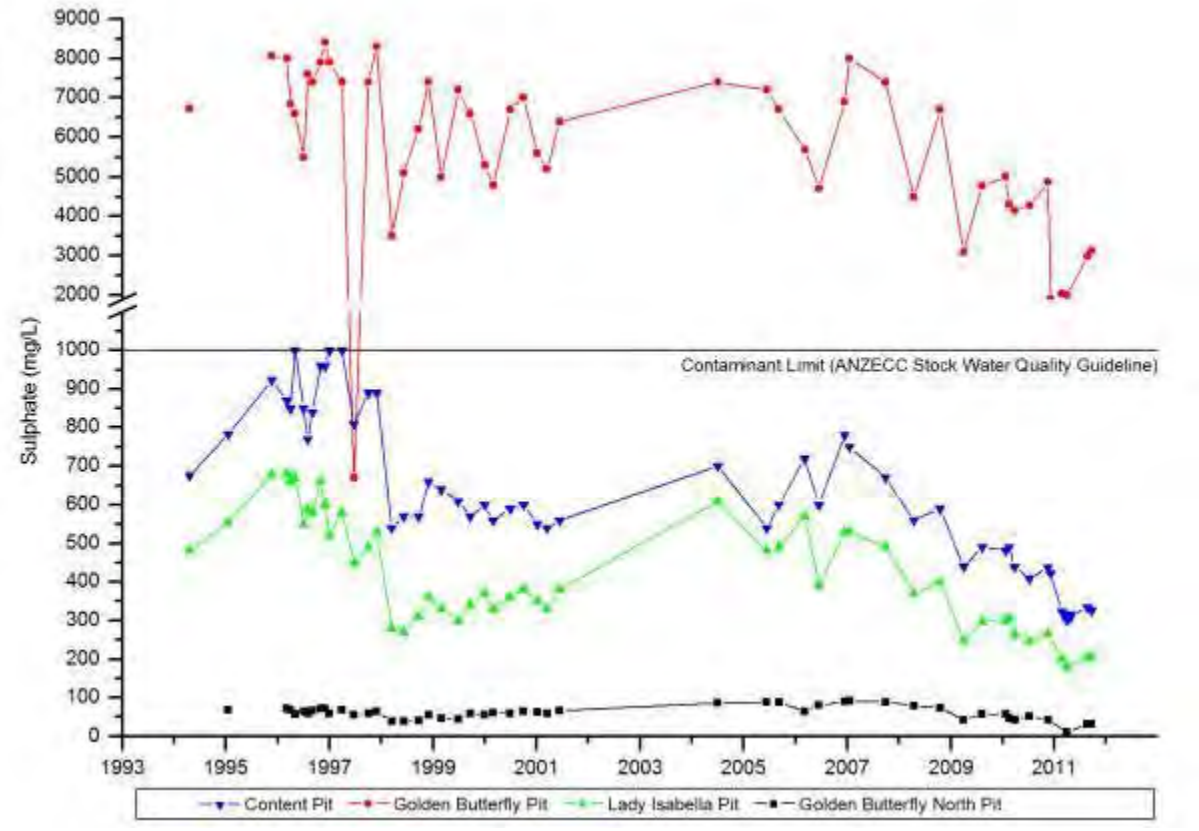

Figure 8: Croydon Pit Lake Sulfate Concentration Time Series Graph

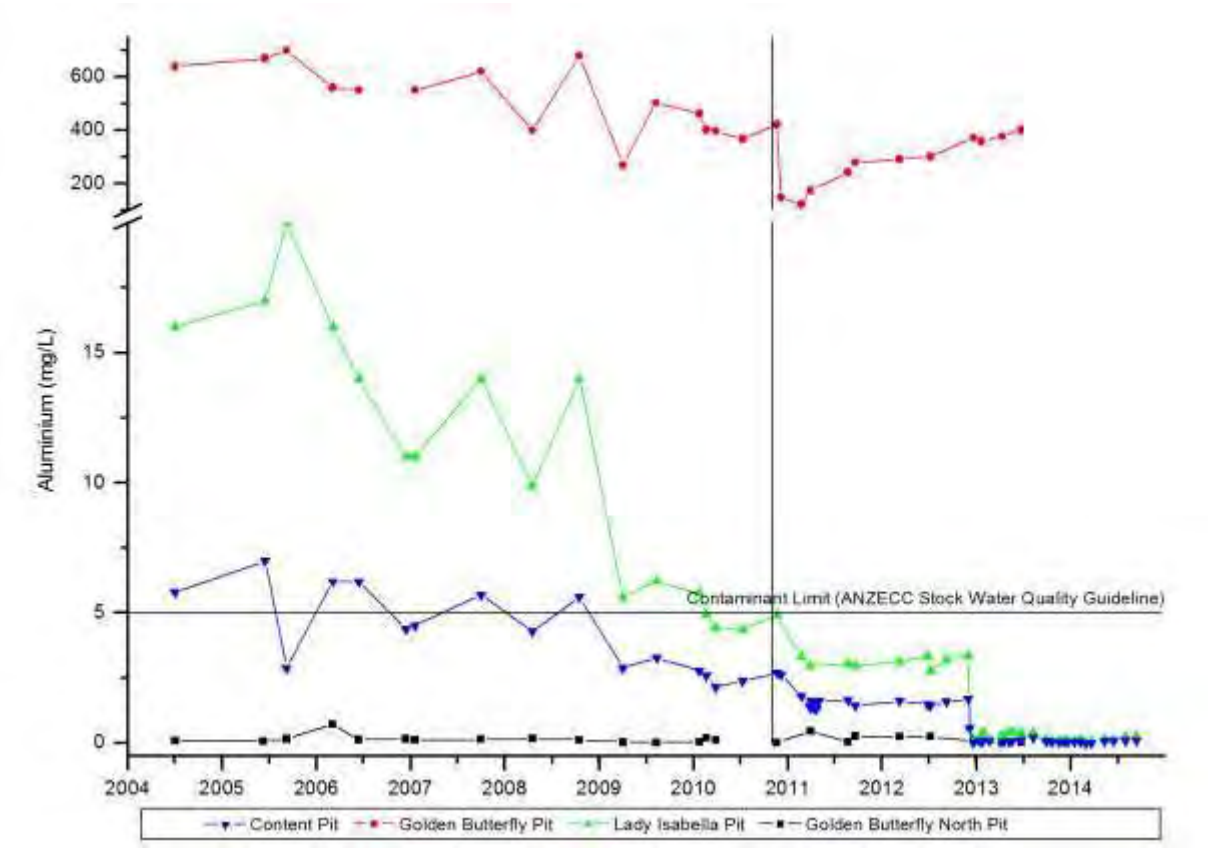

Figure 9: Croydon Pit Lake Aluminium Concentration Time Series Graph

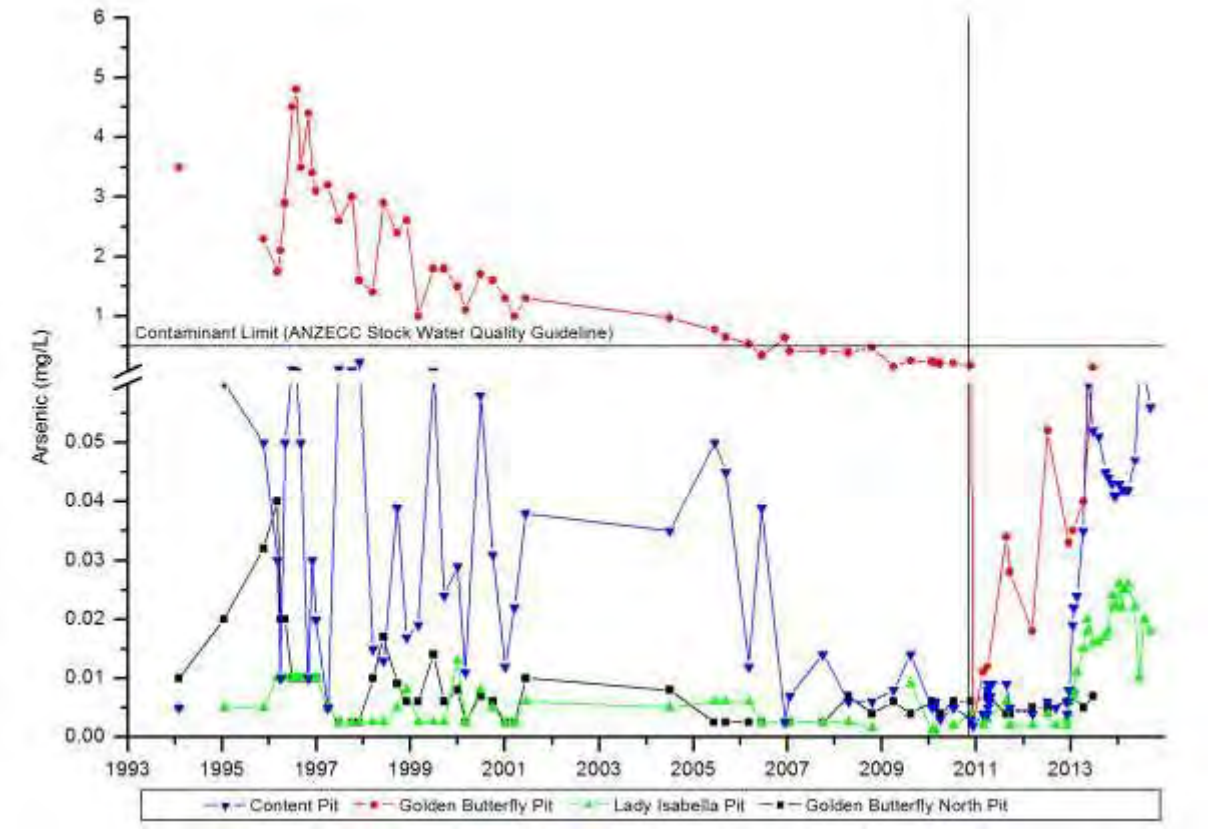

Figure 10: Croydon Pit Lake Arsenic Concentration Time Series Graph

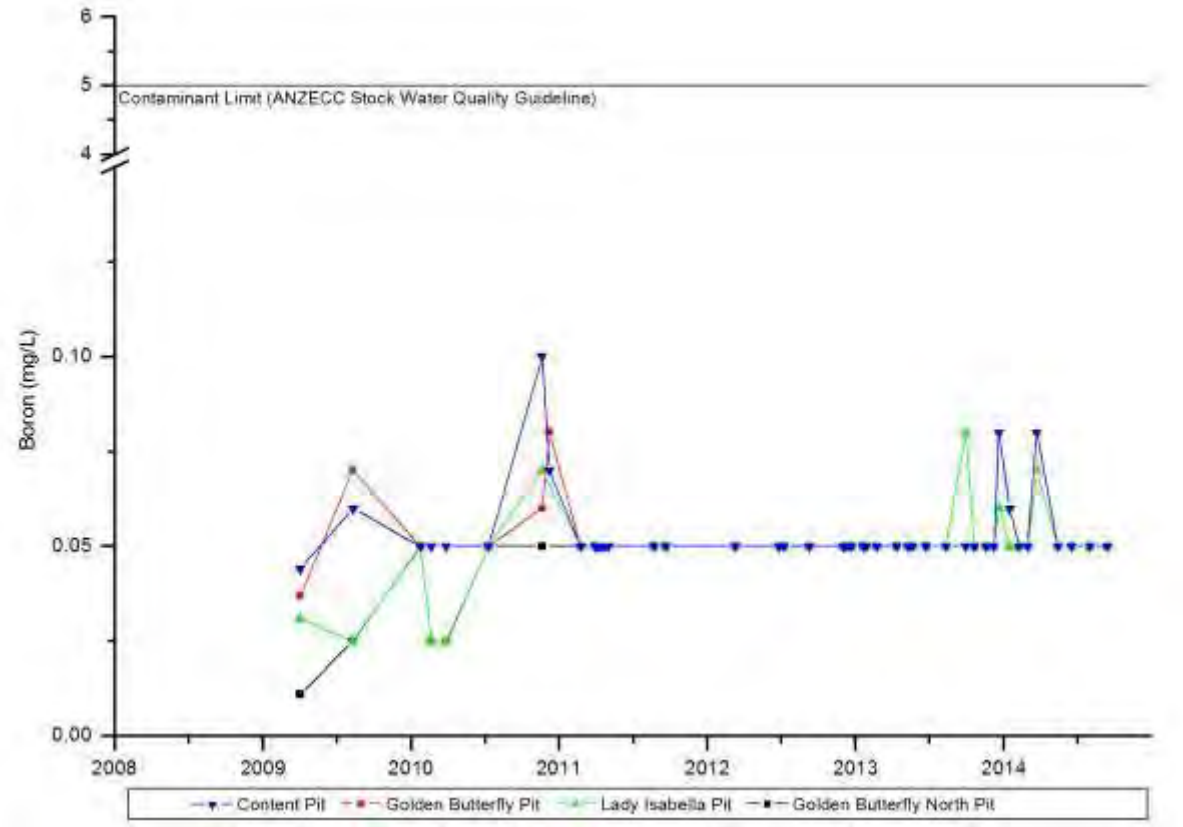

Figure 11: Croydon Pit Lake Boron Concentration Time Series Graph

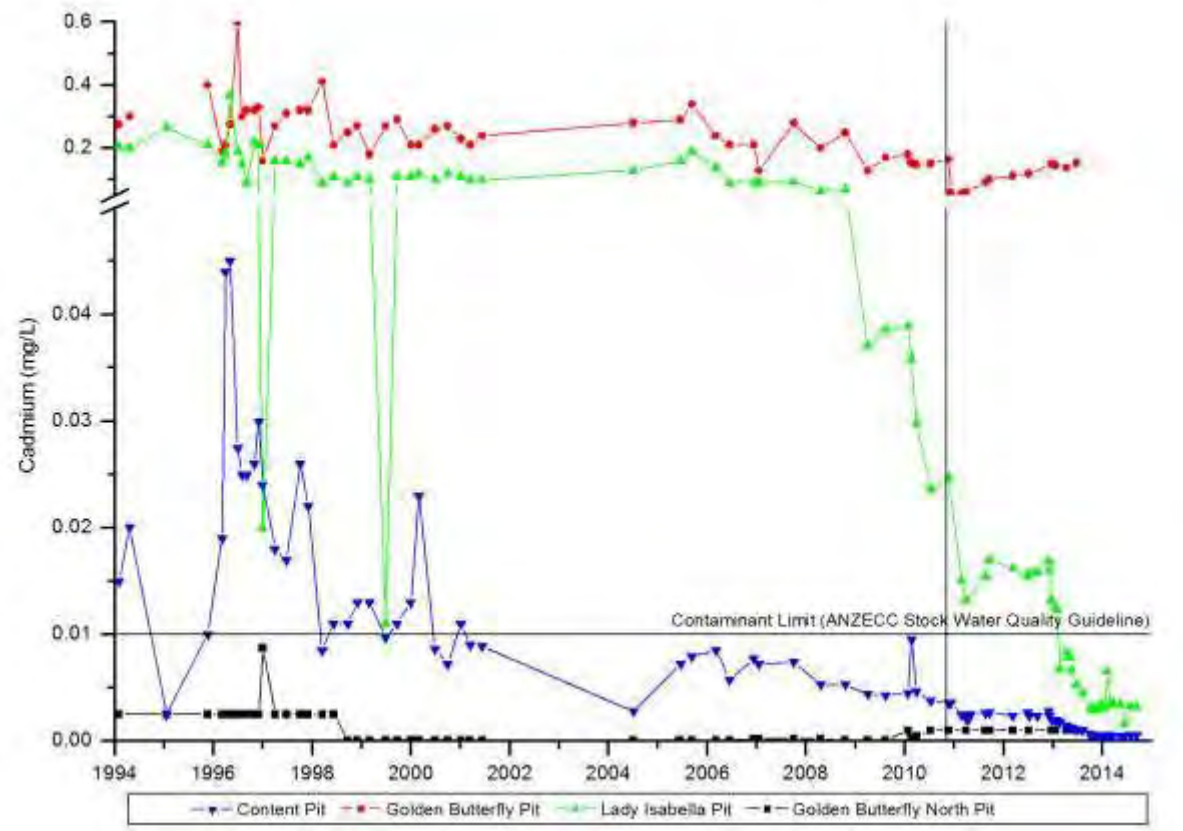

Figure 12: Croydon Pit Lake Cadmium Concentration Time Series Graph

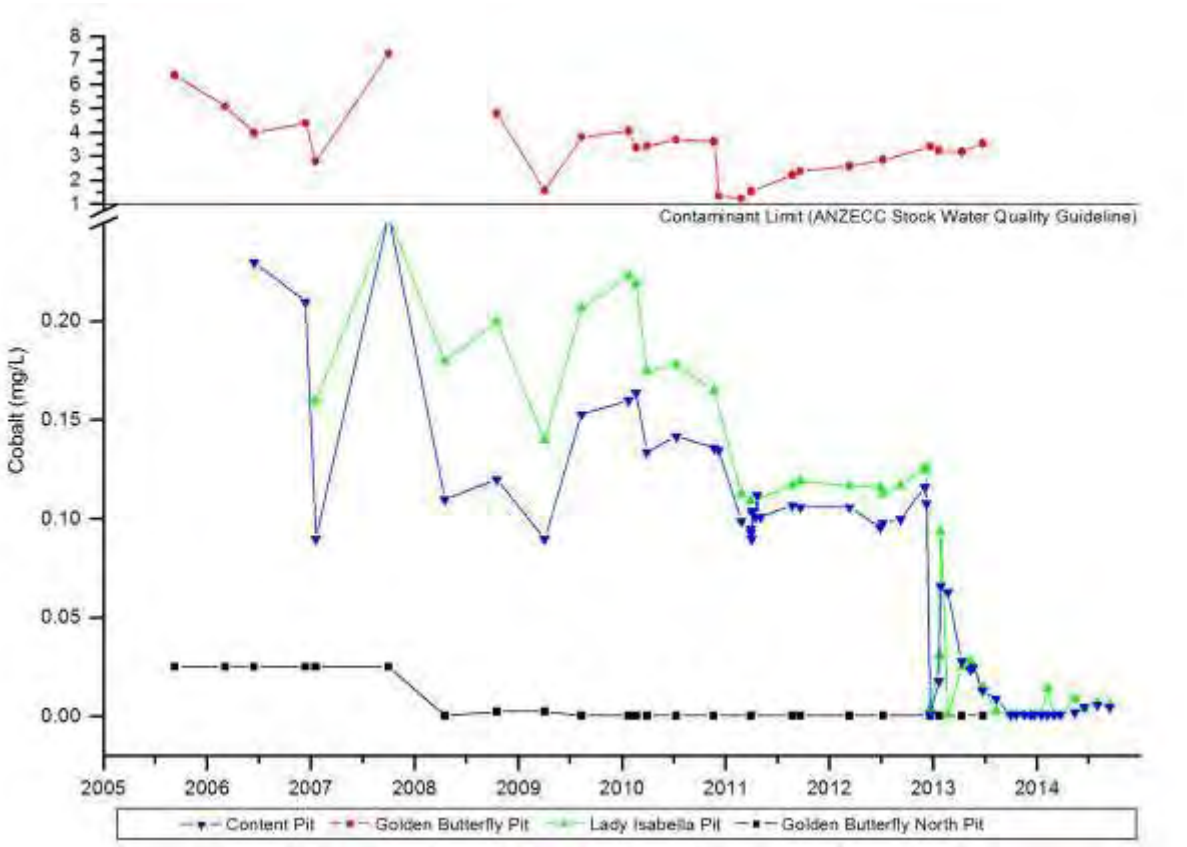

Figure 13: Croydon Pit Lake Cobalt Concentration Time Series Graph

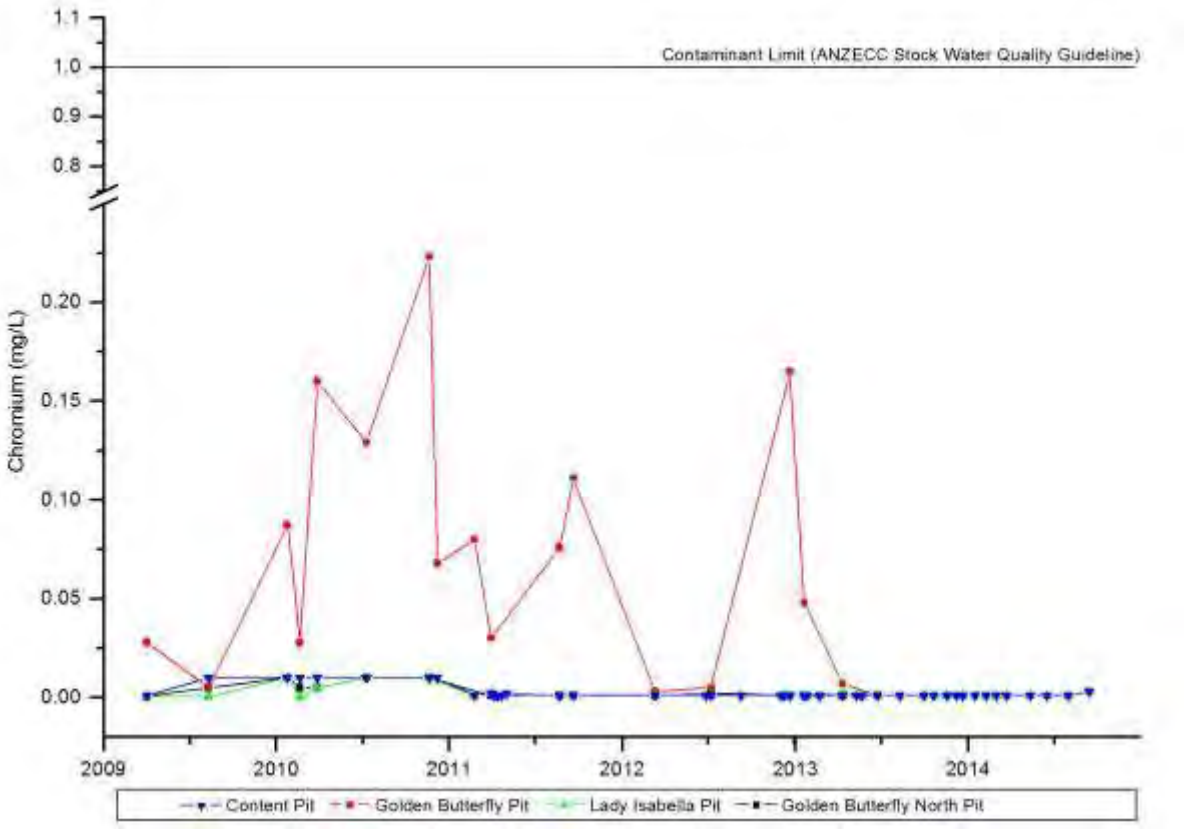

Figure 14: Croydon Pit Lake Chromium Concentration Time Series Graph

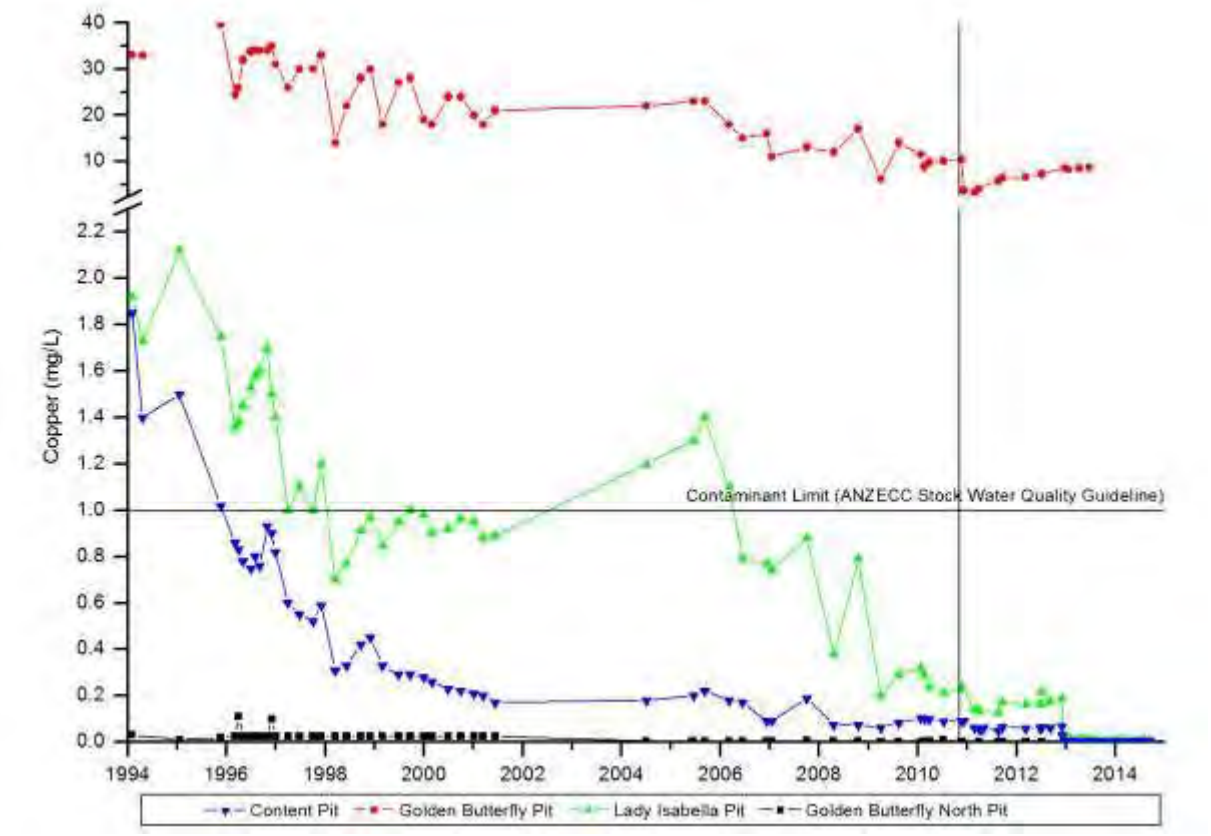

Figure 15: Croydon Pit Lake Copper Concentration Time Series Graph

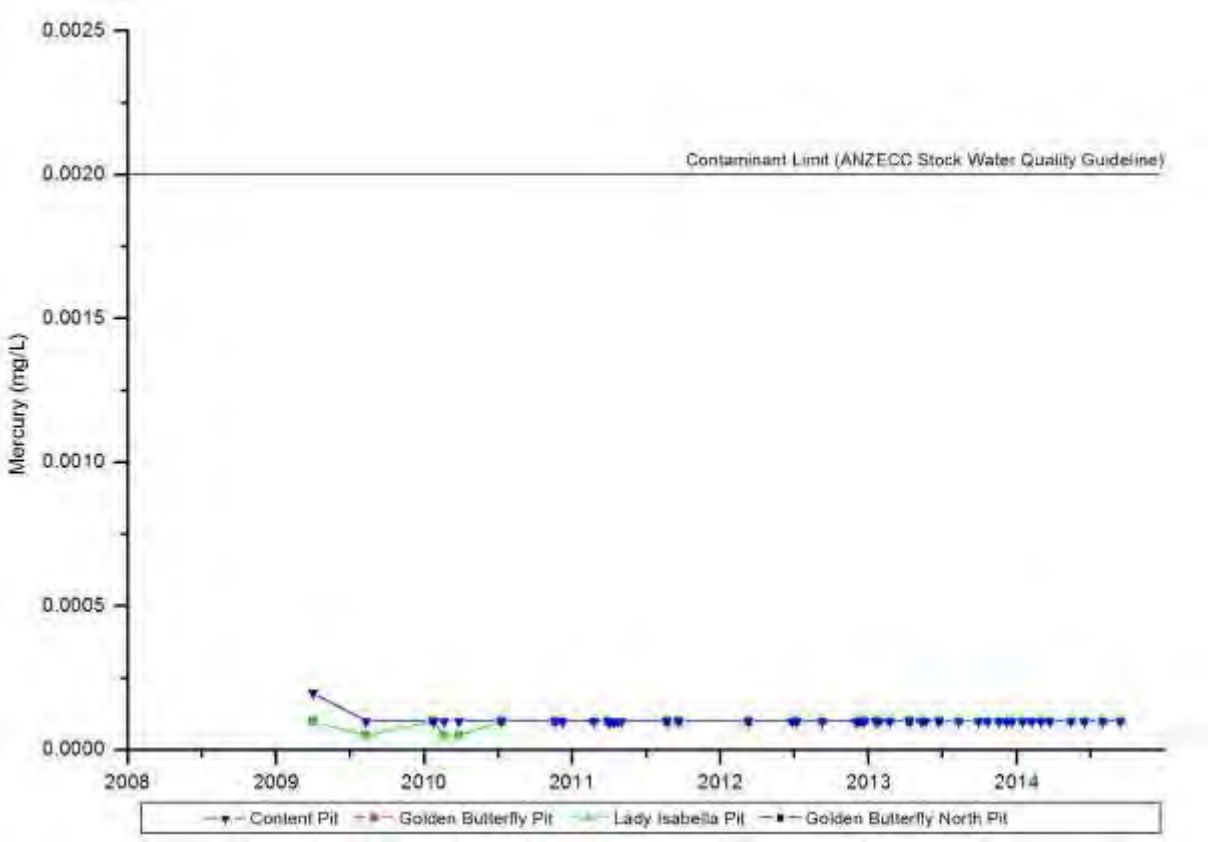

Figure 16: Croydon Pit Lake Mercury Concentration Time Series Graph

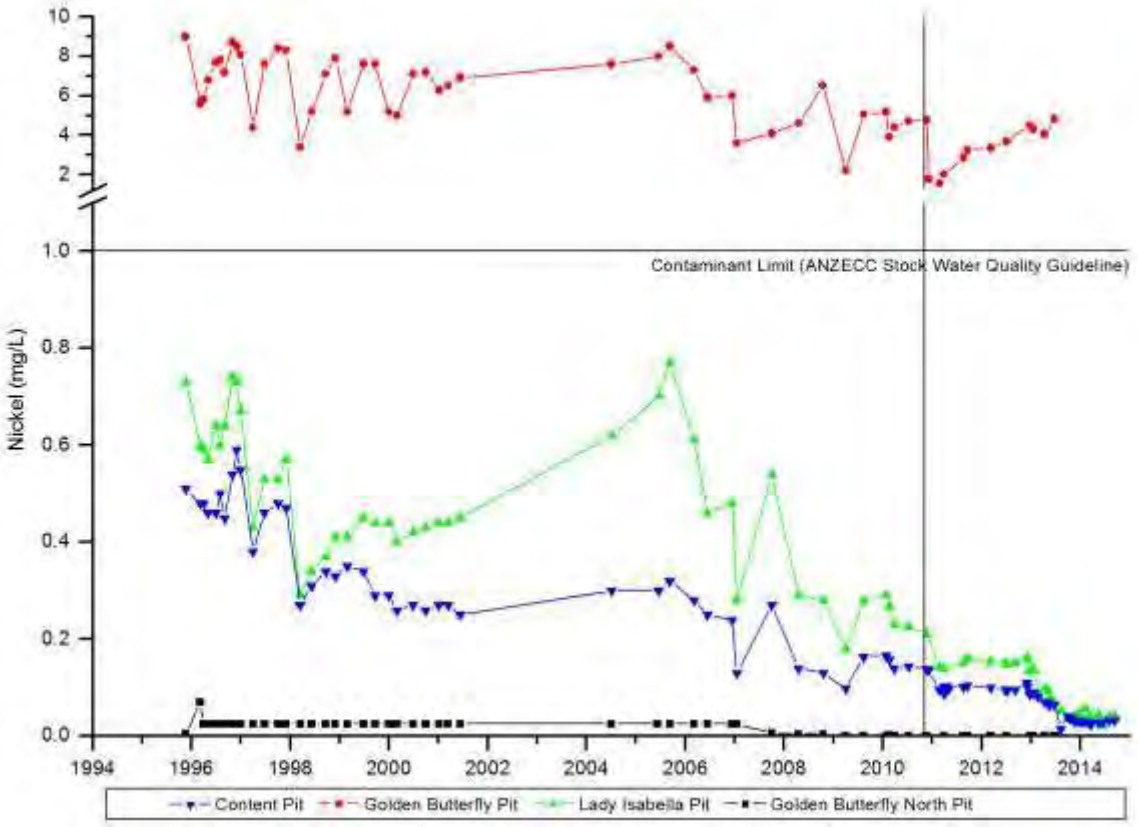

Figure 17: Croydon Pit Lake Nickel Concentration Time Series Graph

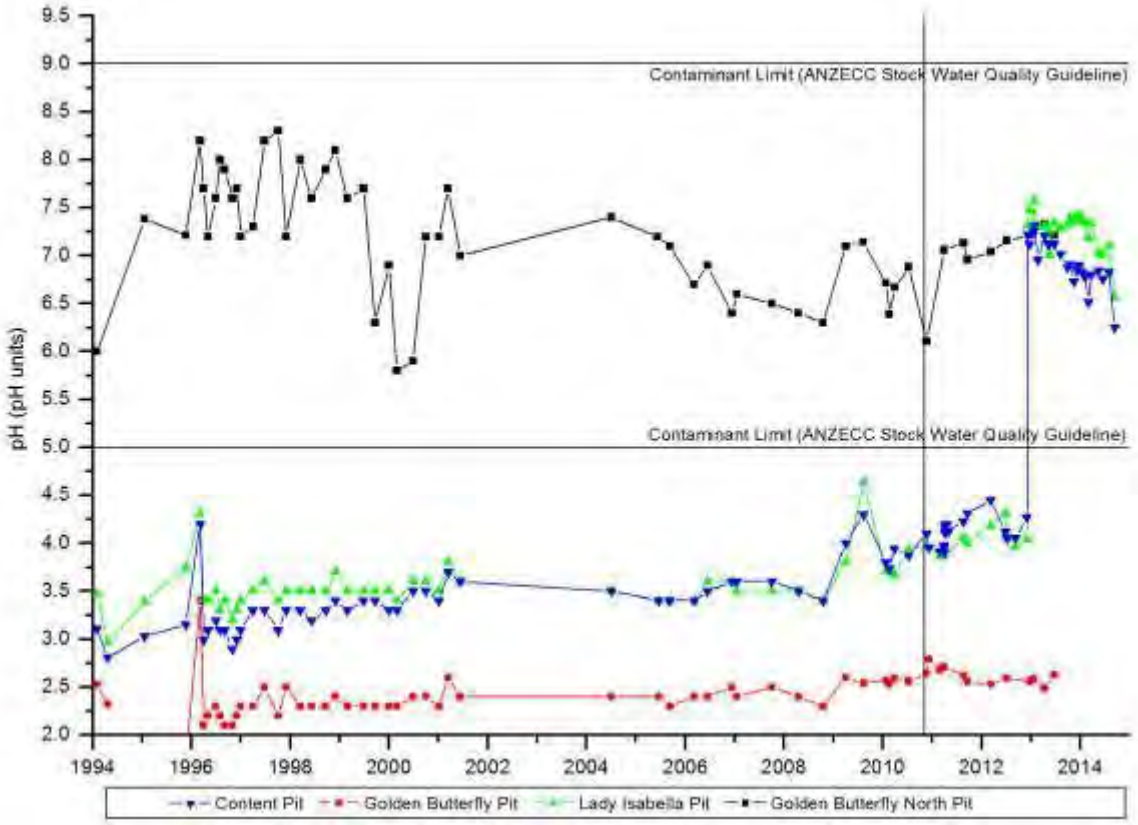

Figure 18: Croydon Pit Lake pH Time Series Graph

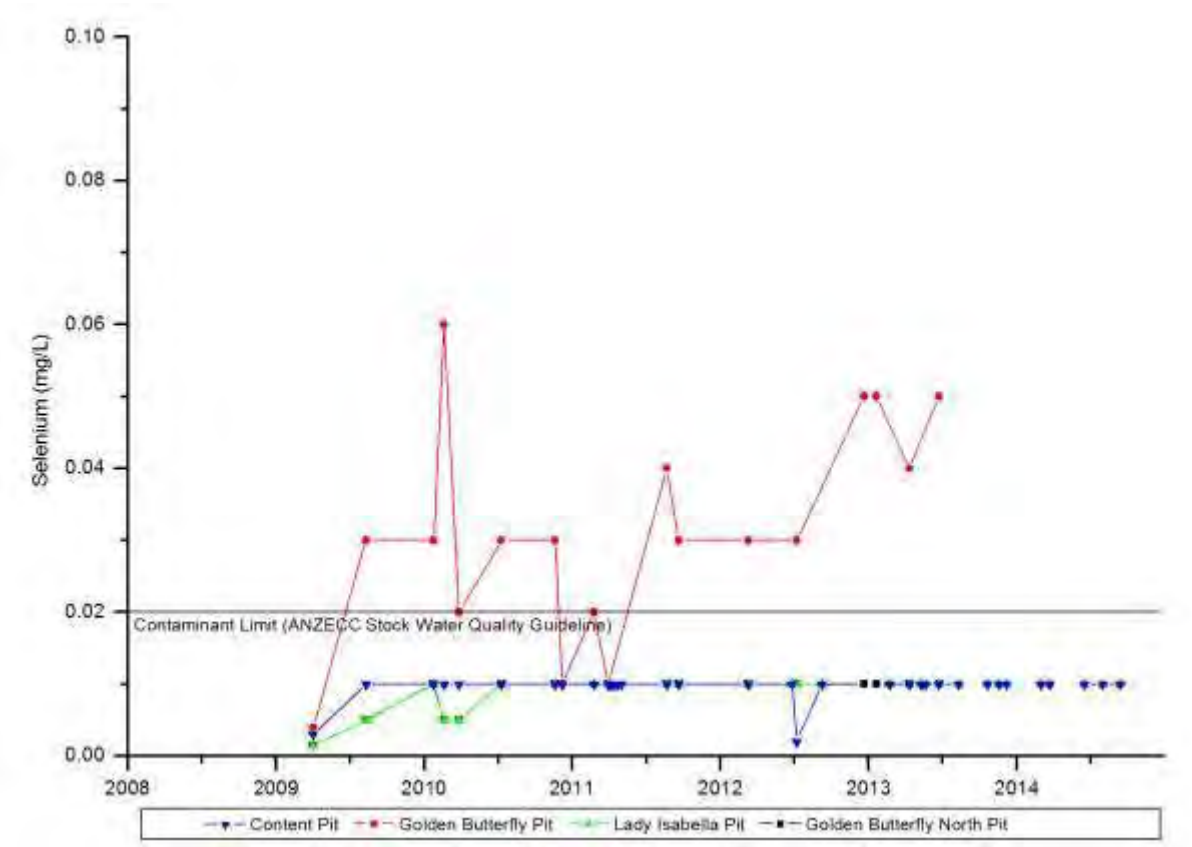

Figure 19: Croydon Pit Lake Selenium Concentration Time Series Graph

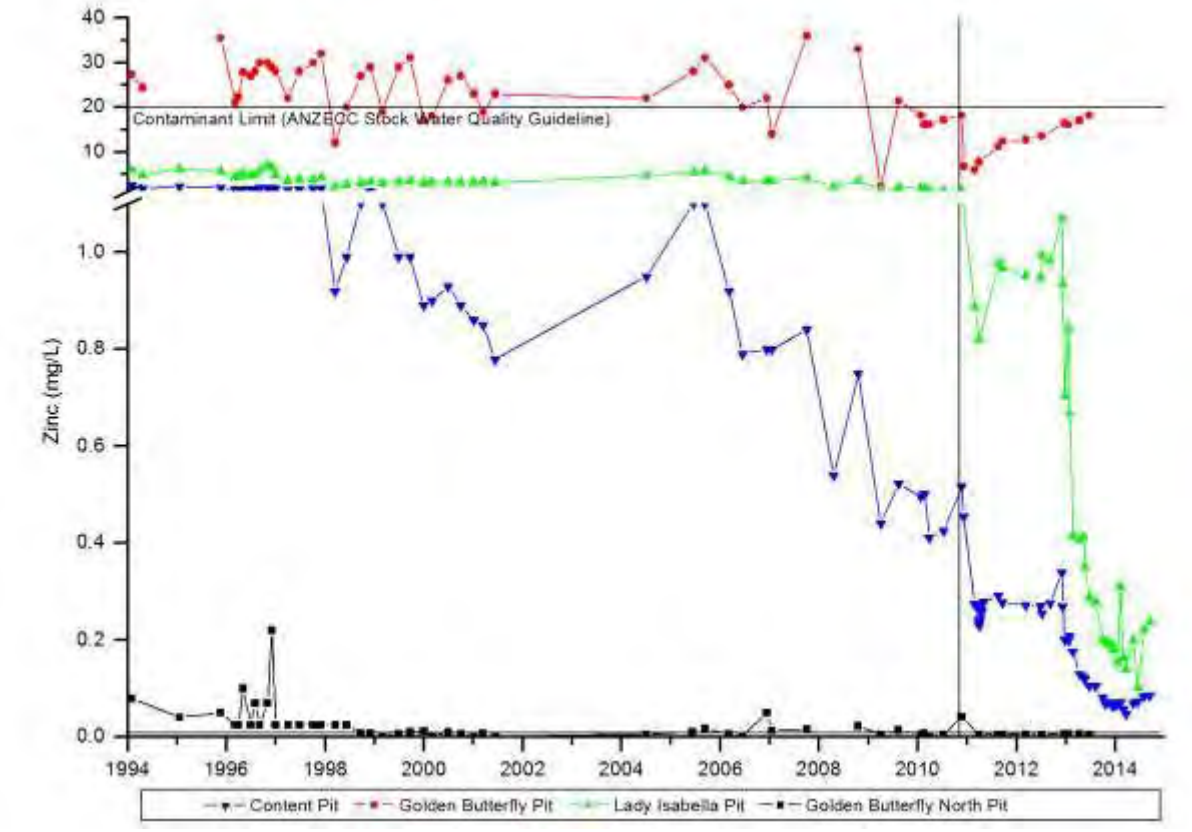

Figure 20: Croydon Pit Lake Zinc Concentration Time Series Graph

Appendix E

EROSION AND SEDIMENT CONTROL PLAN

CROYDON GOLD MINE EROSION AND SEDIMENT

CONTROL PLAN

JULY 2017

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Figure 2: Site Location and Location of Vegetation Monitoring Stations 4

1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low- grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Wilson Pty Ltd (Wilson) now holds the Environmental Authority No. EPML00950913 (EA) for the Project.

This Erosion and Sediment Control Plan (ESCP) has been prepared in accordance with EA Condition F5-1:

> *F5-1 An erosion and sediment control plan must be developed and implemented for the activities on the licensed place which has been certified by a Certified Professional in Sediment and Erosion Control (CPESC), or a professional with appropriate experience and / or qualifications accepted by the Administering Authority and be included in the Plan of Operations.*

EA Conditions F5-2, C1-2 and C1-3 are also of relevance to this ESCP and are provided below:

> *F5-2 Erosion protection measures and sediment control measures must be implemented and maintained to minimise erosion and the release of sediment and contamination of storm water.*
>
> *C1-2 Drain the surface of the Content Waste Rock Dump to Content Pit, fill low-lying areas on the Content Waste rock Dump and import additional growth medium to the Content Waste Rock Dump.*
>
> *C1-3 All waste rock dump slopes must be covered with a regrowth medium to support vegetation regrowth and limit erosion.*

EA Conditions F5-2, C1-2 and C1-3 are addressed where relevant in this ESCP.

In accordance with EA Condition F5-1 this ESCP has been developed with the assistance of Metago Environmental Engineers and will be included in the Croydon Gold Mine Plan of Operations.

The remainder of this ESCP is structured as follows:

Section 2: Provides a review of the erosion and sediment control conducted and the current sources of erosion and sediment at the Project.

Section 3: Describes the principles that underpin this ESCP.

Section 4: Outlines the proposed erosion and sediment control plans for the Project.

Section 5: Identifies the erosion and sediment monitoring program.

Section 6: Describes the review process for this ESCP.

Section 7: Lists the references cited in this ESCP.

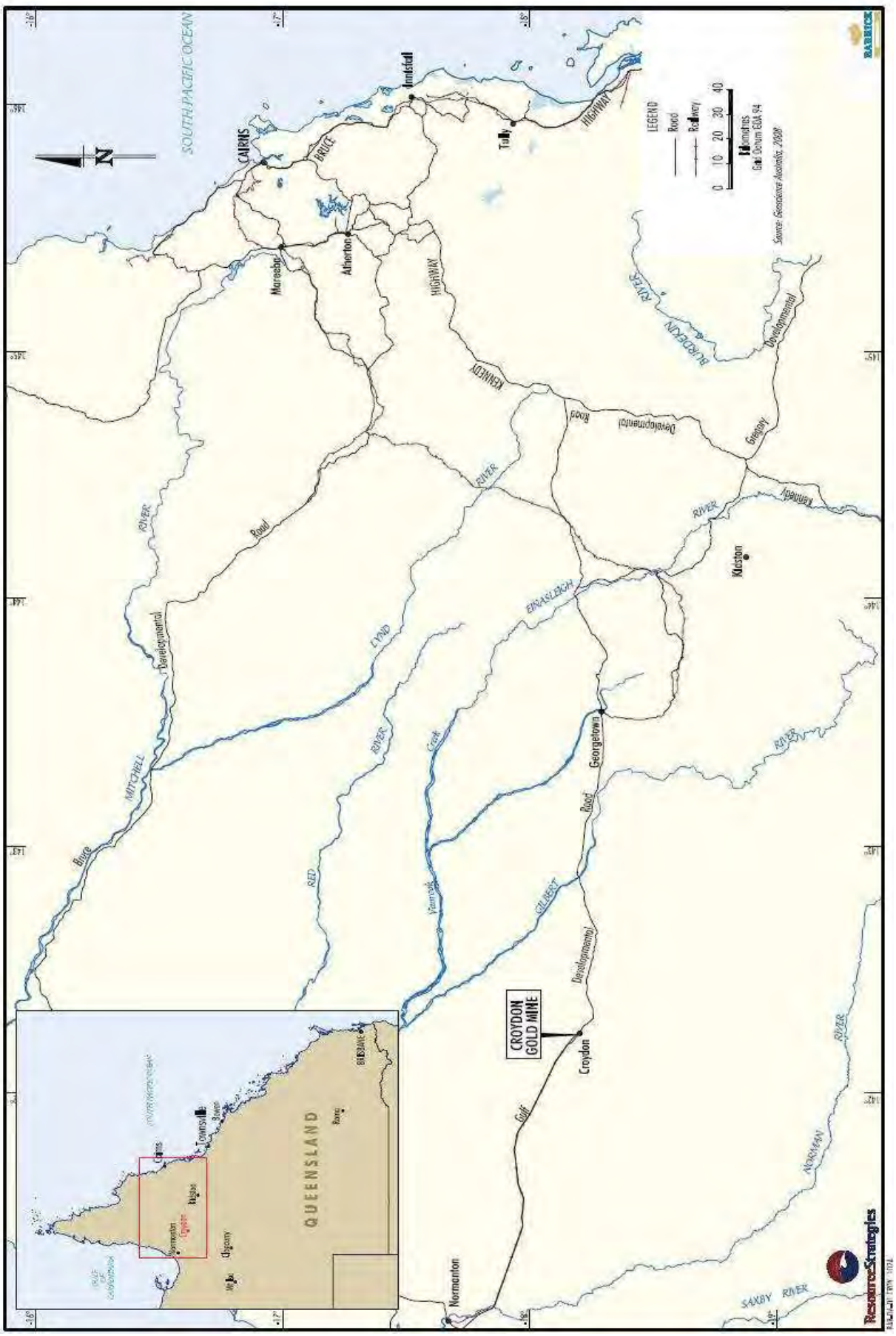

Figure 1: Regional Location

2 EROSION AND SEDIMENT CONTROL REVIEW

Since the Project was decommissioned/closed and final rehabilitation works completed in 1996/1997 erosion and sediment monitoring has been conducted at the vegetation monitoring sites shown in Figure 2. To date, erosion and sediment monitoring has indicated minimal erosion on ML 5248 due to the effective drainage design and revegetation with a mix of pasture grasses and native tree species. Vehicle access on-site is restricted to the main service road. This exclusion has assisted revegetation performance and minimised erosion on the ML 5248 area.

2.1 SOURCES OF EROSION AND SEDIMENT

As the Project is decommissioned/closed limited activities have the potential to cause or increase soil erosion. In accordance with Condition C1-3 of the EA all waste rock dump slopes have been covered with a regrowth medium which supports vegetation regrowth and limits erosion. Activities that have the potential to cause or increase erosion will be limited to disturbance associated with reclamation works.

3 EROSION AND SEDIMENT CONTROL PRINCIPLES

In general accordance with the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME, 1995) the following principles underpin the approach to erosion protection and sediment control at the Project:

- Establishing adequate vegetation cover on disturbed areas and areas highly susceptible to erosion.
- Minimising surface disturbance and restricting access to rehabilitated areas.
- Separation of surface runoff from disturbed and undisturbed areas where practicable.
- Construction of surface drains to facilitate the efficient transport of surface runoff.
- Utilising existing on-site water storages to contain runoff.

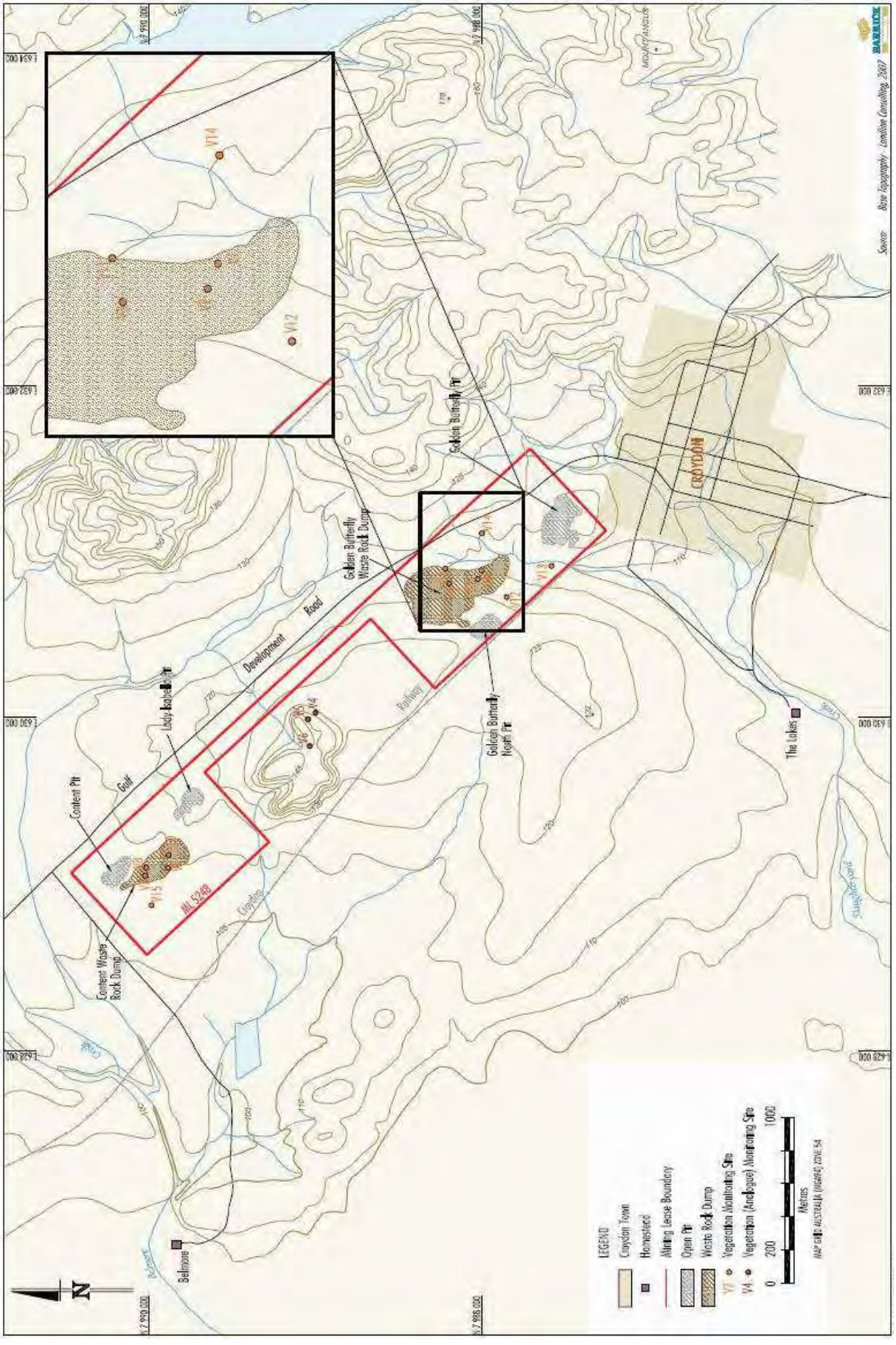

Figure 2: Site Location and Location of Vegetation Monitoring Stations

4 EROSION AND SEDIMENT CONTROL PLAN

In accordance with EA Condition F5-2 the following erosion protection measures and sediment control measures will be implemented during the proposed reclamation works for the Project and will be maintained once the works are complete.

Content Waste Rock Dump and Sediment Dam

General erosion control works were conducted to the north-western part of the waste rock dump in 2009/2010. Several small gullies were beginning to form on the upper crest where water was concentrated in deep vehicle rut marks and localised depressions. Back fill material, sourced from the Golden Butterfly waste rock dump east haul ramp, was utilised to fill these localised depressions to reduce infiltration through the waste rock dump. No excavation was conducted on the top surface of the waste rock dump to avoid potential impacts to the integrity of the clay capping layer. Subsequent rainfall and surface runoff has not caused a recurrence and no further general erosion control works on the Content Waste Rock Dump are currently planned.

Continual regular review will be undertaken to ascertain if potential problems are developing in order to schedule any necessary remedial action.

Golden Butterfly Waste Rock Dump

Preventative erosion control works were conducted during the dry season of 2009/2010 in the area to the immediate east of Golden Butterfly waste rock dump. The works involved placement of a series of low rock bunds across the open area to prevent any potential development of sheet flow. The area was partially ripped and reseeded to further improve vegetation cover.

Continual regular review will be undertaken to ascertain if potential problems are developing in order to schedule any necessary remedial action.

5 MONITORING PROGRAM

Erosion monitoring will be conducted at the Project in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Wilson, 2008]). Erosion monitoring will consist of conducting an annual qualitative assessment at the each of the vegetation monitoring transects shown in Figure 2. In general accordance with the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME, 1995) monitoring will include:

- field traverses to observe incidence of erosion;
- recording details of any incidence of erosion (e.g. rills and sheeting); and
- maintaining a photographic record for comparison.

In addition to the above, the following parameters will be monitored as part of the Rehabilitation Monitoring Program at the vegetation monitoring transects to provide an indication of the potential for erosion at the Project:

- tree density;
- pasture biomass;
- pasture cover; and
- pasture species composition.

6 REVIEW

EA Condition A2-4 is of additional relevance to this RMP and is provided below:

(A2-4) *Any management or monitoring plans, systems or programs required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm as often as necessary but at least every two years and amended promptly if required.*

In accordance with Condition A2-4 of the EA this GMP will be reviewed for effectiveness at least every two years and amended promptly when required.

7 REFERENCES

Wilson Gold of Australia (2008) *Croydon Gold Mine – Plan of Operations.*

Department of Mines and Energy (1995) *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland*, Queensland Government.

Environmental Protection Agency (1998) *Draft Guidelines for the Assessment and Management of Contaminated Land*.

CROYDON

RECEIVING ENVIRONMENT MONITORING PROGRAM

2018

Revision No: R01

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Appendix B Monitoring Data and Graphs

1 INTRODUCTION

The Croydon Gold Mine (CGM) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). CGM was formerly a large low-grade gold mine and has since been closed and decommissioned. Activities at CGM include maintenance, monitoring, investigations and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Wilson Minerals Pty Ltd (Wilson) now holds Environmental Authority (EA) No. EPML00950913 for the project.

The mining-related landforms on ML 5248 comprise of waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps.
Specifically they include (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Golden Butterfly waste rock dump;
- Content Pit;
- Content waste rock dump;
- Lady Isabella Pit;
- abandonment bunds across the access ramps of the four open pits;
- hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps;
- water diversion bunds and sediment dams adjacent to the Content and Golden Butterfly waste rock dumps; and
- roads and tracks.

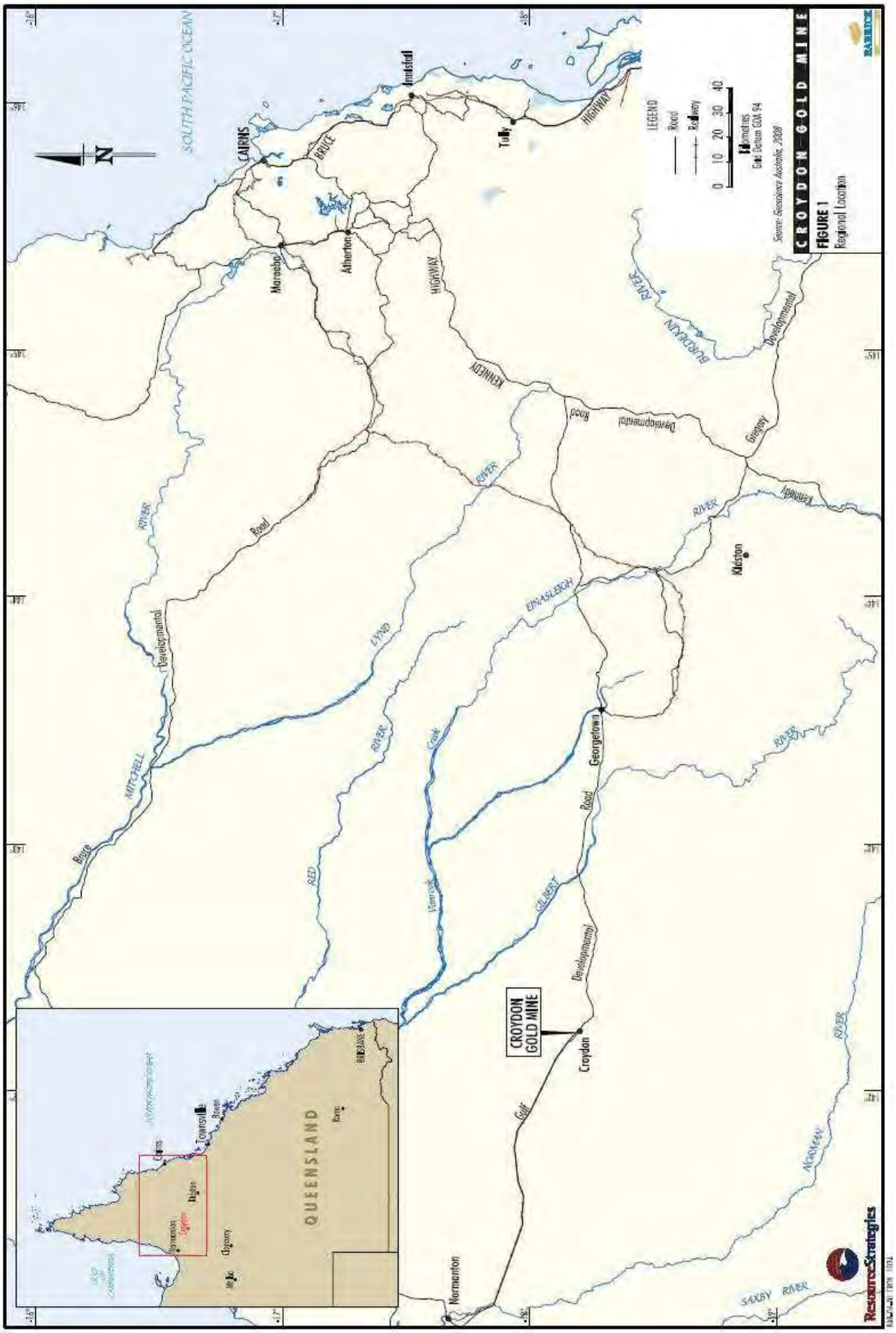


Figure 1: Croydon Regional Location Map

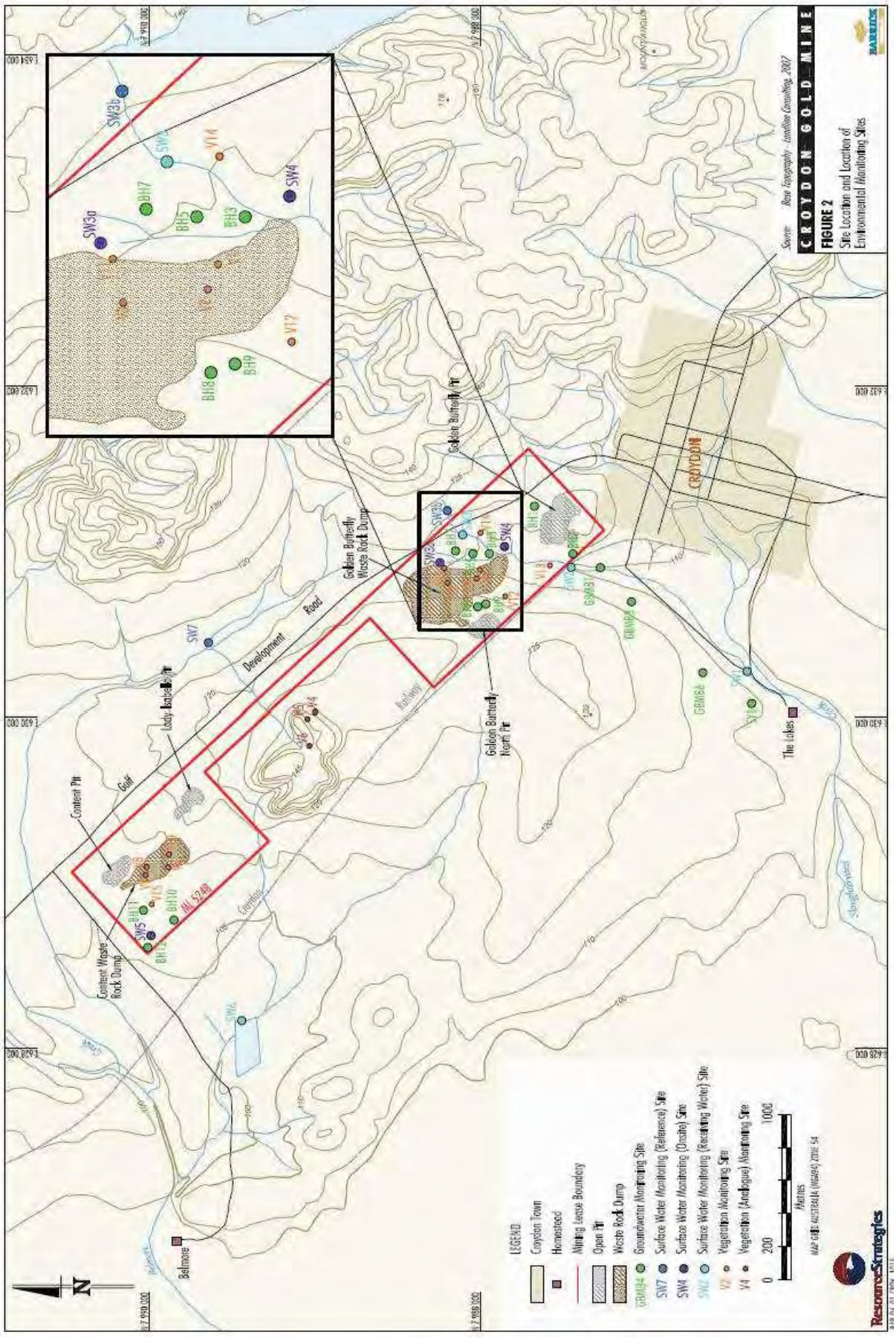


Figure 2: Croydon Site Layout and Landforms

1.1 PURPOSE OF THIS REPORT

This Receiving Environment Monitoring Program (REMP) has been prepared to assist Wilson in the implementation of appropriate environmental management measures during the post-closure operation of CGM.

The aim of this document is to demonstrate how CGM will be relinquished in a manner that meets the applicable environmental management standards and sustainable development objectives.

The Queensland Department of Environment and Heritage Protection (DEHP) is the principle decision making authority with regards to mine closure, rehabilitation and relinquishment of the mining lease.

In accordance with the EA issued to the CGM this document will satisfy components of Schedule F Land and Rehabilitation.

The scope and structure of this REMP is as follows:

Section 1: Provides an overview of CGM and describes the land tenure of the Project area. This section also lists relevant Project consents/approvals, leases and licences and outlines the environmental management system, plans and studies which have been prepared or are to be prepared for the Project.

Section 2: Describes major Project mine components and operation.

Section 3: Provides an overview of the key environmental aspects relevant to the Project.

Section 4: Outlines the mine closure objectives

Section 5: Outlines the lease relinquishment strategy

Section 6: Details of the data collected for the various environmental matrices

Section 7: Details of the monitoring program used for environmental sample collection

Section 8: Lists the references cited throughout this REMP.

1.2 PROJECT OVERVIEW

Extensive gold mining at CGM commenced in the late 1880s for approximately 30 years, before recommencing in 1987. Operational mining ceased in 1990 and the Project was decommissioned by late 1993 (Wilson, 2008). Reclamation performance was audited in 1996/1997 and significant additional reclamation works were undertaken in 1996 and 1997 (Wilson, 2008).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Wilson Gold of Australia (Wilson) in 2005. Wilson holds Environmental Authority (EA) No. MIN100401906 for the Project.

2 PROJECT DESCRIPTION

Major components of the CGM are shown on Figure 2 and include:

- Four open pits, and
- Two Waste Rock Dumps (WRD):

These components are discussed in more detail in the following section.

Schematic diagrams of the final landforms, inclusive of drainage features, are provided in Figure 3 of the Post Mine Landuse Plan (PMLP) (Appendix A). The final landform concept is to achieve a stable post-mining landform that is able to meet the identified post-mining landuse and rehabilitation objectives.

The final landforms were constructed when CGM was decommissioned/closed in 1993 and additional rehabilitation works were substantially completed in 1996/1997. The final landforms on ML 5248 are dominated by low hills (i.e. waste rock dumps) which are compatible with the surrounding topography in terms of elevation and slope and final voids.

2.1 PROJECT (MINE) COMPONENTS

Open Pit Lakes

There are four (4) pits associated with the mining lease 5248 (see Figure 2):

- Golden Butterfly Pit
- Golden Butterfly North Pit
- Content Pit
- Lady Isabella Pit

All four mine pits now contain pit lakes. Pit lake water quality data for each pit lake with pit lake water quality time series graphs presented in Attachment B. The Golden Butterfly Pit Lake has low pH and raised levels of sulphate, aluminium, arsenic, cadmium, copper, nickel and zinc. Both the Content and Lady Isabella Pits have water quality that meets ANZECC (2000) stock water quality guidelines except in the case of Lady Isabella Pit for fluoride. Consequently, the Content and Lady Isabella pit lakes are considered potential stock water supplies. The Content Pit Lake is currently being used for stock water by the local pastoralist. Reference to the time series graphs in Attachment B clearly show an improving trend in water quality versus time within these pits.

Water quality in Golden Butterfly North Pit Lake is considered of good quality and meets ANZECC (2000) livestock drinking water quality guidelines. The Golden Butterfly North Pit does receive a limited amount of surface runoff from the area to the immediate north-east. Water from this pit lake has in the recent past been used by the Croydon Shire Council for irrigation of town recreational areas.

An investigation conducted by HLA-Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping. The pits therefore represent groundwater sinks with limited capacity to influence groundwater quality much beyond the immediate footprint of the pit.

The consecutive unprecedented rainfall totals experienced since 2008/2009 support this conclusion in regards to the Golden Butterfly and Golden Butterfly North Pits. However, the overtopping and discharge from the Content Pit during early 2011 obviously shows that the conceptual hydrogeological model in terms of the Content Pit and Lady Isabella Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation for these two pits.

However, with the improvement is water quality within the Content Pit and Lady Isabella Pit lakes, an alteration to the EA was approved by the DEHP in 2013 permitting discharge from these pit lakes in extreme rainfall situations.

Waste Rock Dumps

Since the Project was decommissioned/closed, reclamation works were conducted on the final landforms identified in Section 2.1. Full details of the reclamation works are reported in Fawcett (2001) and HLA-Envirosciences (2001a).

The slope and cover design of the waste rock dumps have been developed to provide low permeability encapsulation. The reclamation work in 1996/1997 on both the Golden Butterfly and Content waste rock dumps involved:

- battering of slopes to 3H:1V minimum, with benches of 5 metres (m) width provided at a maximum of 5 m[1] vertical spacing; and
- construction of an engineered cover system consisting of a clay capping layer, a rock fill surface protection layer and a layer of topsoil.

Following preparation of the engineered cover system, all areas were sown with a seed mix of native tree and shrub species broadly representative of species found in the surrounding undisturbed woodlands.

Tailings Storage Facility

There is no Tailings Storage Facility associated with the mining lease.

2.2 PROJECT (MINE) OPERATION

CGM is not an operational mine site. Decommissioning was completed in 1994.

[1] HLA-Envirosciences (2001a) stated the vertical spacing of the Golden Butterfly and Content waste rock dumps as 50 m. However, it is considered the correct vertical spacing elevation of the was te rock dumps is 5 m.

2.3 PROGRESSIVE REHABILITATION STATUS

Rehabilitation and revegetation of all mining disturbed areas at CGM have been completed, other than for the footprint of the pit voids. The rehabilitation/revegetation assessment conducted in June 2013 (Williams, P., 2013) concluded:

- Live plant ground cover has been found to be similar between the mine rehabilitation sites compared with the combined analogue sites.
- The 2012-13 summer was very dry and caused a decline in plant cover in all sites. Statistical analyses indicate that the rehabilitated sites did not suffer worse declines in plant ground cover than the analogues. That is, there is no significant difference in the resilience to the initial stages of drought between the rehabilitation and analogue vegetation.
- The rehabilitated mined sites have a greater abundance of annual grasses and herbs than do the analogue sites, which have a greater proportion of perennials. This is likely to mean that, as the drought progresses, the rehabilitated sites may be less able to maintain ground cover than the analogue sites, because annuals require wet season rain to promote new plants each year, and annuals die off naturally in the middle of each year.

The latest revegetation assessment completed in 2016 concludes:

- The rehabilitated vegetation at the Croydon mine site displayed higher ground cover in August 2016 than in the previous years.
- This was probably influenced by above average rainfall in March, May and July 2016. In addition, the 2016 survey was undertaken in August compared to the drier month of October in 2015.
- As per previous annual revegetation assessments, this is an excellent indication that the rehabilitation has progressed to a point that it is providing an ecological equivalent to the surrounding landscape

3 PROJECT ENVIRONMENTAL ASPECTS

3.1 METEOROLOGY

The climate is sub-tropical with a pronounced wet and dry season, where 90% of all rain falls in the November to April period. The annual rainfall is 747.8 mm with an annual evaporation in excess of 2,500 mm. Winter temperatures range from 2.6^{o} to a mild 15^{o} whilst summer temperatures range from 30^{o} to in excess of 45^{o}. The prevailing wind is from the west to southeast.

Daily rainfall records are available from the Queensland Bureau of Meteorology (BoM) Croydon Township Weather Station (station number 29012) since 1889 with various statistics summarised in Table 1 and Figure 3 to Figure 6.

The rainfall statistics show that the 2015/2016 wet season was a below “mean” event. This follows the low rainfall total wet season period for the previous year and thus establishing the current drought conditions.

To date the 2016 calendar year rainfall indicates that the “dry” conditions persist. However, there were unusually high rainfall totals recorded in May and July. This “re-distribution” of rainfall is seen in the improvement of grass cover previously reported in the revegetation monitoring section.

Table 1: Croydon Climate Data

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	
Mean rainfall (mm)	222.1	180.1	116.9	25.1	7.8	8.4	3.9	2.7	5.5	13.9	44.6	115.3	747.8	1889 - 2014
Highest rainfall (mm)	860.5	601.4	591.4	279.8	129.3	139.2	83.4	44.2	92.7	145	384.7	312	1565.8	
Date	1974	1964	1936	2010	1920	1990	2006	1924	1943	1975	1973	1942	2010	
Lowest rainfall (mm)	49.4	5.3	0	0	0	0	0	0	0	0	0	0.5	225.4	
Date	2003	1926	1988	2012	2011	2013	2011	2012	2011	2008	2003	1934	1952	
Decile 1 rainfall (mm)	73.8	45.9	17	0	0	0	0	0	0	0	5.9	36.6	440.1	
Decile 5 (median) rainfall (mm)	196	166.6	93.7	9.2	0.4	0.4	0	0	0	4.6	27.8	102.4	720.2	
Decile 9 rainfall (mm)	395.4	303.3	242	63.6	22.8	20.6	11.1	8.9	19.7	37	95.4	230.7	1038.6	
Highest daily rainfall (mm)	381	367.8	245.9	155.2	63.5	91	35	39.6	77.5	63.5	151.1	153	381	
Date	- - - - - - -	- - - - - - -	- - - - - -	- - - - - - - - -	- - - - - - -	- - - - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - - - -	- - - - - - - - -	- - - - - - -	- - - - - - - - - -	
Mean number of days of rain	12.8	12.3	8.4	2.1	1.1	1	0.6	0.4	0.6	1.8	4.5	8.3	53.9	
Mean number of days of rain ≥ 1 mm	11.9	11.3	7.3	1.8	0.8	0.8	0.5	0.3	0.5	1.4	3.8	7.5	47.9	
Mean number of days of rain ≥ 10 mm	6	5.5	3.3	0.6	0.2	0.2	0.1	0.1	0.2	0.5	1.3	3.3	21.3	
Mean number of days of rain ≥ 25 mm	2.8	2.2	1.4	0.3	0.1	0.1	0	0	0.1	0.1	0.5	1.4	9	
Monthly rainfall (mm)	201.9	135.4	197.4	5.2	65.4	4	60.8	1.4	4	10.8	-	-	-	2016
Highest daily rainfall (mm)	10	9	12	2	3	2	3	1	1	2	-	-	-	
Number of days of rain	9	8	11	2	3	2	2	1	1	1	-	-	-	
Number of days of rain ≥ 1 mm	7	4	7	0	2	0	2	0	0	1	-	-	-	
Number of days of rain ≥ 10 mm	4	1	2	0	2	0	1	0	0	0	-	-	-	
Number of days of rain ≥ 25 mm	201.9	135.4	197.4	5.2	65.4	4	60.8	1.4	4	10.8	-	-	-	

Note: Data sourced from www.bom.gov.au (Croydon Station No 29012)

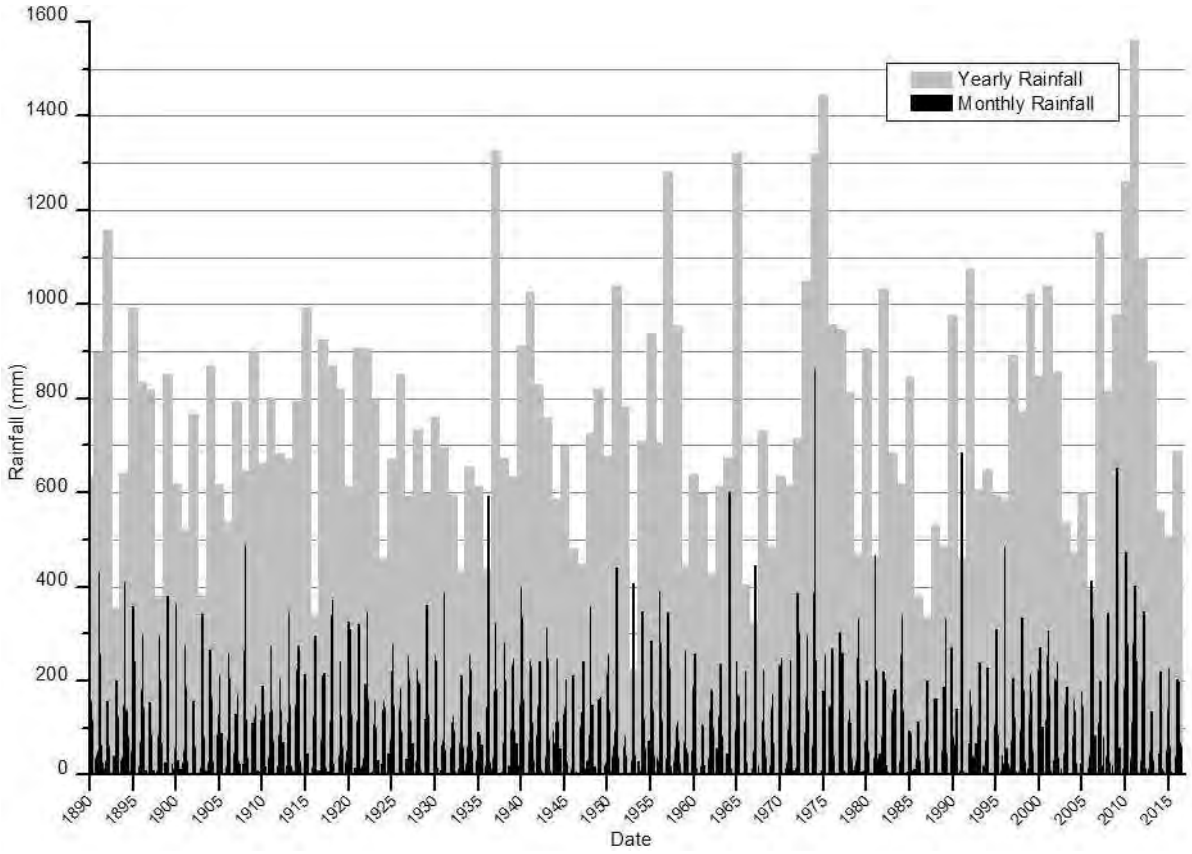


Figure 3: Yearly rainfall totals from Croydon Weather Station, 1889 to 2016

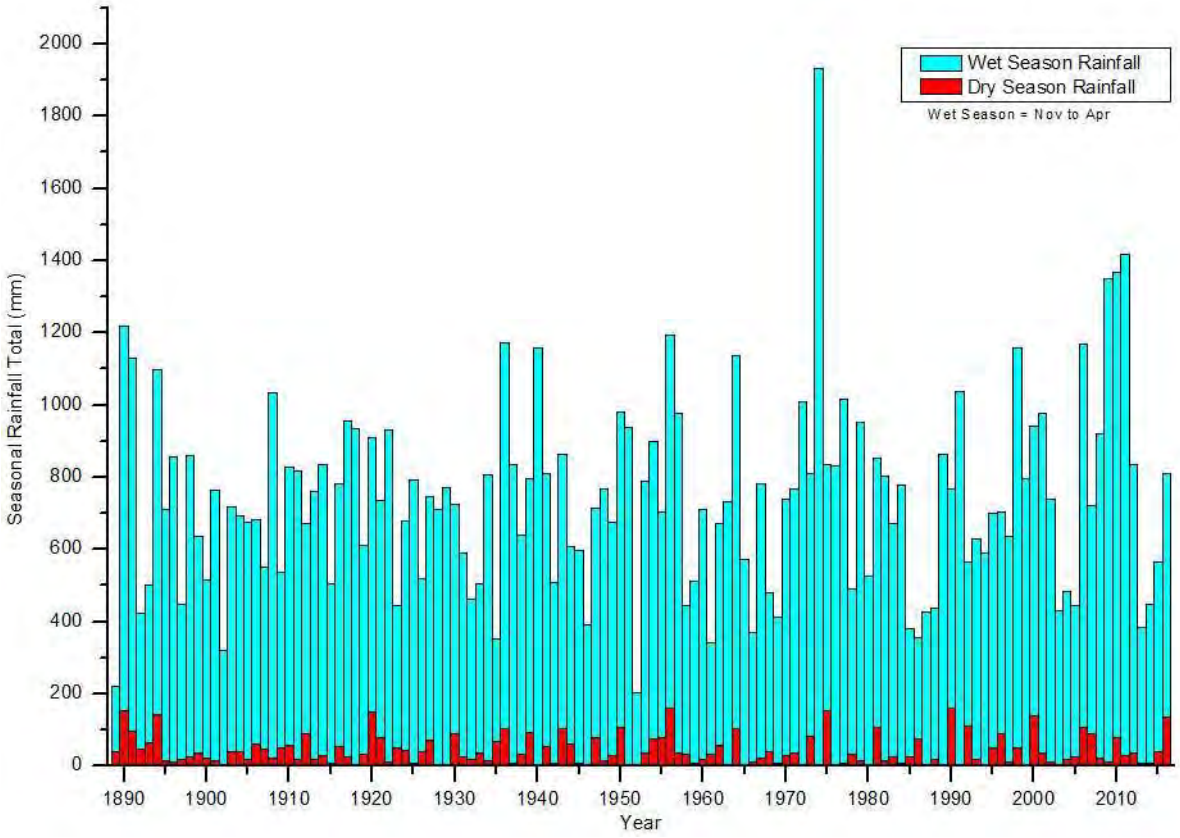


Figure 4: Wet and dry season rainfall totals from Croydon Weather Station, 1889 to 2016

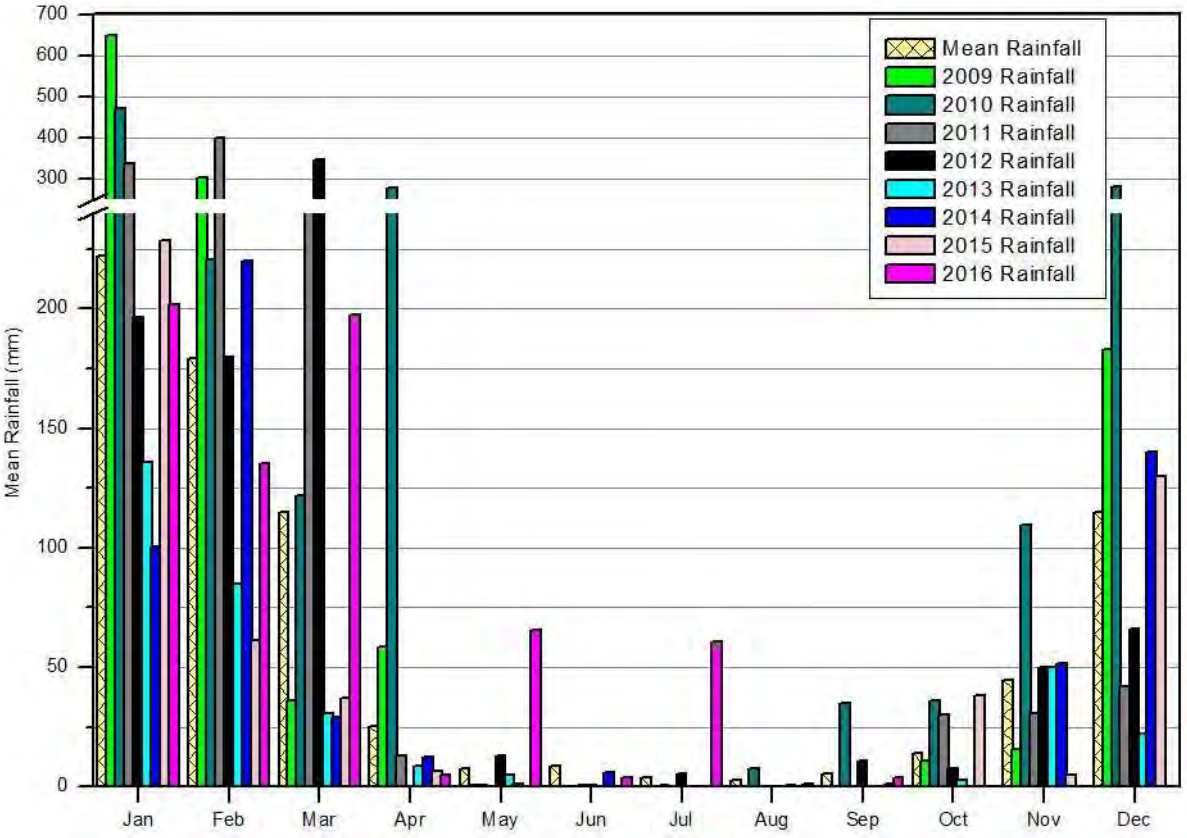


Figure 5: Mean monthly rainfall totals for Croydon

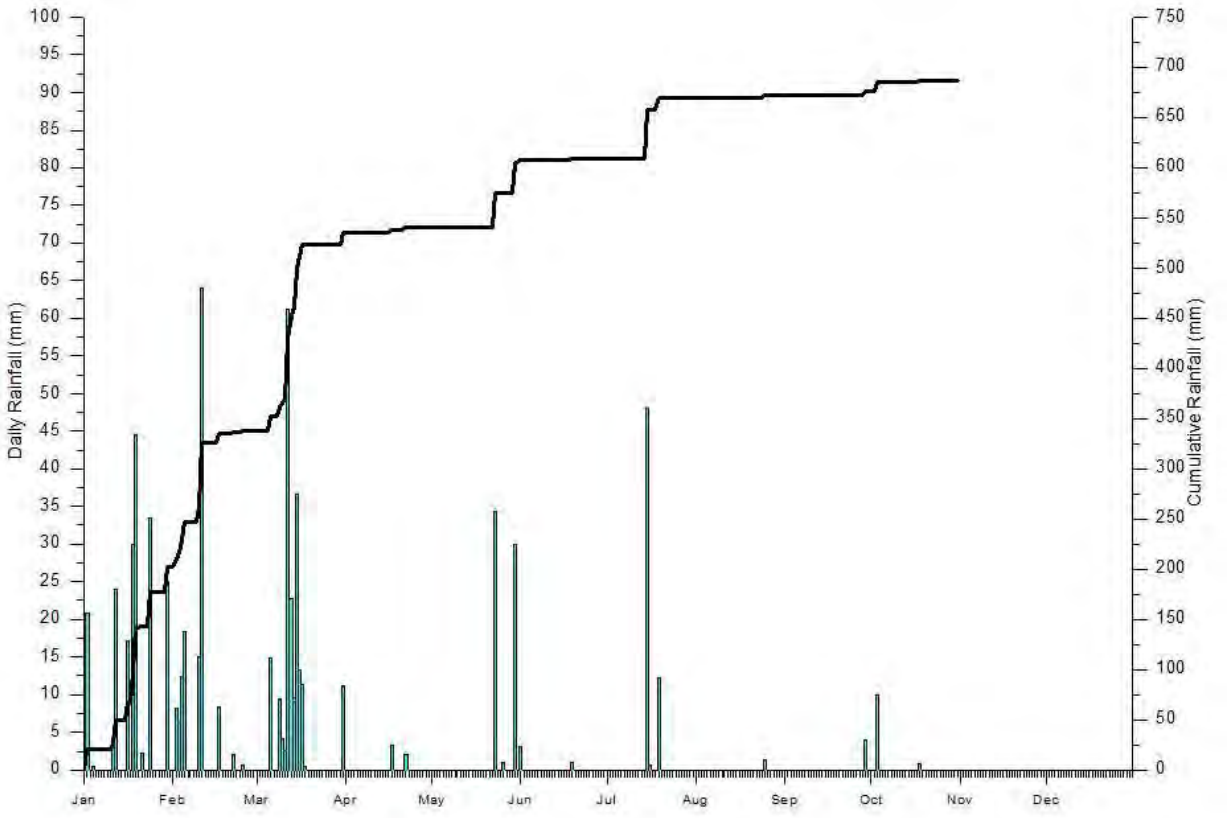


Figure 6: Daily and cumulative 2016 rainfall for Croydon

3.2 LAND RESOURCES

Croydon Gold Mine is located in the Croydon Shire, in far north Queensland. It is located approximately 1 km north west of the township of Croydon (18°12' 18' S and 142° 14' 42" E). The elevation is approximately 110m AHD and located approximately 600 km west of Cairns (See Figure 1).

Mining and Pastoral

The mining lease ML5248 lies within the surrounding pastoral leases granted to Kevin Pickering.

Topography

The Project is located on the edge of the Gulf Country in Northern Queensland. There is little to no elevation difference across ML 5248 with the only significant natural landform a low (approximately 25 metre) hill located between the two mined areas (Figure 2). The south-eastern section of ML 5248 (i.e. the Golden Butterfly mining area) is within the upper catchment of Slaughteryard Creek and has a single shallow drainage line that flows from north to south across ML 5248.

The north-western section of ML 5248 (i.e. Content and Lady Isabella mining areas) lies within the Belmore Creek catchment with a very gentle slope (1:140) to the north-west with no defined drainage network. Sheetflow is the dominant hydrological runoff mechanism.

3.3 VISUAL CHARACTER

The area surrounding the mining lease is predominately used as a pastoral lease for cattle grazing and has not been affected by the prior mining operation. The vegetation is open woodland and similar to other savannah regions in Northern Australia.

3.4 ABORIGINAL CULTURAL HERITAGE

The traditional owners of the area which contains the CGM mining lease are the Tagalaka People. There are no current registered native title claims for the area encompassing the CGM mining lease area.

3.5 NON-ABORIGINAL CULTURAL HERITAGE

A European cultural heritage survey was conducted at the Croydon Gold Mine (CGM) on Mining Lease (ML) 5248 north of Croydon, North Queensland, on 4 and 5 June 2009, to identify any European cultural heritage features. This survey was preceded by a desk study of available historical information.

The original Content Mine area, at the western boundary of ML 5248, was operated from 1896 to 1917 and this area is listed in the Queensland Heritage Register (QHR) as a State Heritage Place under the *Queensland Heritage Act, 1992* (QH Act). The European cultural heritage features within the Content Mine area were surveyed in detail in 1996 (Lennon and Associates, 1996) and the layout of the area has generally remained the same.

The 2009 survey located a number of historical mine shafts and adits within ML 5248 that had not been previously recorded. These shafts are located around the QHR listed Content Mine area and the Lady Isabella area. Two of these shafts are considered of cultural heritage value and are included within the QHR boundary for the original Content Mine area. One of the shafts is a rare example of a sawn timber lined shaft and is of State significance to the Croydon District.

Except for the QHR listed Content Mine area and the machinery/plant/equipment and shafts within this area, no other sites or historic features on ML 5248 satisfy criterion A to H of the QH Act and do *'not contribute significantly to our understanding of the wider pattern and evolution of Queensland's history and heritage*' (QHC, 2006).

3.6 FLORA

Queensland is divided into thirteen bioregions that are based on broad differences in structural geology, climate and biological assemblages. Each of these bioregions is subdivided into subregions that define differences in landscape. The Croydon project is located in the Gulf Plains bioregion.

The relevant regulated vegetation management map (DNRM) shows that the entire area contained within the mining lease, including all surrounding areas, is classified as “Category B: Remnant Vegetation”.

The vegetation surrounding the lease area is open woodland and similar to other savannah regions in Northern Australia. The main species are native grasses with ironbark trees and Gilbert river boxes. Around the creek beds the predominant trees are casuarinas, callistemons, melaleucas and red river gums.

The mined areas were rehabilitated with mainly native tree and shrubs and the sowing of pasture grass seeds, in particular Rhodes grass (Chloris gayana), Buffel grass (Pennisteum ciliare) and couch (Cynodon dactylon).

3.7 FAUNA

The local fauna comprises mainly domestic cattle, wild pigs, dingoes, kangaroos, wallabies, rabbits, small marsupials, lizards and snakes.

The area supports a prolific bird life with main species being parrots, galosh, pigeons, small honey eaters, the kingfishers (including kookaburras), plain turkeys and water birds including cranes, ducks, pelicans and brolgas.

Aquatic fauna is seasonal dependent upon the river flow and comprises of invertebrates, frogs and small fish, mainly rainbow fish and spangled grunters.

Threatened Fauna Species

CGM has no species of protected fauna within the mining lease or within close proximity of the mining lease.

3.8 HYDROLOGY (SURFACE WATER DRAINAGE)

ML 5248 contains no springs or groundwater supported surface drainage features.

3.9 HYDROGEOLOGY (GROUNDWATER)

Groundwater occurs in deep fractured rock aquifers, but is not utilised as a water resource on or adjacent to ML 5248. Any aquifers linked to the main mineralised zones might be expected to have raised levels of metals and sulphate. This assumption is supported by water quality analysis from the monitoring bores located in this area. It is likely that water quality will vary significantly between individual fractured rock aquifers, with limited hydrogeological linkage between aquifers. These aquifers would therefore not be considered potential potable water supplies, irrespective of potential yields.

The original Croydon town borefield, decommissioned more than 15 years ago, is located within Slaughteryard Creek approximately 1 km south-west of Golden Butterfly Pit (see Figure 2). It is considered that the borefield exploits both an unconfined alluvial aquifer and deeper fractured rock aquifers in the underlying sandstone units. A series of monitoring bores (i.e. GBMB series Figure 26) located between the old town borefield and ML 5248 have been monitored for more than 15 years and continue to show no influence (i.e. hydrogeological linkage) between Golden Butterfly Pit and the borefield.

A conceptual hydrogeological model (Figure 7) was developed for the Project and surrounds during preparation of the Environmental Management Plan (EM Plan). The conceptual hydrogeological model was based on the hydrogeological study conducted by HLA-Envirosciences and available groundwater quality information.

The hydrogeological study indicates that the pit lakes are expected to act as groundwater sinks and have limited capacity to influence groundwater quality much beyond the immediate footprint of the pits. In addition, the hydrogeological study showed that historic rainfall and evaporation data indicate a relatively large deficit (due to short wet season and high evaporation during most of the year) and that even in the wettest years there is no risk of the pit lakes overtopping. Despite these conclusions from the conceptual hydrogeological model the unprecedented rainfall totals experienced since 2008/2009 (see Section 3.1) raised concerns about the model's robustness.

The 2008/2009 and 2009/2010 wet seasons resulted in extraordinary rainfall totals (see Figure 3). In recognition of the possibility of a discharge from the Content Pit, Wilson had undertaken short-term remediation works involving the transfer from water from the Content Pit to the Golden Butterfly Pit to minimise the risk of the Content Pit overtopping during the 2010/2011 wet season. The water level of the Content Pit was decreased by approximately four (4) meters during November and December 2010 (with a subsequent increase of one (1) meter in the Golden Butterfly Pit). Nevertheless, on the 29th March 2011 the Content Pit began discharging water which continued until the 13th April 2011 when no flow was observed to be entering receiving streams. This event obviously shows that the conceptual hydrogeological model in terms of the Content Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation.

In order to provide additional information to assist in modifying the conceptual hydrological model, a series of water level monitoring stations were installed in each of the pit lakes at Croydon (see Figure 8) in January 2012. Each of these stations is fitted with a pressure sensor transducer connected to a data logger with solar powered battery supply. Additionally, in the event of a further discharge from the Content Pit, a measuring flume has been installed in the v-drain which will direct any outflow from the Content Pit.

The additional information now available proceeding the extraordinary succession of wet season rainfall totals from 2009 to 2011 followed by reversion to median conditions in 2012 allow the conceptual model to be refined as follows.

The pit lake water levels in the Golden Butterfly Pit and Golden Butterfly North Pit were observed to increase over the period since closure in 1995 but maintain significant freeboard capacity up to 2009. After which occurred a period of three successive record wet season rainfall totals from 2009 to 2011. However, this still resulted in freeboard capacity within the Golden Butterfly Pit and Golden Butterfly North Pit lakes remaining greater than approximately nine meters. The subsequent return to median rainfall conditions during 2012 has resulted in a decrease in pit lake levels of approximately 2m. Therefore, the conceptual hydrological model for the Golden Butterfly Pit and Golden Butterfly North Pit lakes acting as groundwater sinks having limited capacity to influence groundwater quality much beyond the immediate footprint of the pits, with an overall long-term negative water balance never leading to pit overtopping is supported by the collected field data.

The situation for the Content Pit and Lady Isabella Pit lakes however differs in response to the potential situation of successive high rainfall total wet seasons. The approximately fifteen year period prior to 2009 resulted in the Content Pit and Lady Isabella Pit lakes fluctuating in response to climatic and hydrological factors but maintaining freeboard capacity and not overtopping. However, the three successive record wet season rainfall totals from 2009 to 2011 demonstrated that the Content Pit and potentially the Lady Isabella Pit can overtop. The subsequent return to median rainfall conditions during 2012 show that these pit lakes again show a negative water balance with reducing pit lake levels.

During December 2012 limestone dosing of both the Content Pit and Lady Isabella Pit lakes was performed to raise the pH to approximately neutral conditions. This enabled the Content Pit lake water to meet all stock watering guidelines and similarly for Lady Isabella Pit, with the exception of fluoride. Subsequently the local pastoralist and Shire Council received approval to abstract water from the Content Pit and Lady Isabella Pit lakes for stock watering and road construction purposes respectively. This water abstraction from the Content Pit and Lady Isabella Pit lakes is expected to keep the pit lakes at low levels due to anthropogenic usage. Therefore, overtopping of the Content Pit and Lady Isabella Pit lakes is not expected to occur in the future.

Table 2: Croydon Pit Lake Levels

	Content Pit[f]		Golden Butterfly Pit[f]		Lady Isabella Pit[f]		Golden Butterfly North Pit[f]	
	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate
10th July 2010	102.53	1.54	102.07	12.57	106.93	3.13	112.01	9.71
13th Aug 2010	102.35	1.36	102.0	12.5	106.75	2.95	111.8	9.5
27th Aug 2010	102.30	1.40	101.97	12.47	na	na	na	na
18th Oct 2010	102.10	1.60	na	na	106.53	3.17	111.44	9.86
19th Nov 2010	101.98	1.72	101.86	12.64	106.37	3.33	111.27	10.03
7th Dec 2010	98.98	4.72	103.36	11.14	106.48	3.23	na	na
29th Dec 2010	99.305	4.395	103.56	10.94	na	na	na	na
23rd Feb 2011	103.7	0	na	na	109.7	0.0	na	na
23rd Aug 2011	103.24	0.47	106.31[a]	8.19	108.26[a]	1.44	113.31	9.40
20th Oct 2011	102.89	0.81	104.91[a]	9.59	107.90 [a] 108.13 [b]	1.57	112.64	10.07
6th Dec 2011	102.65[d]	1.05	104.75[d]	9.75	107.96[c] 107.82[d]	1.74	na	na
22nd Dec 2011	102.57[d]	1.13	104.74	9.76	107.76[d]	1.94	113.78[d]	8.92

a. Using Dumpy Level
b. Compared to last gauge board reading (8th Dec 2010)
c. Using gauge board reading
d. Using survey equipment
e. Reference RL's: Content Pit 103.7m; Golden Butterfly Pit 114.5m; Lady Isabella Pit 109.7m; Golden Butterfly North Pit 122.7m
f. After Dec 2011 water levels were automatically monitored using pressure sensors

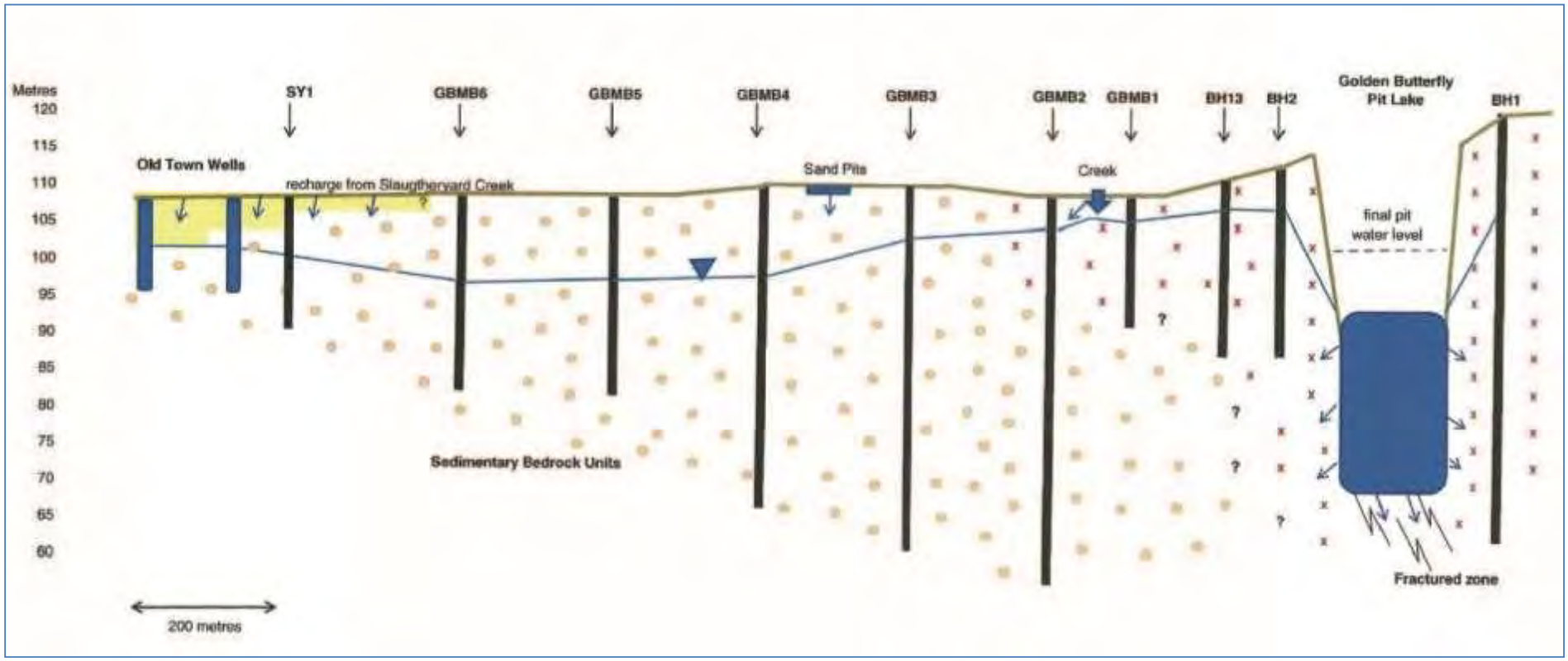


Figure 7: Croydon conceptual hydrological model

Lady Isabella Pit

Golden Butterfly North Pit

Golden Butterfly Pit

Content Pit

Figure 8: Croydon Pit Lake water level monitoring stations

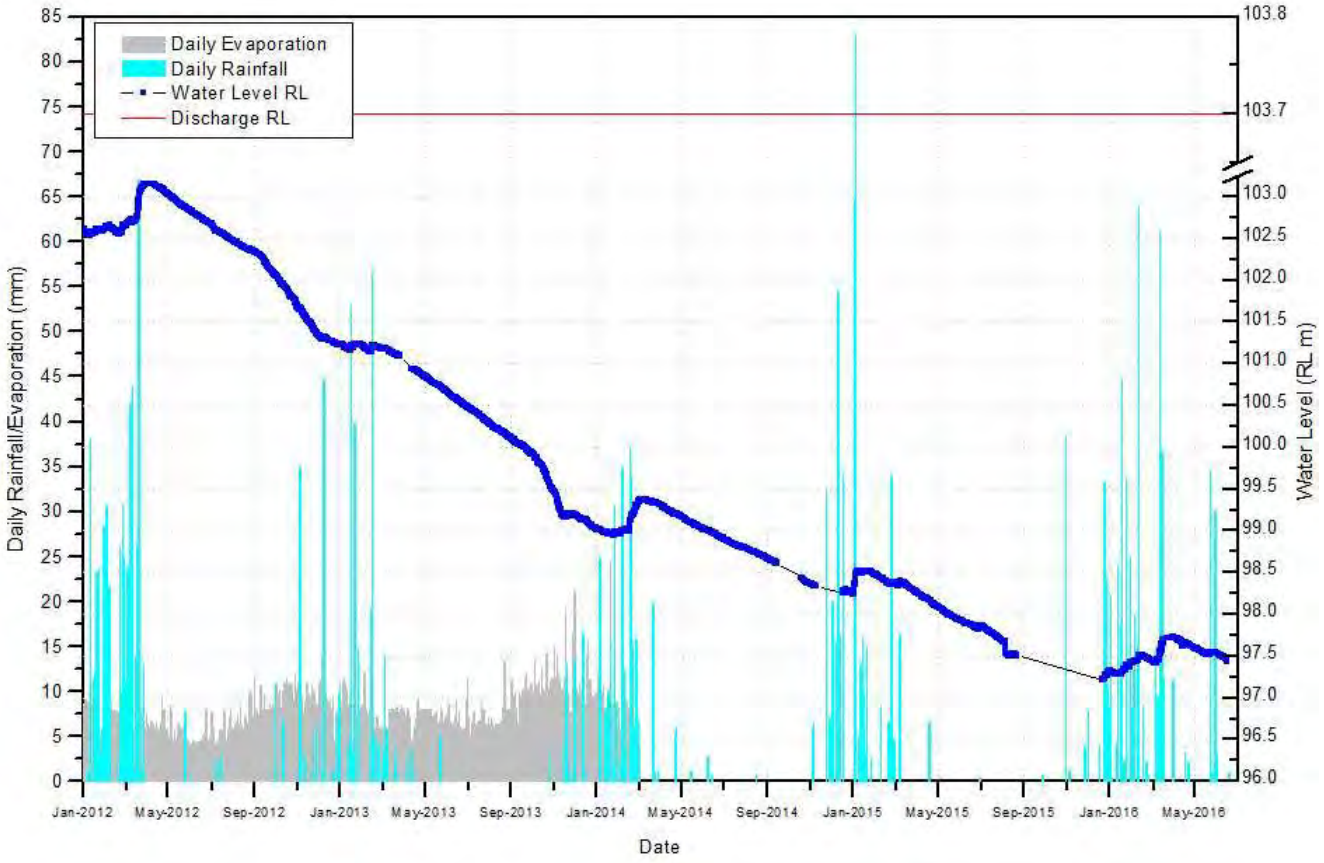


Figure 9: Pit Lake Water Level - Content Pit

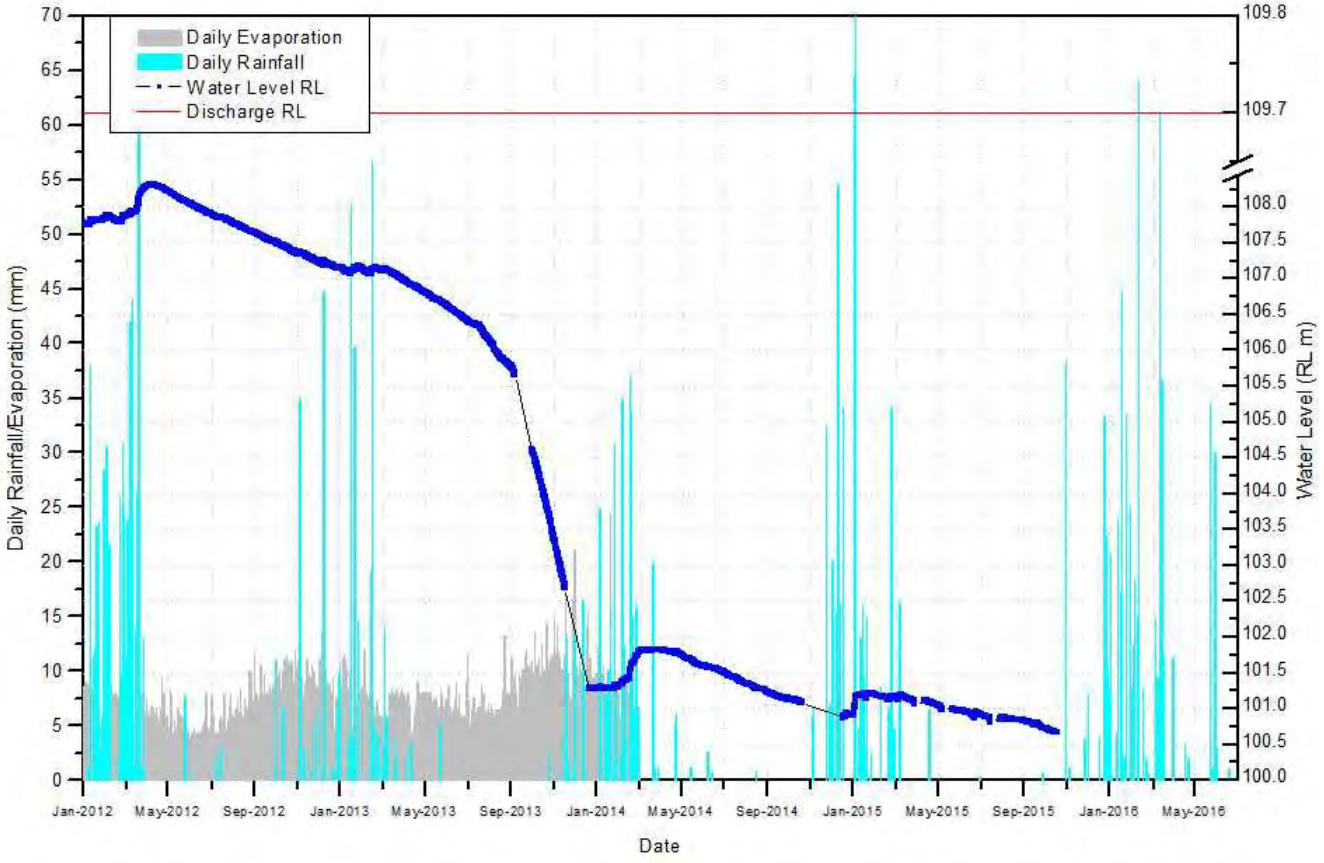


Figure 10: Pit Lake Water Level - Lady Isabella Pit

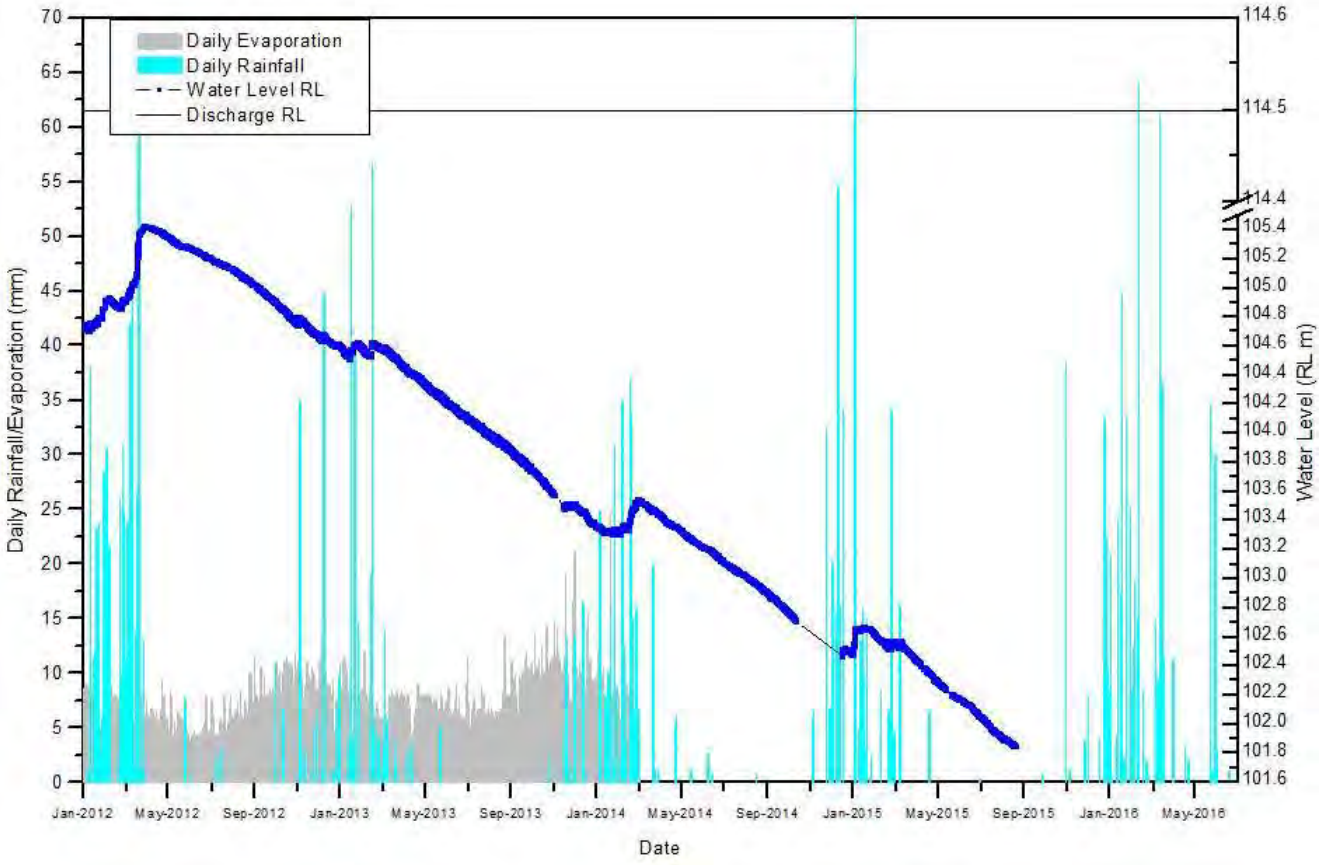


Figure 11: Pit Lake Water Level - Golden Butterfly Pit

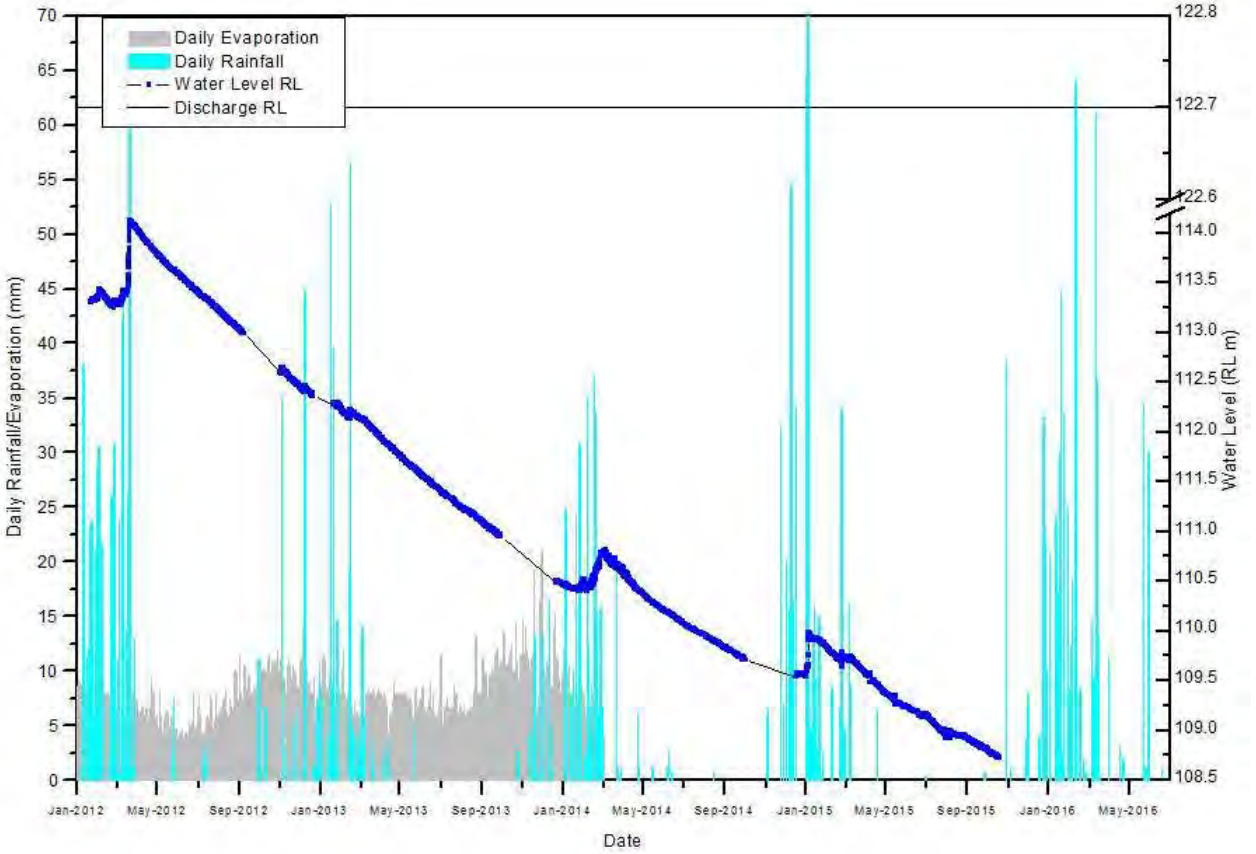


Figure 12: Pit Lake Water Level - Golden Butterfly North Pit

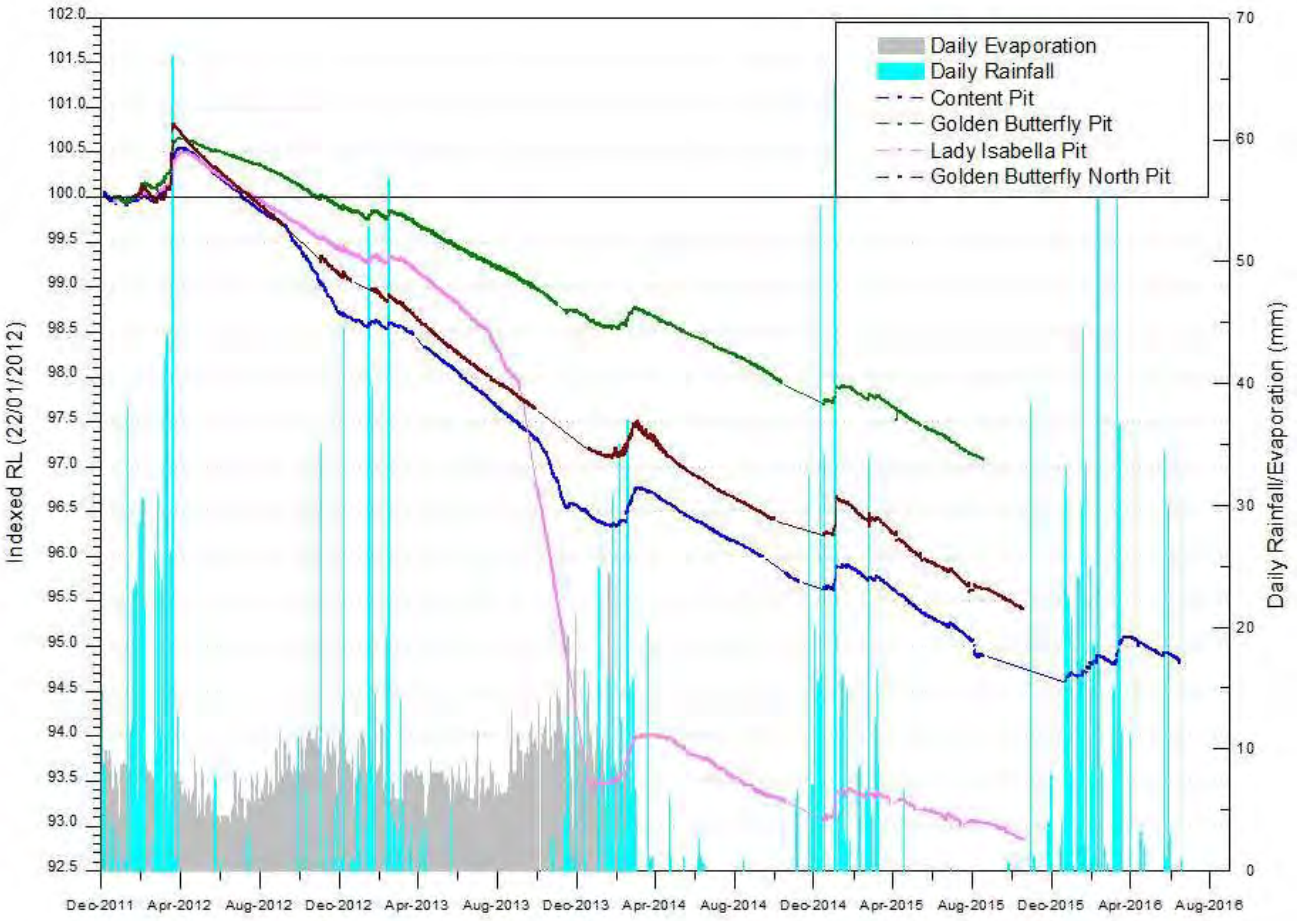


Figure 13: Pit Lake Water Level Comparison – Indexed to 100 (22nd Jan 2012)

3.10 NOISE

CGM is not an operational mine site. Decommissioning was completed in 1993. The only on site machinery are light vehicles for transport undertaking environmental monitoring activities.

3.11 AIR QUALITY

CGM is not an operational mine site. Decommissioning was completed in 1993. The only on site machinery are light vehicles for transport undertaking environmental monitoring activities.

3.12 TRANSPORT

CGM is not an operational mine site. Decommissioning was completed in 1993. The only site presence is limited to regular visits to conduct environmental monitoring activities.

3.13 REGIONAL ECONOMY

The nearest town to CGM is the Croydon Township which is immediately adjacent to the mining lease. The immediate area surrounding CGM are pastoral leases.

3.14 POPULATION, EMPLOYMENT AND COMMUNITY INFRASTRUCTURE

Due to the remote location of CGM and that the nearest town, Croydon, only has a population of approximately 300 people, the project has minimal impact on local communities.

3.15 KEY ENVIRONMENTAL VALUES

“Environmental values are particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits. They were often called ‘beneficial uses’ in the water quality literature” (ANZECC 2000).

The following environmental values are recognised in ANZECC guidelines in terms of receiving water bodies:

- aquatic ecosystems,
- primary industries (irrigation and general water uses, stock drinking water, aquaculture and human consumption of aquatic foods),
- recreation and aesthetics,
- drinking water,
- industrial water (no water quality guidelines are provided for this environmental value), and
- cultural and spiritual values (no water quality guidelines are provided for this environmental value).

Belmore Creek forms the western boundary to the site, and is the receiving water body for potential off-site discharges from the Content and Lady Isabella pits and Content Waste Rock Dump. Belmore Creek is an ephemeral water body, but nonetheless forms an aquatic ecosystem that would be expected to be maintained at a minimum of the existing condition. Therefore, environmental values of stock drinking water, and irrigation and general water uses are applicable.

Groundwater is not used for livestock or human consumption in the Croydon area due to poor groundwater resources and the ready availability of water in the Lake Belmore drinking water dam.

CGM has no species of protected fauna within the mining lease or within close proximity of the mining lease (Section 3.7). Similarly, CGM has no area listed of concern regarding flora biodiversity.

4 MINE CLOSURE OBJECTIVES

4.1 KEY TERMINOLOGY

The following mine closure terminology is used to facilitate consistent in mine closure objectives across all Wilson operations.

"*Reclamation*" includes activities associated with physical stabilisation of a site, for example: reforming land surfaces; and revegetation.

"*Closure*" includes activities associated with chemical stabilisation of a site. Closure activities may include "remediation", which is generally associated with contaminated land and may involve rectifying an environmental impact by repairing, rehabilitating and/or restoring the part of the environment affected.

"*Decommissioning*" involves the decontamination, dismantling, removal and/or demolition of infrastructure/equipment.

"*Mine Closure*" is the result of all activities required to attain site relinquishment/surrender. This includes reclamation, closure and decommissioning works. A completed mine has progressed to a state where mining lease ownership can be surrendered/relinquished and responsibility accepted by the next land user (Commonwealth Department of Industry, Tourism and Resources, 2006). Mine Closure aims to (*ibid*.):

> "*prevent or minimise adverse long-term environmental, physical, social and economic impacts, and to create a stable landform suitable for some agreed subsequent landuse*"*.*

If mine closure is not undertaken in a planned and effective manner, a site may continue to be hazardous and a source of pollution for many years to come (Commonwealth Department of Industry, Tourism and Resources, 2006).

4.2 POST CLOSURE LANDUSE

The EA for CGM states the following requisite post closure land use requirements.

Rehabilitation Landform Criteria

All areas significantly disturbed by mining activities must be rehabilitated to a safe, stable, non-polluting landform with a self-sustaining vegetation cover in accordance with the following table.

Grazing Pasture Outcome

Areas that are to be rehabilitated to low intensity grazing must comply with the following outcomes:

- Possess a self-sustaining vegetation with vegetation cover, dry matter production and species composition and distribution comparable to analogue sites identified in the Rehabilitation Monitoring Manual;
- Result in stable landforms with rates of erosion comparable to those of analogue sites; and,
- Meet the acceptance criteria listed in Table F1 – Rehabilitation Requirements of the EA.

Residual Void Outcome

Residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer other than the environmental harm constituted by the existence of the residual void itself and subject to any other condition within the EA.

Infrastructure

All infrastructure constructed by or for mining activities including water storage structures must be removed from the licensed place prior to mining lease surrender except where agreed to in writing by the land owner / holder.

Table 3: CGM Landform Post-Mine Land Use Descriptions (as per EA)

Landform (refer Schedule H – Map 1)	Surface area (hectares)	Rehabilitation Objectives		
		Post-mine land description	Land classification[1]	Analogue site identification
Golden Butterfly North Pit	1.6	Non-beneficial land use	Class VIII	Sites to be rehabilitated to a standard nominated in the rehabilitation program developed in accordance with Condition C2-1 based on analogue sites.
Golden Butterfly Pit	5.1	Non-beneficial land use	Class VIII	
Lady Isabella Pit	1.7	Non-beneficial land use	Class VIII	
Content Pit	2.1	Non-beneficial land use	Class VIII	
Content Dump	6.3	L.I.G.[2]/disturbed native habitat	Class VI or better	
Golden Butterfly Dump	15.2	L.I.G.[2]/disturbed native habitat	Class VI or better	
Content Hardstand	2.0	L.I.G.[2]/disturbed native habitat	Class VI or better	
Golden Butterfly Hardstand	0.5	L.I.G.[2]/disturbed native habitat	Class VI or better	
Sediment Dams	1.5	L.I.G.[2]/disturbed native habitat	Class VI or better	
Roads / Tracks	3.5	L.I.G.[2]/disturbed native habitat	Class VI or better	

4.3 CLOSURE OBJECTIVES

The Croydon closure objectives aim to facilitate well-planned and effective mine reclamation, closure and decommissioning (and therefore mine closure) for the Project by providing a process to (adapted from ANZMEC and MCA, 2000):

- enable all stakeholders to have their interests considered during the mine closure process;
- allow closure to occur in an orderly, cost-effective and timely manner;
- enable the cost of closure to be adequately represented in Company accounts;
- provide clear accountability, and adequate resources, for closure;
- establish a set of indicators which will demonstrate the success of the closure process; and
- reach a point where the Company has met agreed closure criteria to the satisfaction of the relevant authority.

Wilson have established the following closure objectives:

- Mine closure planning is fully integrated with operational mine planning throughout the life of the Project ensuring orderly, cost-effective and timely mine completion.
- Ensure that all site closure activities (decommissioning and rehabilitation) ensure the safety and health of workers.
- Any known ore reserves or mineralised waste material that might have potential value to future generations is, where practically possible, preserved for potential future exploitation.
- Mine closure planning includes effective internal and external stakeholder consultation ensuring that all concerns/issues are considered during the development and implementation of the Mine Closure Plan.
- Final mine landform designs achieve long term (200 year) geotechnical stability and effective containment of any contaminated material. To remove, re-contour, re-vegetate and/or stabilise landforms and disturbed areas to ensure effective drainage, minimise erosion and limit subsidence.
- Access is effectively denied to any landforms or structures that are deemed unstable and/or unsafe. Instability being considered over a 200-year period, based on local climatic and geotechnical conditions.
- All reagents and chemicals are removed from site with any residual site contamination neutralised or controlled through treatment such as not to detrimentally impact on future land use and water resources.
- All water discharging from/off mine related landforms and structures will be of a quality that it is within the assimilative capacity of the receiving environment.
- Where possible features of heritage value consistent with the mining history of the area will be retained for conservation by future landowners or local authorities.
- Transport facilities considered of value to the local community are to be retained in an operational condition for transfer to local and regional authorities. Ongoing maintenance and liability for such structures passing to the local authority.
- To rehabilitate all previously disturbed areas to a self-sustaining ecosystem that where practically possible blends with the surrounding landscape.
- To utilise closure strategies that return relinquished leases/tenements to a self-sustaining condition with little or no need for ongoing care and maintenance.
- To monitor rehabilitation performance during all phases of the project and to implement appropriate actions where observed trends do not reflect agreed closure criteria.
- To ensure that adequate closure provision is made to cover all agreed to closure commitments until such time as final lease relinquishment.
- Comply with mine closure permitting and regulatory requirements and at all times obtain documented confirmation of compliance.

5 CLOSURE CRITERIA

5.1 THE PRINCIPLE

Closure criteria are used to facilitate the fulfilment of mine closure objectives and are generally specific to each Project. With respect to closure criteria, ANZMEC and MCA (2000) state:

- Closure criteria are specific to the mine being closed, and should reflect its unique set of environmental, social and economic circumstances.
- Closure criteria are the basis on which successful reclamation is determined, and should be developed in consultation with stakeholders. This ensures that there is broad agreement on both the end land use objectives and the basis for measuring the achievement of that objective. Ideally, closure criteria should reflect the specific environmental and socio-economic circumstances of the site.
- Closure criteria should be flexible enough to adapt to changing circumstances without compromising the agreed end objective. This provides certainty of process and outcome (relinquishment of tenement when the conditions have been met). There should be an agreed process for the periodic review and modification of closure criteria in light of improved knowledge or changed circumstance.

Figure 14 illustrates the role of closure criteria in the mine closure process, including the feedback loops to determine whether criteria are met and the mining lease can be surrendered/ relinquished.

5.2 CLOSURE CRITERIA

Detailed specific closure criteria have yet to be specified by DEHP. The requisite Post Mine Land Use Plan (EA clause C2-2) however indicates issues and or measureable items that will likely form components of the final closure criteria. The following table summarises potential criteria that would be advantageous in the assessment of lease relinquishment at CGM.

Table 4: CGM Potential Closure Criteria

Criteria Type	Key Closure Criteria
Water Quality	• Surface water parameters below *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000) trigger threshold values for livestock drinking water quality.
Surface Drainage	• Safe, stable, adequately drained post-mining landforms consistent with the local surrounding landscape and suitable for the proposed post-mining landuse.
Physical Stability	• Waste rock dumps are geotechnically stable over 200yr timeframe with no erosion exposed PAF material. • Mine pit abandonment bund constructed
Vegetation	• Revegetated areas to be within agreed upon percentage of analogue sites. • Revegetated areas targeting a low intensity grazing outcome have self-sustaining vegetation for the identified stocking rates[1]
Post-mining Landuse	• Infrastructure with no on-going beneficial use removed from the site or buried. • Perimeter bunding around all mine pits/voids to deny vehicle access.
Social (Site Relinquishment)	• No outstanding regulatory commitments or claims by stakeholders

[1] As determined by Wilson Revegetation (Cedar Creek) Protocol and/or similar systems-based monitoring approach (see Appendix A)

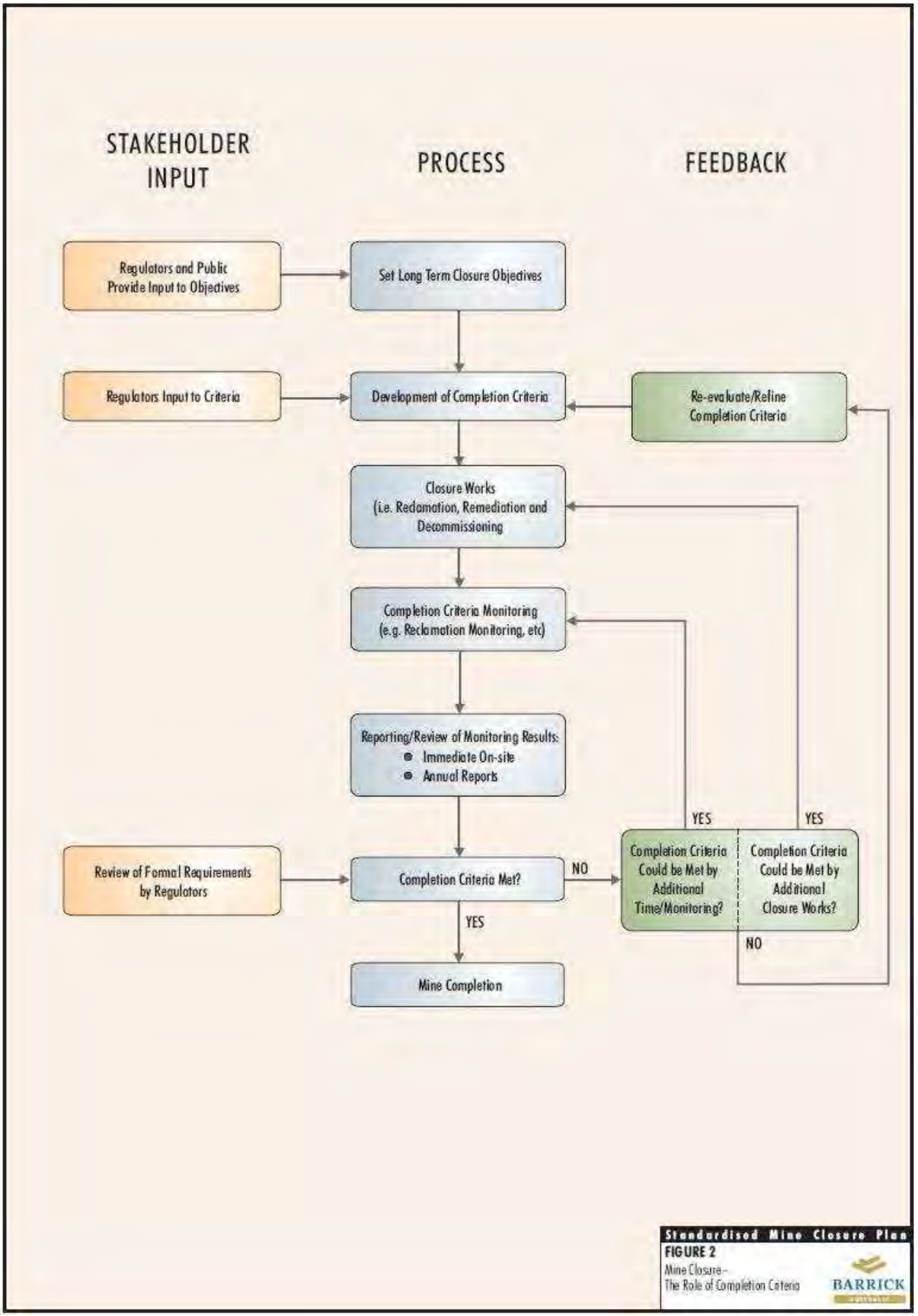


Figure 14: The Role of Completion Criteria in Mine Closure

6 MONITORING DATA

6.1 Sediments

Sediment monitoring sites are located on both Belmore Creek and Slaughteryard Creek (Figure 2). The individual sample sites are detailed in Table 8 and are summarised as follows:

- Slaughteryard Creek
  - Site SW1 – Lower Slaughteryard Creek
  - Site SW2 – Slaughteryard West Tributary at ML Boundary
  - Site SW3 – Slaughteryard Creek upstream of Golden Butterfly WRD
  - SW6 – Belmore Creek borrow pit/stock dam
  - SW3b – Slaughteryard Creek reference site
- Belmore Creek
  - Site BCDS – Belmore Creek Downstream
  - Site BCUS – Belmore Creek Upstream (reference site)

Sediment monitoring frequency has generally been on an annual basis scheduled to coincide with the end of the wet season period. The ephemeral nature of the water courses at Croydon provides the benefit of enabling representative samples to be collected transversely across the water bodies by simple surface grab samples and compositing. The sediment sampling method is detailed in Section 7.1.

Sediment monitoring parameters are as per the analytes detailed in the EA Schedule F Table 6 namely: aluminium, arsenic, boron, cadmium, chromium, cobalt, copper, mercury, nickel, selenium and zinc. The various analytes are analysed as “total” concentrations after mineral acid dissolution of the whole sample proceeding oven drying to establish dry weight. Sediment monitoring data for the analytes detailed in the EA Schedule F Table 6 is listed in Table 5.

Sediment trigger level and contaminant limits are based upon ANZECC (2000) Interim sediment quality guidelines, low and high values respectively. The Croydon EA makes provision for the trigger level and contaminant limits for the specified parameters to be based upon the reference site values if these values are higher than the relevant ANZECC (2000) Interim sediment quality guideline. Sediment data in Table 5 for Belmore Creek and Slaughteryard Creek for all sites is below both trigger level and contaminant limits.

Table 5: Sediment Metal Monitoring Results

Site[1]	Date	Aluminium (mg/kg)	Arsenic (mg/kg)	Boron (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Cobalt (mg/kg)	Copper (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Selenium (mg/kg)	Zinc (mg/kg)
SW1	9/09/2005	-	35	-	<1	-	<2	<5	-	<2	-	8
	4/04/2006	-	36	-	<1	<2	<2	5	<0.1	<2	-	8
	29/01/2007	-	33	-	<1	5	-	8	<0.1	<2	-	13
	14/11/2007	-	62	-	<1	-	<2	9	<0.1	<2	-	12
	17/04/2008	-	24	-	<1	3	<2	7	<0.1	<2	-	16
	7/07/2009	840	20	<50	<1	3	<2	<5	<0.1	<2	<5	12
	24/01/2010	910	22	<50	<1	2	<2	<5	<0.1	<2	<5	9
	11/07/2010	1440	53	<50	<1	8	<2	12	<0.1	2	<5	11
	23/02/2011	1800	27	<50	<1	3	<2	8	0.2	<2	<5	15
	30/03/2011	1710	95	<50	<1	10	<2	10	<0.1	<2	<5	25
	22/08/2011	790	19	<50	<1	4	<2	<5	<0.1	<2	<5	12
	20/09/2011	1300	24	<50	<1	8	<2	6	<0.1	<2	<5	10
	10/03/2012	1630	31	<50	<1	22	<2	5	<0.1	<2	<5	10
	8/07/2012	1180	29	<50	<1	3	<2	5	0.3	<2	<5	14
	11/04/2013	1840	58	<50	<1	3	<2	12	1	<2	<5	15
	30/09/2013	2010	33	<50	<1	6	<2	10	0.1	<2	<5	17
	23/03/2014	690	16	<50	<1	3	<2	<5	<0.1	<2	<5	10
	19/10/2014	1000	24	<50	<1	4	<2	6	0.1	<2	<5	14
	23/04/2015	1210	29	<50	<1	5	<2	<5	<0.1	<2	<5	13
	24/03/2016	3740	29	<50	<1	5	<2	<5	<0.1	<2	<5	13
	20/09/2016	2460	<5	<50	<1	10	2	5	<0.1	3	<5	12
SW2	9/09/2005	-	-	-	-	-	-	-	-	-	-	-
	4/04/2006	-	14	-	<1	<2	<2	<5	<0.1	<2	-	<5
	29/01/2007	-	17	-	<1	<2	-	<5	<0.1	<2	-	<5
	14/11/2007	-	44	-	<1	<2	<2	14	0.4	<2	-	11
	17/04/2008	-	17	-	<1	<2	<2	<5	<0.1	<2	-	6
	7/07/2009	680	18	<50	<1	<2	<2	<5	<0.1	<2	<5	5
	24/01/2010	900	16	<50	<1	<2	<2	<5	<0.1	<2	<5	<5
	11/07/2010	1410	61	<50	<1	3	2	12	0.2	3	<5	26

Site[1]	Date	Aluminium (mg/kg)	Arsenic (mg/kg)	Boron (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Cobalt (mg/kg)	Copper (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Selenium (mg/kg)	Zinc (mg/kg)
	23/02/2011	920	7	<50	<1	<2	<2	<5	<0.1	<2	<5	<5
	30/03/2011	2700	14	<50	<1	3	<2	9	<0.1	2	<5	10
	22/08/2011	440	6	<50	<1	<2	<2	<5	<0.1	<2	<5	<5
	20/09/2011	380	8	<50	<1	<2	<2	<5	<0.1	<2	<5	<5
	10/03/2012	470	10	<50	<1	<2	<2	<5	<0.1	<2	<5	<5
	7/07/2012	720	<5	<50	<1	<2	<2	<5	0.2	<2	<5	<5
	11/04/2013	1200	16	<50	<1	<2	<2	5	<0.1	<2	<5	7
	30/09/2013	740	16	<50	<1	<2	<2	<5	<0.1	<2	<5	<5
	23/03/2014	2390	8	<50	<1	3	<2	8	<0.1	<2	<5	7
	19/10/2014	1030	27	<50	<1	4	<2	6	<0.1	<2	<5	13
	23/04/2015	3740	35	<50	<1	8	<2	10	<0.1	2	<5	13
	24/03/2016	3400	35	<50	<1	8	<2	10	<0.1	2	<5	13
	20/09/2016	2230	<5	<50	<1	11	<2	<5	<0.1	<2	<5	12
SW3	9/09/2005	-	30	-	<1	-	6	21	-	4	-	38
	4/04/2006	-	7	-	<1	<2	<2	5	<0.1	<2	-	8
	29/01/2007	-	15	-	<1	<2	-	8	<0.1	<2	-	10
	14/11/2007	-	9	-	<1	-	<2	9	<0.1	<2	-	12
	7/07/2009	3020	33	<50	<1	8	3	13	<0.1	2	<5	25
	24/01/2010	2860	11	<50	<1	3	<2	8	<0.1	2	<5	19
	23/02/2011	1970	14	<50	<1	3	<2	6	<0.1	<2	<5	6
	30/03/2011	1820	24	<50	<1	4	<2	8	<0.1	2	<5	8
	7/07/2012	1970	8	<50	<1	<2	<2	<5	0.2	2	<5	16
	11/04/2013	2410	15	<50	<1	3	3	8	<0.1	3	<5	21
	30/09/2013	1120	8	<50	<1	<2	<2	<5	<0.1	<2	<5	13
	23/03/2014	2910	16	<50	<1	23	<2	9	<0.1	<2	<5	10
	23/04/2015	3400	30	<50	<1	6	<2	10	<0.1	<2	<5	14
	24/03/2016	3900	30	<50	<1	6	<2	10	<0.1	<2	<5	14
	20/09/2016	3710	10	<50	<1	14	3	7	<0.1	4	<5	20
SW3b	29/01/2007	-	19	-	<1	6	-	14	<0.1	3	-	26
	14/11/2007	-	-	-	-	-	-	-	-	-	-	-

Site[1]	Date	Aluminium (mg/kg)	Arsenic (mg/kg)	Boron (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Cobalt (mg/kg)	Copper (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Selenium (mg/kg)	Zinc (mg/kg)
	17/04/2008	-	7	-	<1	8	4	<5	<0.1	2	-	<5
	7/07/2009	2790	22	<50	<1	2	<2	13	<0.1	2	<5	17
	24/01/2010	3930	16	<50	<1	4	<2	13	<0.1	<2	<5	9
	11/07/2010	1420	23	<50	<1	15	<2	<5	<0.1	<2	<5	<5
	23/02/2011	2160	5	<50	<1	3	<2	<5	<0.1	<2	<5	<5
	3/03/2011	3540	6	<50	<1	3	<2	18	<0.1	<2	<5	7
	23/08/2011	2020	19	<50	<1	6	<2	8	<0.1	<2	<5	9
	20/09/2011	2960	24	<50	<1	14	3	15	0.3	3	<5	20
	10/03/2012	2800	32	<50	<1	6	<2	14	<0.1	<2	<5	11
	7/07/2012	4120	28	<50	<1	7	<2	10	0.2	3	<5	10
	11/04/2013	4380	42	<50	<1	46	3	11	<0.1	3	<5	12
	30/09/2013	3040	26	<50	<1	9	<2	11	<0.1	<2	<5	9
	23/03/2014	2630	6	<50	<1	3	<2	8	<0.1	<2	<5	7
	19/10/2014	1100	35	<50	<1	6	<2	8	<0.1	<2	<5	15
	23/04/2015	3900	60	<50	<1	5	2	14	0.2	3	<5	21
	24/03/2016	2140	60	<50	<1	5	2	14	0.2	3	<5	21
	20/09/2016	3300	8	<50	<1	19	3	10	<0.1	3	<5	16
SW6	4/04/2006	-	<5	-	<1	9	4	<5	<0.1	<2	-	<5
	29/01/2007	-	<5	-	<1	5	-	<5	<0.1	<2	-	<5
	14/11/2007	-	<5	-	<1	-	<2	<5	<0.1	<2	-	<5
	17/04/2008	-	44	-	2	6	18	182	<0.1	24	-	116
	7/07/2009	590	<5	<50	<1	5	<2	<5	<0.1	<2	<5	<5
	23/01/2010	7250	6	<50	<1	8	5	6	<0.1	3	<5	6
	11/07/2010	5470	13	<50	<1	15	10	8	<0.1	4	<5	<5
	23/02/2011	1600	<5	<50	<1	7	<2	<5	<0.1	<2	<5	<5
	30/03/2011	4580	<5	<50	<1	6	3	<5	<0.1	<2	<5	<5
	5/04/2011	3300	6	<50	<1	6	4	5	<0.1	3	<5	13
	22/08/2011	1850	6	<50	<1	6	5	<5	<0.1	2	<5	<5
	20/09/2011	820	<5	<50	<1	6	<2	<5	0.1	<2	<5	<5
	10/03/2012	1180	<5	<50	<1	6	<2	<5	<0.1	<2	<5	<5

Site[1]	Date	Aluminium (mg/kg)	Arsenic (mg/kg)	Boron (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Cobalt (mg/kg)	Copper (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Selenium (mg/kg)	Zinc (mg/kg)
	7/07/2012	2020	12	<50	<1	9	4	<5	0.2	2	<5	<5
	11/04/2013	1700	6	<50	<1	7	3	<5	<0.1	<2	<5	<5
	30/09/2013	1890	<5	<50	<1	6	3	<5	<0.1	<2	<5	<5
	23/03/2014	1200	<5	<50	<1	6	<2	<5	<0.1	<2	<5	<5
	19/10/2014	1300	31	<50	<1	4	<2	8	0.1	<2	<5	18
	23/04/2015	2140	32	<50	<1	7	<2	<5	<0.1	<2	<5	10
	24/03/2016	1880	32	<50	<1	7	<2	<5	<0.1	<2	<5	10
	20/09/2016	3680	13	<50	<1	13	3	18	<0.1	4	<5	27
BCUS	05/04/2011	2110	160	<50	<1	7	<2	6	0.6	<2	<5	30
	23/08/2011	1190	91	<50	<1	4	2	<5	0.5	2	<5	47
	08/07/2012	2960	523	<50	<1	7	<2	19	1.6	2	<5	38
	11/04/2013	1760	363	<50	<1	3	<2	11	1.4	<2	<5	14
	30/09/2013	1820	145	<50	<1	4	<2	<5	0.3	<2	<5	21
	23/03/2014	1860	106	<50	<1	4	<2	<5	0.4	<2	<5	22
	19/10/2014	1870	124	<50	<1	5	<2	<5	0.4	<2	<5	25
	23/04/2015	1920	138	<50	<1	3	<2	<5	0.5	<2	<5	20
	24/03/2016	2110	138	<50	<1	3	<2	<5	0.5	<2	<5	20
	20/09/2016	3240	<5	<50	<1	13	3	8	17	<2	<5	3
BCDS	05/04/2011	3190	74	<50	<1	10	8	24	0.7	3	<5	30
	23/08/2011	1040	82	<50	<1	3	<2	<5	0.4	<2	<5	42
	08/07/2012	5840	39	<50	<1	5	4	13	1	4	<5	53
	11/04/2013	1870	82	<50	<1	9	<2	<5	0.3	<2	<5	22
	30/09/2013	1920	107	<50	<1	5	<2	<5	0.4	<2	<5	20
	23/03/2014	1800	106	<50	<1	4	<2	<5	0.4	<2	<5	20
	19/10/2014	1970	148	<50	<1	5	<2	<5	0.5	<2	<5	29
	23/04/2015	1880	108	<50	<1	3	<2	<5	0.4	<2	<5	20
	24/03/2016	1920	108	<50	<1	3	<2	<5	0.4	<2	<5	20
	20/09/2016	3450	6	<50	<1	13	3	8	21	<2	<5	4

Notes:

1. Site locations refer Figure 2
2. Metal analysis performed as “total metals” after acid dissolution

6.2 Macro-Invertebrates

Aquatic macro-invertebrates are considered potential good indicators of water body quality since (USEPA, 1997, p.47):

- They are affected by the physical, chemical, and biological conditions of the stream.
- They can't escape pollution and show the effects of short- and long term pollution events.
- They may show the cumulative impacts of pollution.
- They may show the impacts from habitat loss not detected by traditional water quality assessments.
- They are a critical part of the stream's food web.
- Some are very intolerant of pollution.
- They are relatively easy to sample and identify.

However, natural variability of the physico-chemical and geomorphological characteristics of water courses in conjunction with climatic and seasonal responses impact on the effectiveness of the use of macro-invertebrates in pollution monitoring and assessment. Macro-invertebrate communities respond to changes in a range of environmental factors in addition to water chemistry, including substrate type, amount of riparian cover, geographical distribution of species, time of day, recent flow history, flow variability and shade (New Zealand Ministry for the Environment, 1999 p.27).

Notwithstanding such potential confounding variables, assessment of macro-invertebrates can provide a biological indicator to detect possible long-term changes in water quality. This is due to aquatic organisms being adapted to specific environmental conditions, and if these conditions change, some organisms can disappear (intolerant) and be replaced by others (tolerant). Hence, variations in the composition and structure of aquatic organism assemblages can indicate possible “pollution” (Benetti, C.J *et al*., p.98).

There are a number of monitoring approaches to using macro-invertebrates for water quality assessment (New Zealand Ministry for the Environment, 1999 pp.6-7):

- Indicator organisms
- Diversity Indices
- Similarity Indices
- Multimetric Methods
- Biotic Indices

The simplest and generally least useful approach for monitoring is based on the indicator organism concept where the presence or absence of a key macroinvertebrate species, or group of species, is used as a water quality or pollution indicator. This approach has proved to be of limited value and is not recommended in most circumstances (New Zealand Ministry for the Environment, 1999 p.6).

There are a number of advantages and disadvantages to the other potential macro-invertebrate monitoring approaches. Since each approach requires similar data (and fundamentally all require careful selection of reference sites and actual physical sampling locations) a range of indicators are applicable including:

- Number of Macro-Invertebrates
- Number of Taxa
- Shannon Diversity Index/Shannon Equitability Index
- Stream Invertebrate Grade Number Average Level (SIGNAL2 Index)
- Australian River Assessment System (AusRivAS)

However, since there are no regular discharges from mining related landforms, it is considered that monitoring of macro-invertebrates will only produce information related to the ephemeral nature of the receiving streams (i.e., Belmore Creek and Slaughteryard Creek) with seasonal rainfall runoff being the predominant factor. Therefore, there is little benefit in routine monitoring of macro-invertebrates, particularly when coupled with the previously discussed difficulties associated with confounding variables.

In response to the discharge from the Content Pit to Belmore Creek during the 2010/2011 wet season, as the result of extreme rainfall associated with cyclonic events, a baseline macroinvertebrate survey in Belmore Creek was undertaken (FRC, 2011).

2010/2011 Macro-Invertebrate Data Interpretation

In general, aquatic habitat condition was good at most survey sites, with cobble, pebble and gravel substrates suitable for macroinvertebrates and native vegetation was dominant in the riparian zones. The least suitable macroinvertebrate habitat was at comparative (upstream) sites SW7 and SW6. These sites had substrates dominated by fine sand and silt, poor riparian zones and low in-stream habitat diversity. Note that both sites SW7 (which is upstream of the mining lease area) and SW6 (which is also not on the mining lease area and is not hydrologically connected to surface flow from the Content Pit) could not have been impacted by discharge from the Content Pit.

The FRC reported concluded that the overtopping of the Content Pit appears to have had either no or only minor impact on macroinvertebrate communities in Belmore Creek. A number of other factors such as habitat condition, land use and background water quality appear to be the dominant effect on the macroinvertebrate communities.

This supports the hypothesis that routine macro-invertebrate monitoring is not particularly powerful in the current situation providing elucidation of any potential mining related landform impacts on Belmore Creek. The subsequent limestone dosing of the Content and Lady Isabella Pit Lakes in December 2012, producing pit lakes with water quality meeting ANZECC stock watering guidelines is a further factor against routine macro-invertebrate monitoring, as any possible future discharge from these locations has been further mitigated.

6.3 Revegetation/Flora

The revegetation of mining disturbed areas performed as a component of the Croydon rehabilitation has been growing for approximately two decades (Fawcett, 1997). The mining disturbed areas (waste rock dumps) were revegetated by direct seeding, sowing a selection of native tree species broadly representative of those found in the surrounding undisturbed woodlands. Wherever possible seeds of local provenance were used.

The progress of the vegetation rehabilitation was assessed in 2010, 2012 and 2013 by staff of Cedar Creek (Colorado, USA), Vegetation Management Science (Malanda, Australia) and Wilson Gold Corporation (Australia) using the Wilson standard methodology (see Appendix A for details). During 2014 and 2015, Vegetation Management Science (Malanda, Australia) have conducted annual vegetation monitoring.

The Wilson standard methodology implemented at Croydon involves a number of representative rehabilitated areas and two (2) analogue sites. The various “monitoring areas” are surveyed using a systematic grid format where individual samples were taken at regular intervals across the sites, using a 100m grid formation. This allows a thorough survey across each site/area. Each sample involved documenting the abundance, using the point cover method, of each plant species, rocks, bare ground and fallen leaf litter over a 10 m linear transect using a “laser pointer” method to eliminate sample bias.

Revegetation Data Interpretation

There were two landforms monitored in 2010 for ground cover and soil stability in an effort to gauge readiness for bond/liability relinquishment as per the Wilson Reclamation Monitoring & Final Relinquishment protocol (Cedar Creek, 2011). Data show that both landforms fell below the recommended success criteria of 75% of the appropriate analogue areas for ground cover (Figure 15). However a significant portion of this adverse finding is a result of inadvertent sampling during the low point in the vegetative production cycle which compromised the ability to identify all grass species. Further complicating identification of grasses as well as the overall evaluation was over-utilization of forage by horses illegally pastured on the Golden Butterfly Waste Dump during the time of the survey.

An additional component to ground cover monitoring, and a criterion for successful rehabilitation, is species diversity, which can be a measure of biodiversity. There are two optional success criteria for species diversity. The landform must either exhibit:

1) greater than three non-exotic species with greater than 2% relative cover, or
2) 50% of the number of non-exotic species with greater than 2% relative cover from the appropriate analogue area.

Both units at Croydon exceeded both of these optional success criteria based on the analogue areas (Figure 16).

It was determined that soil stability results were closely tied to the vegetation cover results. All evaluated slopes of the Content Waste Dump passed the soil stability standard. However, only two of four slopes of the Golden Butterfly Waste Dump could pass the standard that was based on analogue areas. If grazing pressures were removed, and the vegetative cover of Golden Butterfly was allowed to recover, this unit would likely pass the soil stability standard as well. Figure 17 displays average soil loss for the entire landform compared to the appropriate analogue areas.

Rehabilitation units at the Croydon Mine display good potential for adequate and diverse plant communities. However, the 2010 evaluations of the rehabilitation did not occur during peak vegetative production and the Golden Butterfly landform was significantly impacted by unauthorized grazing by horses. This grazing pressure from horses has been detrimental to the plant community given that grasses were grazed to a very short stubble height and the lower branches of most tree species had been largely defoliated. This impact on the vegetation community has significantly affected overall plant cover of the unit which in turn is influencing soil stability. Evaluation of these units during peak vegetative production will facilitate a more thorough assessment of the rehabilitation.

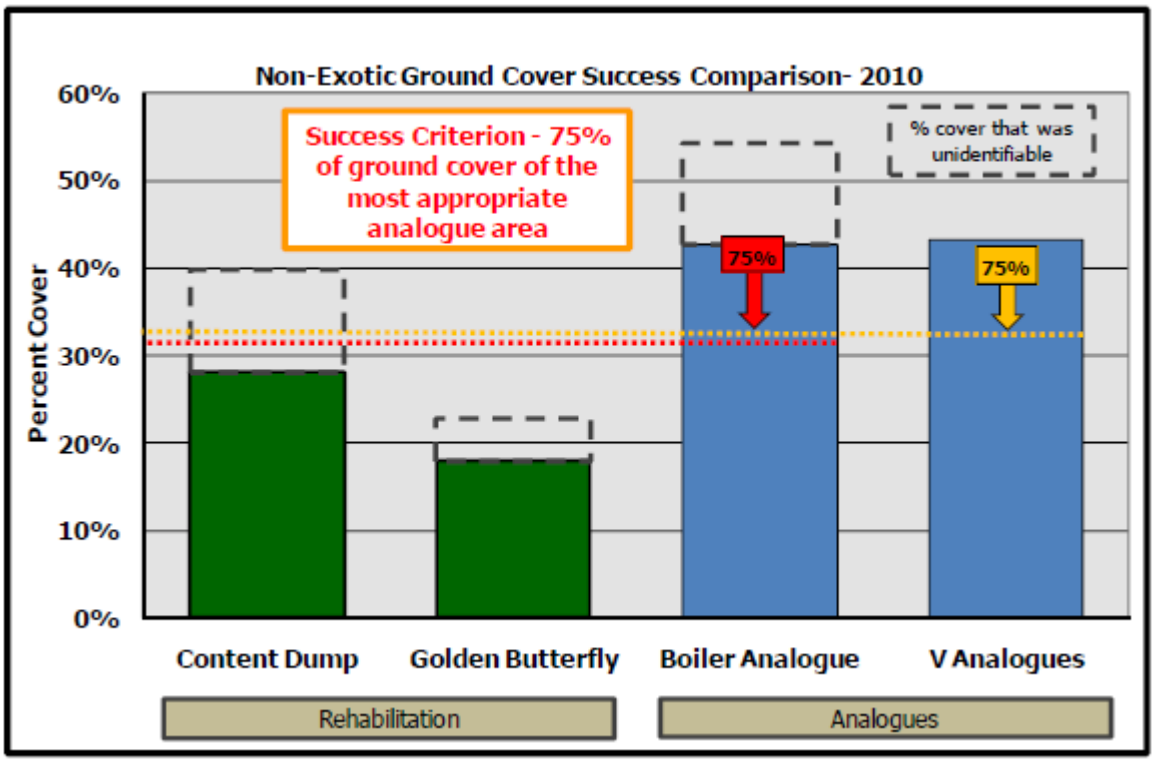


Figure 15: Non-Exotic Ground Cover Success Comparison - 2010

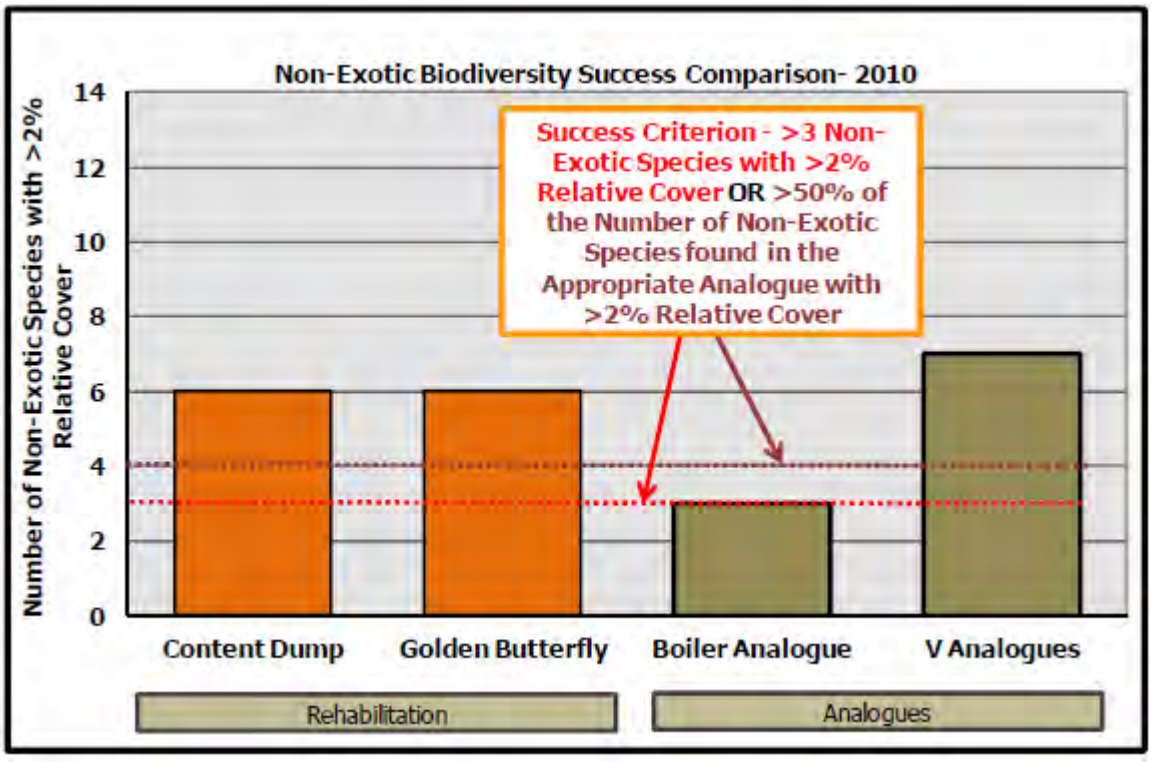


Figure 16: Non-Exotic Biodiversity Success Comparison - 2010

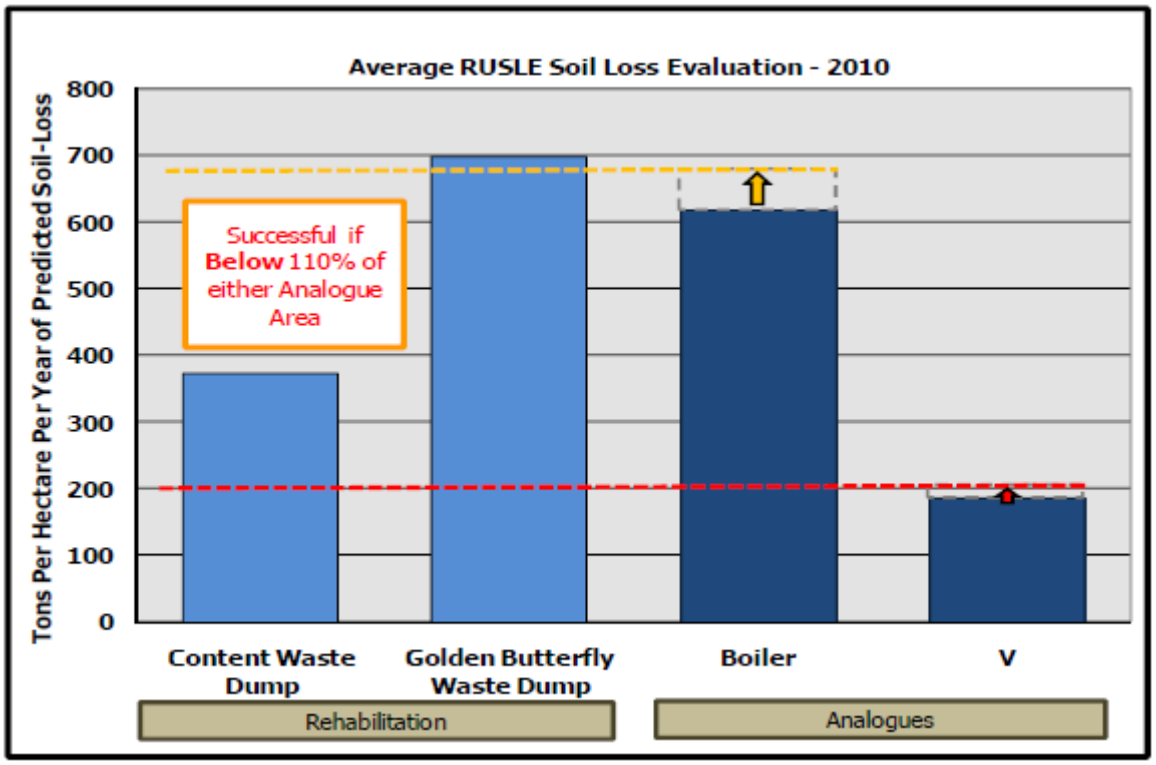


Figure 17: Average RUSLE Soil Loss Evaluation – 2010

The third follow-up assessment the rehabilitation at the Corydon mine (Williams, 2013) found that live plant ground cover was similar between the mine rehabilitation sites compared with the combined analogue sites.

The 2012-13 summer was very dry and caused a decline in plant cover in all sites. Statistical analyses indicate that the rehabilitated sites did not suffer worse declines in plant ground cover than the analogues. That is, there is no significant difference in the resilience to the initial stages of drought between the rehabilitation and analogue vegetation.

However, the rehabilitated mined sites have a greater abundance of annual grasses and herbs than do the analogue sites, which have a greater proportion of perennials. This is likely to mean that, as the drought progresses, the rehabilitated sites may be less able to maintain ground cover than the analogue sites, because annuals require wet season rain to promote new plants each year, and annuals die off naturally in the middle of each year.

The decline in live plant cover was replaced mostly by increased bare ground, rather than leaf litter. The increase in bare ground at Croydon, rather than leaf litter, exposes the soil to potential erosion. There is some difference in the species of trees and shrubs dominating different sites. However, all of the trees are native to the Croydon area, so the differences should not be considered of enormous consequence.

It was again found that grazing animals, particularly goats, were adversely affecting vegetation growth. It was also recommended that promotion of perennial grasses should also be considered for the rehabilitated sites, to increase resilience to dry conditions. Sowing of the perennial grasses that have proven to be successful in the Croydon area, such as Spear grass or Buffel grass will likely be the best way to successfully establish perennial grasses and improve ground cover on the Content Dump and Golden Butterfly rehabilitation sites. This establishment of palatable perennial grasses will help provide persistent cover that is useful for returning the sites to an end land use of grazing.

The annual Croydon rainfall has been below average since 2012, so the 2014 through 2016 vegetation surveys document the durability of the rehabilitation. The rehabilitated vegetation at the Croydon mine site persists through considerable fluctuation in annual rainfall. Plant cover was universally down since 2014, but was comparatively higher in the rehabilitation sites than in the adjacent analogue sites.

This is an excellent indication that the rehabilitation has progressed to a point that it is providing an ecological equivalent to the surrounding landscape. There was no regrowth of the weed Rubbervine previously sprayed on the Golden Butterfly dump. The scalded flats to the north of the Content Waste Rock Dump, which was ripped and seeded in the 2013-14 wet season, contained no significant clumps of grass. Due to the inability to rely upon suitable rainfall after sowing, this could be reattempted but with irrigation in order to obtain more success.

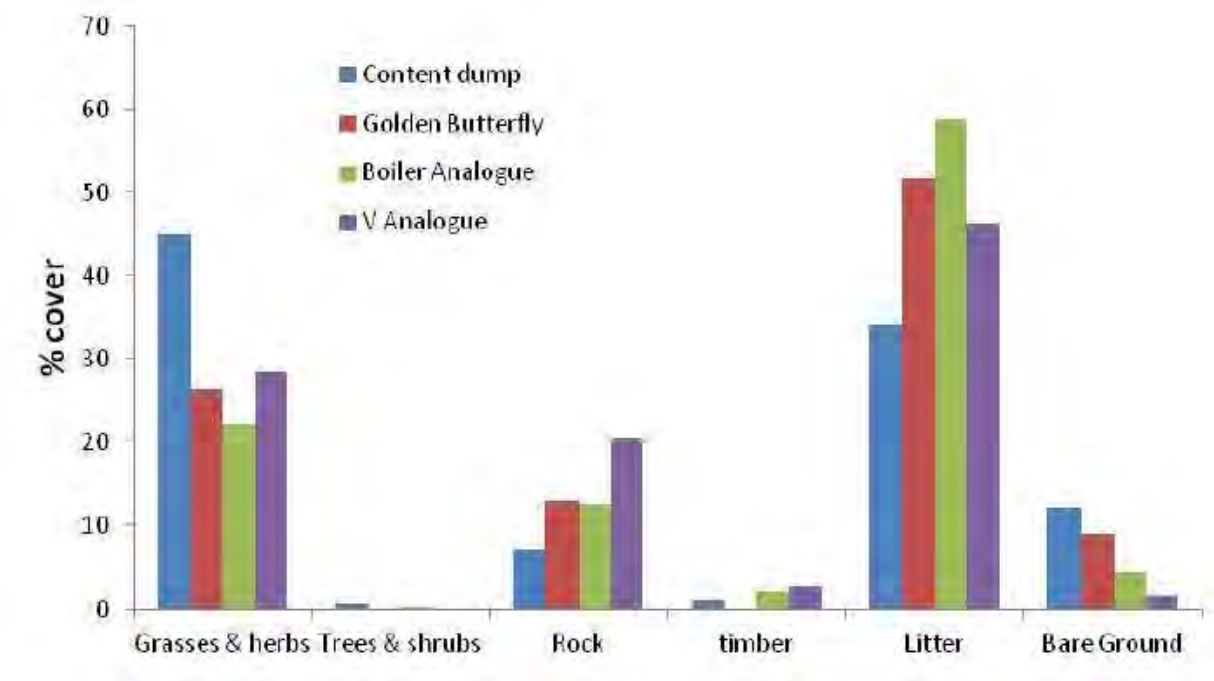


Figure 18: Groundcover Rock Dumps vs Analogues (2016)

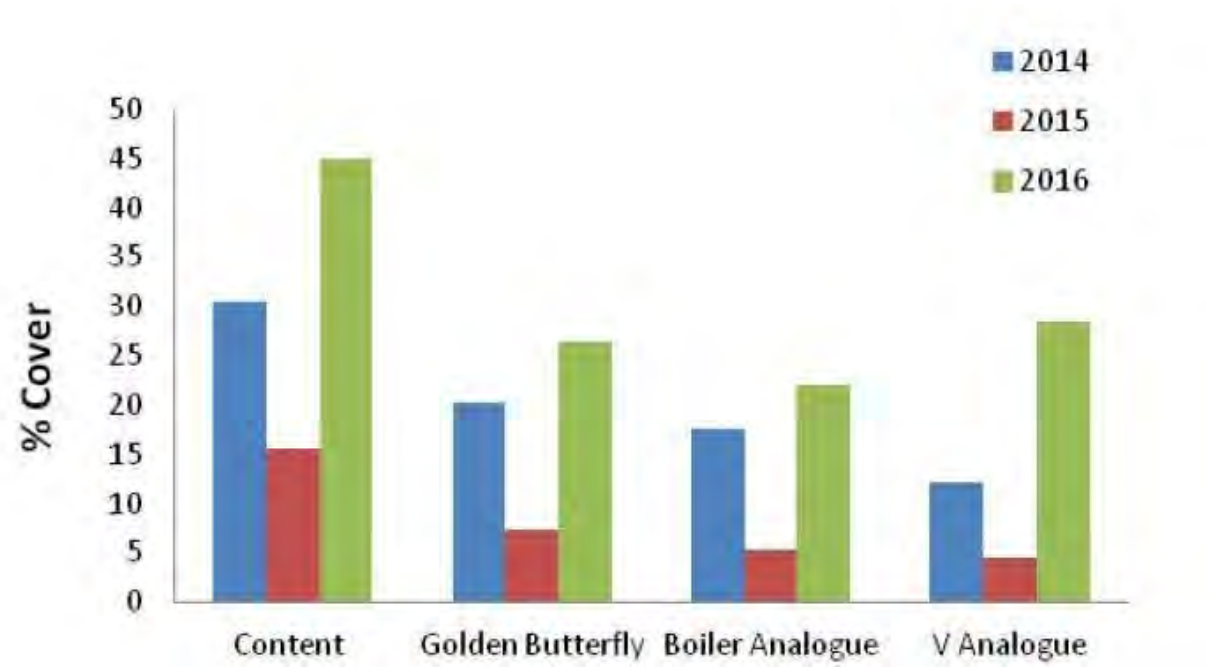


Figure 19: Grass and Herb Cover Rock Dumps vs Analogues (2016)

6.4 Groundwater

The groundwater quality results for the EA monitoring bores are provided in Appendix A both in tabular format and as a sequence of time series graphs.

The various groundwater monitoring bores (see Figure 26 and Figure 27) are strategically located to provide information about possible impacts from various geographical features on the mining lease such as the mining pits and waste rock dumps. Consequently, groundwater quality monitoring results in terms of the various trigger level exceedances are discussed in the following groupings in subsequent sections:

1. Golden Butterfly Pit Monitoring Bores: BH1, BH2, GBMB1, GBMB3, GBMB6 and SY1
2. Golden Butterfly North Pit Monitoring Bores: BH8 and BH9
3. Content Pit Monitoring Bores: BH10, BH11 and BH12
4. Golden Butterfly Dump Monitoring Bores: BH3, BH4, BH5, BH6, BH7

6.4.1 Golden Butterfly Pit Monitoring Bores

The Golden Butterfly Pit Monitoring Bores consist of the following locations BH1, BH2, GBMB1, GBMB3, GBMB6 and SY1 (see Figure 26). Monitoring bore BH1 is located within 50 meters of the north-eastern wall of the Golden Butterfly Pit and monitoring bore BH2 is located approximately 150 meters to the south-west. The remaining bores, GBMB1, GBMB3, GBMB6 and SY1 are located successively further away from the Golden Butterfly Pit towards the south-west, approximately following the course of a tributary to Slaughteryard Creek that drains from the mine lease area.

Figure 31 presents time series graphs for the various monitoring parameters, which also indicate any trigger level exceedances that may have occurred.

Electrical Conductivity

Electrical conductivity observed at the Golden Butterfly Pit Monitoring bores has approximately flat trends when viewed over the greater than fifteen year period for which data is available (Figure 36). Consequently, the observed trigger level exceedance of electrical conductivity at monitoring bores BH1, BH2 and GBMB1 is as per previous reporting periods and not an emergent issue.

The major difficulty in assessing the relevance of the observed electrical conductivity trigger level exceedance is that no reference sites have been stipulated against which to judge the results. The default of using the ANZECC(2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems does not appear appropriate considering that groundwater is being assessed, not surface water, and further, the bores are located within a metalliferous area that has hosted mining for over one hundred years. Notwithstanding these difficulties, time series graphs and hydrochemical pattern diagrams such as Piper-Hill Plots and Durov Diagrams in conjunction with information about lithology, rock structural features, groundwater levels and climate factors such as rainfall enable interpretation of the groundwater analysis data in terms of potential environmental impact from mining associated landforms.

Error! Reference source not found. and Figure 32 present groundwater level for the various bores associated with the Golden Butterfly Pit (see **Error! Reference source not found.** for locations). Figure 31 shows a decreasing trend in groundwater levels within bores in the immediate vicinity of the Golden Butterfly Pit, whereas, groundwater levels in bores located further away downstream in the Slaughteryard Creek drainage remain approximately constant. Figure 20 overlays a graph of bore water level RL versus distance from the Golden Butterfly Pit on the aerial photograph with locations of bores.

This groundwater data supports the conceptual hydrogeological model (see Section 3.9) showing that the Golden Butterfly Pit is a hydrological sink (i.e., groundwater levels within the bores are higher than the pit lake level leading to a hydraulic head towards the pit). Therefore, the trigger level exceedance at monitoring bores BH2 and GBMB1 is not the result of potential input from the Golden Butterfly Pit Lake.

Electrical conductivity of a water sample is directly related to the concentration of dissolved anions and cations and the resultant ability to pass an electric current. Hence, waters of entirely different origins with dissimilar anionic and cationic constituents can record comparable electrical conductivity. Therefore, when considering the relevance of the observed trigger level exceedance of electrical conductivity at monitoring bores BH1, BH2 and GBMB1 it is important to also consider the actual concentrations of the contributory cations and anions.

Piper plots and Durov diagrams (see Figure 39 to Figure 45) provide a suitable means to summarise the major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and anions (SO_4^{2-}, HCO_3^{-}/CO_3^{2-}, Cl^{-}) present in groundwater in regards to potential similarity of composition and/or origin. The Piper plot has an advantage of depicting analytical data of a large number of samples in one diagram. It is also used for the classification of water samples into various hydrochemical types depending on the relative concentration of major cations and anions. Further, it is possible to demonstrate changes in water quality due to mixing of water of two extreme types and also the effect of base-exchange (Singhal et al., 2010).

Figure 40 is the Piper Plot for the various bores associated with the Golden Butterfly Pit and the Slaughteryard Creek drainage. The data suggests that the bores GBMB1, GBMB3, GBMB6 and SY1 group as a category distinct from BH1 and BH2. Which in turn are distinct from the composition of water within the Golden Butterfly Pit. This categorisation is supported by the overall lithology with GBMB1, GBMB3, GBMB6 and SY1 being located in flood plain alluvium and or lateritised fine lag gravels/soil overlain by nodular ferricrete. Whereas BH1 and BH2 are within very coarse to medium grained (muscovite) biotite granite, porphyritic in part (see Figure 21) and the Golden Butterfly Pit lake being dominated by sulphate from the oxidation of sulfides.

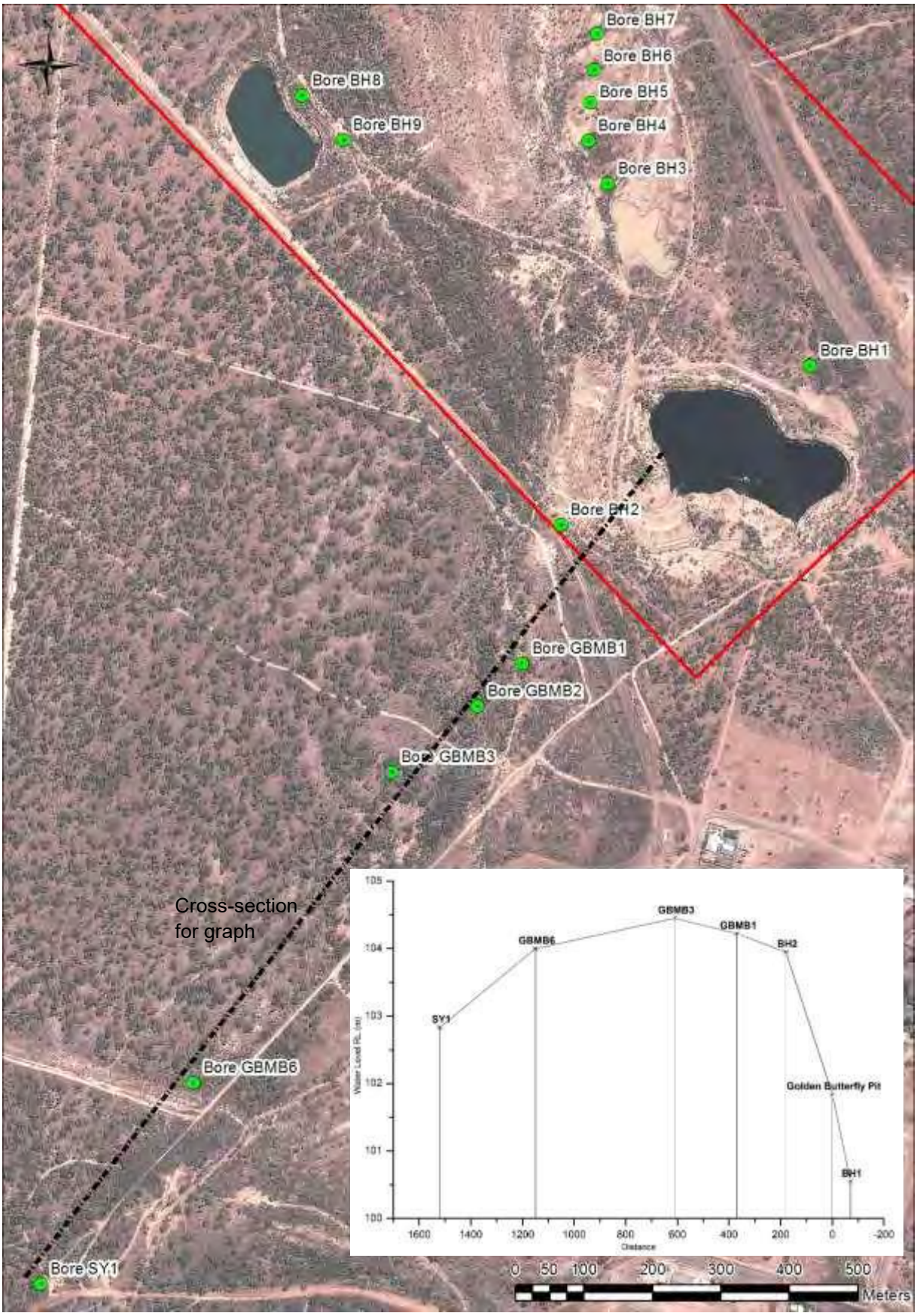
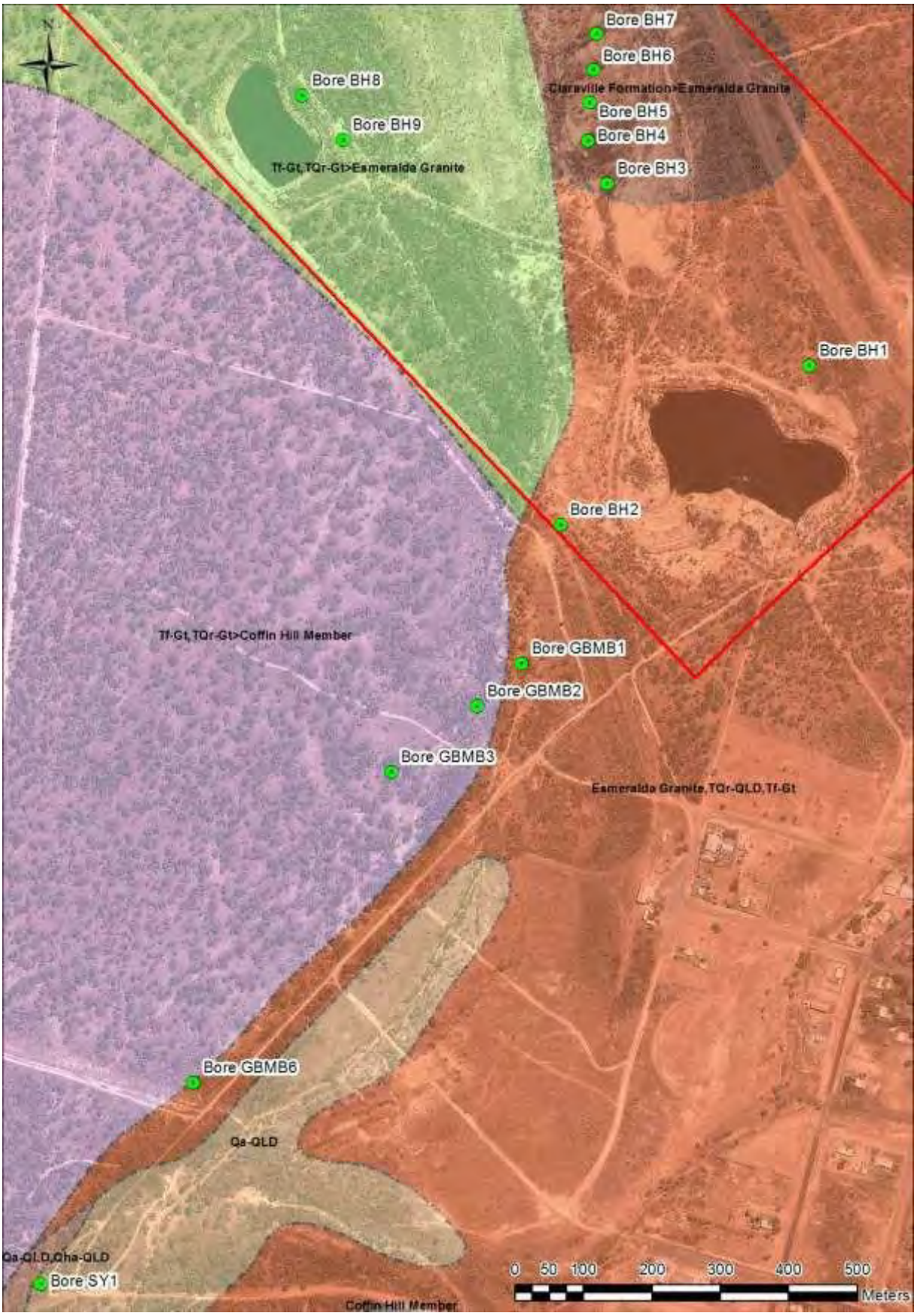


Figure 20: Golden Butterfly Pit Bores – Cross Section Distance versus Water Level



Data sourced from Qld DME

Figure 21: Croydon Surface Geology – Golden Butterfly Pit/Slaughteryard Creek Area

Consideration of the data points on the Piper Plot for a location versus time can show if a groundwater is mixing between sources. Figure 40 shows no evidence of groundwater within the various bores being influenced or mixing with potential input from the Golden Butterfly Pit Lake (which would be indicated by a movement towards increasing proportion of sulphate contributing to the overall dissolved chemical load). This is supported by the earlier conclusion from the groundwater level data that showed the potential hydraulic head is towards the pit lake.

A disadvantage of Piper plot is that it shows the relative concentration of different ions and not their absolute concentration. The Durov diagram overcomes this limitation in that it can provide a better display of different types of water and also some hydrochemical processes such as ion exchange, simple dissolution and mixing of waters of different qualities. The Durov diagram is also a type of tri-linear plot but enables extension from the central square to display other chemical characteristics, in this case pH and total dissolved solids (TDS).

Figure 44 is the Durov diagram for the various bores associated with the Golden Butterfly Pit and the Slaughteryard Creek drainage. Again it can be readily seen that bores GBMB1, GBMB3, GBMB6 and SY1 group as a category distinct from BH1, BH2 and the Golden Butterfly Pit lake water. BH1 and Golden Butterfly Pit lake water appear similar in terms of total anions versus total cations (the central square of the diagram). However, the distinct difference in terms of pH and TDS readily show that BH1 bore water is distinct from Golden Butterfly Pit lake water. Therefore, the observed electrical conductivity trigger level exceedance at BH1 is due to local geological features and not from potential input from Golden Butterfly Pit lake water. Similarly, Figure 44 again shows BH2 bore water is a distinct composition unrelated to the other locations. The low pH of bore water from BH2 being most readily explained as related to features associated with the immediate localised geology (noting that there is an indicated hydraulic gradient towards the pit lake at the location of BH2).

The preceding discussion is pertinent to the issue that no reference bore sites have been stipulated against which to judge the results. The default of using the ANZECC (2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems does not appear appropriate considering that groundwater is being assessed. The analysis of the Golden Butterfly Pit bores (GBMB1, GBMB3, GBMB6, SY1, BH1 and BH2) using time series graphs, Piper plots and Durov diagrams indicate that bores GBMB1, GBMB3, GBMB6, and SY1 form a potential grouping that is indicative of groundwater undisturbed by landforms associated with the mining lease. A statistical summarisation of groundwater data from these locations to give “reference values” would be initially indicated. However, it has also been demonstrated that bores BH1 and BH2 are similarly not likely influenced by landforms associated with the mining lease (i.e., the Golden Butterfly Pit lake) but have water quality widely at variance with those within Slaughteryard Creek.

Considering that the area encompassed and surrounding the mine lease is within a metalliferous zone that has hosted mining for over one hundred years, coupled with the complex localised geology, the concept of a single “reference bore” is perhaps not appropriate. The underlying issue is to identify if landforms associated with the mining lease are impacting off site groundwater quality. Since groundwater levels versus pit lake water level show a potential hydraulic gradient towards the pit, this indicates that the Golden Butterfly Pit cannot be affecting off site bores GBMB1, GBMB3, GBMB6, and SY1. Hence the quality of the groundwater in bores GBMB1, GBMB3, GBMB6 and SY1 is moot in terms of impact from on lease sources and comparison to any potential standards.

In terms of bores BH1 and BH2, the immediate localised geology is indicated as the significant factor influencing observed groundwater quality from these locations (and in terms of BH2, again the potential hydraulic gradient towards the pit shows no possible interaction with the Golden Butterfly Pit lake). Since both BH1 and BH2 appear to be from difference hydrochemical facies, it would appear that a number of sets of “reference values” based upon the existing data from the relevant bores, each applicable to a particular hydrogeological regime would be necessary.

However, an alternative proposition is to assess the available hydrological, geochemical, geological and climatological data holistically to determine the likelihood and or extent of possible impact of landforms associated with the mining lease on off-site groundwater quality. This is in contrast to the existing restricted approach, which due to the absence of appropriate baseline data, is focussed solely on the attainment of necessarily arbitrary water quality criteria (which may or may not be appropriate to the situation at hand).

pH Value

Bores BH1 and BH2 also exceeded the trigger levels for pH, and in the case of BH2 pH contaminant limits, during the reporting period. Again with reference to the relevant time series for pH (Figure 36) such exceedance's are not indicative of emergent issues, but in line with the long term monitoring record and highlight the lack of suitable reference sites and or baseline data.

Discussion in the previous section regarding electrical conductivity showed that observed groundwater levels in the bores versus the Golden Butterfly Pit lake level indicate a hydraulic gradient towards the pit lake. Hence this negates the possibility of Golden Butterfly Pit lake water as a casual factor in the observed pH trigger level exceedance at bores BH1 and BH2. Further, it was shown via the use of hydrochemical pattern diagrams that these locations belong to separate facies. Therefore, the observed pH is due to localised hydrogeochemical factors.

Trace Metals

Groundwater from bore BH2 exceeded the trigger levels for aluminium, cobalt, copper, nickel and zinc. The observed median groundwater pH of 3.6 (range 3.1 – 6.5, $\bar{x}$=3.7, n=52) in bore BH2, which spans the period from 1995 to present, favours the dissolution of mineral phases and increased concentrations of metals in the groundwater is expected (see Figure 22).

Discussion in the previous sections regarding pH and electrical conductivity showed that observed groundwater levels in the bores versus the Golden Butterfly Pit lake level indicate a hydraulic gradient towards the pit lake. Hence this negates the possibility of Golden Butterfly Pit lake water as a casual factor in the observed pH trigger level exceedance at bore BH2 and by extension the elevated metal concentrations.

Further, it was shown via the use of hydrochemical pattern diagrams that the location in the vicinity of bore BH2 belongs to a separate geochemical facies compared to other bores in the area. Therefore, the observed pH and hence elevated metal concentrations are due to localised hydrogeochemical factors.

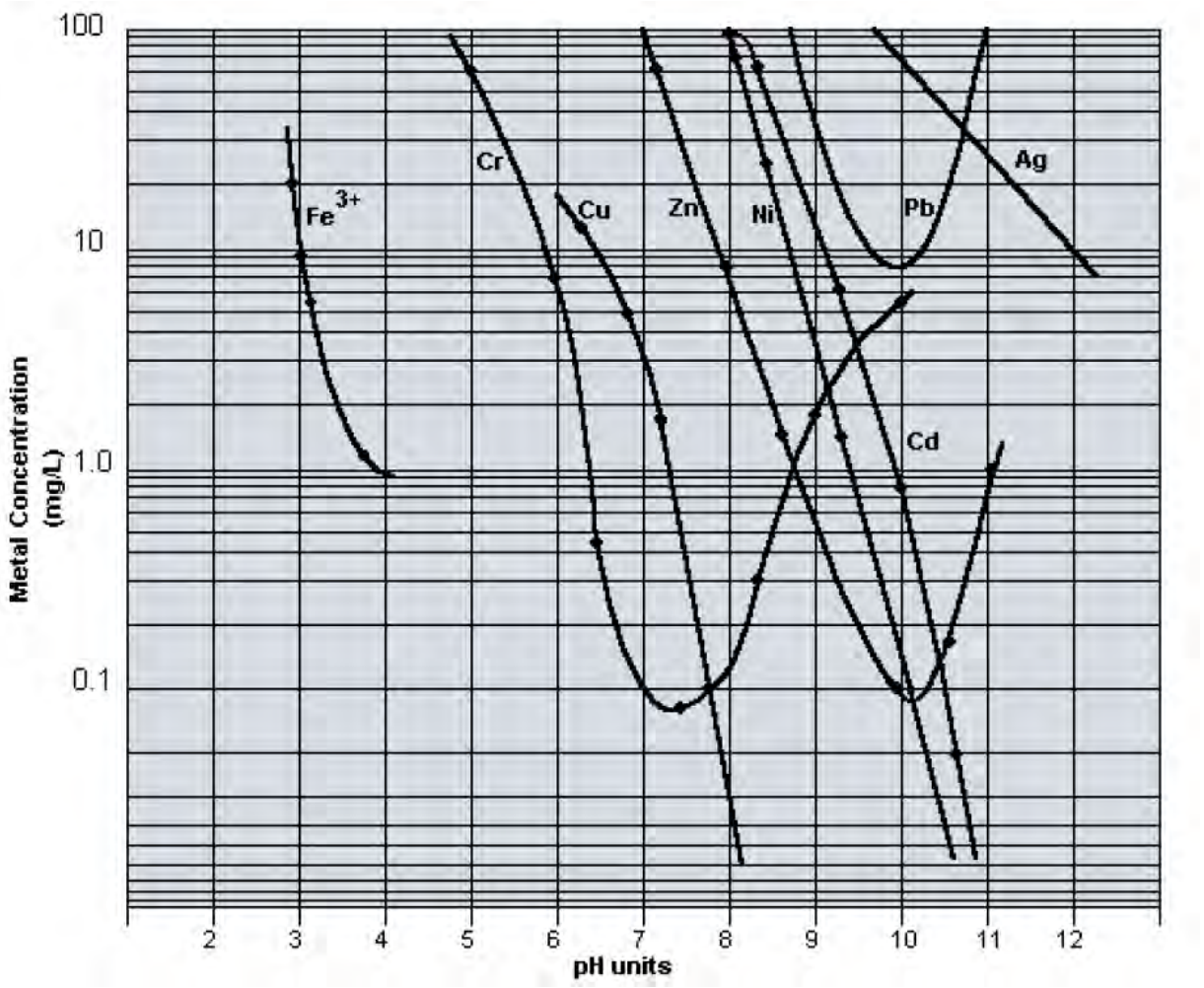


Figure 22: Metal Hydroxide Solubility Curves versus pH

In addition to bore BH2, bores at sample locations SY1, BH1, GBMB1, GBMB3 and GBMB6 on occasion showed trigger level exceedances for trace metals such as arsenic, copper and and zinc. In each case the trigger level exceedance for the listed metals is in the order of parts-per-billion, being within the limits of analytical method/sampling variability and of no significance to the potential for environmental harm. Note sites SY1, BH1 and GBMB1 exceeded the trigger limit for copper even though the observed result was below the analytical detection limit. This is a function of the median of the three previous monitoring results being required to be used for the comparison.

Similarly, GBMB3 exceeded the trigger limit for aluminium even though the observed result was below the analytical detection limit. This again is a function of the median of the three previous monitoring results being required to be used for the comparison, which for GBMB3 involved 0.06 mg/L aluminium being recorded in 2015 and 2.2 mg/L aluminium in 2014.

The GBMB series bores also recorded trigger level exceedance for arsenic. Figure 36 presents the time series graph for arsenic in the GBMB series bores which show no discernible trend over time, which demonstrates that the elevated arsenic concentrations is not an emergent issue. During field sampling of the GBMB series bores, depending upon time of year and previous rainfall pattern, a strong odour of hydrogen sulfide is evident. This indicates reducing conditions which in turn influence the speciation of arsenic (As^{3+} being more soluble in reducing conditions). The redox condition of the groundwater therefore presents a mechanism to explain the observed variability (notably in the series for GBMB3 and GBMB6).

Discussion in the previous sections regarding pH and electrical conductivity showed that observed groundwater levels in the bores versus the Golden Butterfly Pit lake level indicate a hydraulic gradient towards the pit lake. Hence this negates the possibility of Golden Butterfly Pit lake water as a casual factor in the observed arsenic trigger level exceedance at the GBMB series bores. Further, it was shown via the use of hydrochemical pattern diagrams that the GBMB series bores belongs to a separate geochemical facies compared to other bores in the area. Therefore, the observed arsenic concentrations are due to localised hydrogeochemical factors.

Fluoride

Groundwater bore BH1 exceed the contaminant limit of 2 mg/L for fluoride with an observed concentration of 4.0 mg/L (range 3.3 – 4.7 mg/L, $\bar{x}$ =3.8 mg/L, median= 3.8 mg/L, n=11). Figure 36 presents the time series graph for fluoride in bore BH1 which show no discernible trend over time for the previous five year period which data is available. This demonstrates that the elevated fluoride concentration in bore BH1 is not an emergent issue.

The concentration of fluoride within the Golden Butterfly Pit lake water was observed to be 0.2 mg/L (range 0.2 – 2.6 mg/L, $\bar{x}$ =0.83 mg/L, median= 0.5 mg/L, n=23). This is significantly lower than the observed concentration in the adjacent bore BH1. Therefore, the observed contaminant limit exceedance for fluoride in BH1 is not the result of potential input from the pit lake. This is supported by the earlier discussion regarding the vicinity of BH1 belonging to a different geochemical facies to that of other adjacent areas. Therefore, the observed fluoride concentration in BH1 is due to localised hydrogeochemical factors.

6.4.2 Golden Butterfly North Pit Monitoring Bores

The Golden Butterfly Pit Monitoring Bores consist of the locations BH8 and BH9 (see Figure 26). Both these monitoring bores are located within 50 meters of the north-eastern wall of the Golden Butterfly North Pit approximately 100 meters apart. In a number of individual sampling event cases the trigger level exceedance is in the order of parts-per-billion, being within the limits of analytical method/sampling variability and of no significance to the potential for environmental harm.

Further, observed groundwater levels at bore BH8 and BH9 are higher compared to the Golden Butterfly North Pit lake level. This shows that the Golden Butterfly North Pit is a hydrological sink and hence cannot influence groundwater at bore BH8 and BH9. Consequently, the observed pH trigger limit exceedance at BH9 is also due to localised hydrogeochemical factors. Similar to the discussion in the previous sections, the trigger level exceedances at BH8 and BH9 are more indicative of inappropriate limits, lack of suitable reference sites and or baseline data.

6.4.3 Content Pit Monitoring Bores

The Content Pit Monitoring Bores consist of the locations BH10, BH11 and BH12 (see Figure 27). Monitoring bore BH11 is located approximately 250 meters from the south-western wall of the Content Pit. Bores BH10 and BH12 are also located to the south-west of the Content Pit but at a distance of approximately 500 meters. Bores BH10 and BH12 are approximately 150 meters apart.

Figure 37 presents time series graphs for the various monitoring parameters, which also indicate any trigger level exceedances that may have occurred

Electrical Conductivity

Electrical conductivity observed at the Content Pit Monitoring bores has approximately flat trends when viewed over the five year period for which data is available (Figure 36). Consequently, the observed trigger level exceedance of electrical conductivity at monitoring bores BH10, BH11 and BH12 is as per previous reporting periods and not an emergent issue. Further, the flat trend lines for electrical

conductivity versus time in the groundwater at these bore locations indicates pseudo-equilibrium or static conditions prevail (i.e., no evident mixing).

Electrical conductivity of a water sample is directly related to the concentration of dissolved anions and cations and the resultant ability to pass an electric current. Hence, waters of entirely different origins with dissimilar anionic and cationic constituents can record comparable electrical conductivity. Therefore, when considering the relevance of the observed trigger level exceedance of electrical conductivity at monitoring bores BH10, BH11 and BH12 it is important to also consider the actual concentrations of the contributory cations and anions. As previously discussed, Piper plots and Durov diagrams (see Figure 39 to Figure 45) provide a suitable means to summarise the major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and anions (SO_4^{2-}, HCO_3^{-}/CO_3^{2-}, Cl^{-}) present in groundwater in regards to potential similarity of composition and/or origin.

Figure 41 is the Piper Plot for the various bores associated with the Content Pit. The data suggests that the bores BH11 and BH12 group as a category distinct from BH10 and the composition of water within the Content Pit Lake. Note for bore BH10, the data for the two data points in 2010 appear anomalous (pH > 11.5). The grouping of bore BH10 together with the Content Pit lake water potentially infers an influence on groundwater quality from the pit lake.

However, BH10 is in close proximity to BH12 (~150 m) and further from the pit lake than the intervening bore BH11. Therefore, if a solvent plume from the pit is inferred to explain the similarity between groundwater at bore BH10 and the Content Pit lake water, it would be expected to observed similar composition at both BH11 and BH12. Since this is not the case, the elevated electrical conductivity at BH10 is likely due to localised hydrogeochemical factors. This is notwithstanding the potential hydraulic gradient from the Content Pit Lake (see Figure 33); which however due to recent poor rainfall and water abstraction is now reversed toward the pit void.

The composition of Content Pit lake water is dominated by sulphate, which is as expected from the oxidation of sulfides exposed during previous mining (as would be any potential inputs from the Content waste rock dump). However, the Piper Plot (see Figure 41) shows the composition of BH11 and BH12 has higher proportion of carbonate and chloride. The Durov Diagram (see Figure 45) shows groundwater at bore BH12 has significantly higher TDS and is alkaline compared to the pit lake water which is neutral to acidic.

Further, the time series for electrical conductivity (and for sulphate which is the predominant indicator of any potential ARD influence and contributory anionic component toward electrical conductivity if present) show no increasing trends over the six year monitoring period to date. Therefore, the elevated electrical conductivity at bores BH11 and BH12 is clearly shown to be not related to potential input from the Content Pit or waste rock dump. Similar to the discussion in the previous sections, the trigger level electrical conductivity exceedances at BH10, BH11 and BH12 are more indicative of inappropriate limits, lack of suitable reference sites and or baseline data.

Arsenic

Bores BH11 and BH12 exceeded the arsenic trigger levels. Arsenic concentration observed at the Content Pit Monitoring bores has approximately flat trends when viewed over the six year period for which data is available (Figure 36). Consequently, the observed trigger level exceedance for arsenic at monitoring bores BH11 and BH12 is as per previous reporting periods and not an emergent issue.

Previous discussion of electrical conductivity of groundwater at bores BH10, BH11 and BH12, via the use of hydrochemical pattern diagrams and consideration of anionic constituents, indicated that the bores are not being influenced by potential inputs from the Content Pit Lake. Hence elevated arsenic concentration at BH11 and BH12 are due to localised hydrogeochemical factors.

This is further supported by comparison of the arsenic concentration in the Content Pit lake water (range 0.002 – 0.08mg/L, $\bar{x}$= 0.030 mg/L, median = 0.035 mg/L, n=84, monitoring period 2000-2016) to that observed at BH11 (range 0.025 – 0.108 mg/L, $\bar{x}$= 0.052 mg/L, median = 0.059 mg/L, n=13, monitoring period 2009-2016) and BH12 (range 0.015 – 0.094 mg/L, $\bar{x}$ = 0.029 mg/L, median = 0.020, n=13). Arsenic concentration within the pit lake is lower than observed at bore BH11, which shows that the pit lake cannot be the source of arsenic at BH11. Therefore, the arsenic trigger level exceedance at BH11 and BH12 bores is the result of local geology.

Trace Metals

In each case the metal trigger level exceedance is in the order of parts-per-billion, being within the limits of analytical method/sampling variability and of no significance to the potential for environmental harm. Note BH12 exceeded the trigger limit for cobalt, copper and zinc even though the observed results were below the analytical detection limits. This is a function of the median of the three previous monitoring results required to be used for the comparison. During the previous year, cobalt, copper and zinc concentrations in the low parts-per-billion range were recorded at BH12.

Fluoride

The contaminant limit of 2mg/L for fluoride was exceeded at each of the Content Pit Monitoring bores during the reporting period. Fluoride concentration observed at bore BH11 has an approximately flat trend when viewed over the five year period for which data is available (Figure 36). Fluoride concentration in groundwater at bores BH10 and BH12 started at elevated levels and is showing a potential upward trend over the five year period for which data is available (Figure 36). Consequently, the observed trigger level exceedance for fluoride at monitoring bores BH11 and BH12 is as per previous reporting periods and not an emergent issue.

The previous discussion regarding electrical conductivity and the relative positions of the bores in relation to the pit void shows that the Content Pit Lake does not impact down gradient groundwater at bores BH10, BH11 and BH12. This is further supported by the observed fluoride concentration in the Content Pit Lake (range 1.1 - 2.6 mg/L, $\bar{x}$ = 1.57 mg/L, median=1.6 mg/L, n=68) during the monitoring period being significantly lower than that observed in BH10, BH11 and BH12. Therefore, the fluoride contaminant limit exceedance at the Content Pit Monitoring bores is the result of local geology.

6.4.4 Golden Butterfly Waste Rock Dump Monitoring Bores

The Golden Butterfly Waste Rock Dump Monitoring Bores consist of the locations BH3, BH4, BH5, BH6, and BH7 (see Figure 26). These bores are located approximately 100 meters from the toe of the north-eastern side of the Golden Butterfly Waste Rock Dump. Each bore is approximately 75 meters apart trending on a straight line running parallel with the toe of the waste rock dump.

Electrical Conductivity

Electrical conductivity of groundwater at bores BH3, BH5 and BH7 exceeded the 250 µS/cm trigger level during the reporting period. There are two additional bores BH4 and BH6 at this location (see Figure 26). Even though these two bores are not listed in EA Schedule F Table 9 as part of the stipulated programme, are nevertheless monitored regularly to provide additional data to aid interpretation of groundwater results. The electrical conductivity of groundwater at bore BH6 also exceeds the electrical conductivity trigger level.

Figure 35 shows that the electrical conductivity time series data indicates a decreasing trend for electrical conductivity at BH7 which has plateaued in recent years whereas, the other monitoring bores show flat trends over the approximately eighteen year record. Consequently, the observed electrical

conductivity trigger level exceedance at monitoring bores BH3, BH5 and BH7 is as per previous reporting periods and not an emergent issue.

Electrical conductivity of a water sample is directly related to the concentration of dissolved anions and cations and the resultant ability to pass an electric current. Hence, waters of entirely different origins with dissimilar anionic and cationic constituents can record comparable electrical conductivity. Therefore, when considering the relevance of the observed trigger level exceedance of electrical conductivity at monitoring bores BH3, Bh5 and BH7 it is important to also consider the actual concentrations of the contributory cations and anions. As previously discussed, Piper plots and Durov diagrams (see Figure 39 to Figure 45) provide a suitable means to summarise the major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and anions (SO_4^{2-}, HCO_3^{-}/CO_3^{2-}, Cl^{-}) present in groundwater in regards to potential similarity of composition and/or origin.

Figure 42 is the Piper Plot for the various bores associated with the Golden Butterfly Waste Rock Dump. The data suggests that the bores BH3 and BH6 group as a category distinct from bores BH4, BH5 and BH7 (i.e., have different geochemical facies). The Durov Diagram (see Figure 46) provides a similar result.

Groundwater levels within the bores BH3, BH4, BH5, BH6 and BH7 (see Figure 32) show an apparent hydraulic gradient from BH7 towards BH3 (i.e. a downwards gradient running north to south approximately parallel to the toe of the Golden Butterfly Waste Rock Dump). This hydraulic gradient is evident within the groundwater level data over the previous four wet/dry season cycles for which data are available. Further, bores BH3 and BH6 show increased groundwater levels at the peak of each wet season. The groundwater level data suggests that the bores BH3 and BH6 group as a category (potential shallow, unconfined surface aquifer) distinct from bores BH4, BH5 and BH7 (possible confined aquifer), which corresponds to the groupings identified by the groundwater quality data.

Electrical conductivity of groundwater from the grouping of bores BH4, BH5 and BH7 (possible confined aquifer) is greater than 4000 µS/cm, whereas, in bores BH3 and BH6 (potential shallow, unconfined surface aquifer) the electrical conductivity is below approximately 500 µS/cm. This indicates that the Golden Butterfly Waste Rock Dump, which was built on the existing ground surface, is not the source of elevated electrical conductivity in bores BH4, BH5 and BH7. Similar to the discussion in the previous sections, the trigger level electrical conductivity exceedances at BH3 and BH5 are more indicative of inappropriate limits, lack of suitable reference sites and or baseline data.

Trace Metals

In each case the trigger level exceedance is in the order of parts-per-billion, being within the limits of analytical method/sampling variability and of no significance to the potential for environmental harm.

Note BH3, BH5 and BH7 exceeded the trigger limit for copper even though the observed results were below the analytical detection limits. This is a function of the median of the three previous monitoring results required to be used for the comparison. During the previous year, copper concentrations in the low parts-per-billion range were recorded at BH3, BH5 and BH7. This is similar for the observed aluminium concentration at BH3, while the 2016 result being below the trigger limit, the median of the previous three years exceeds the trigger limit.

The arsenic result of 0.184 mg/L for BH3 in conjunction with the prior 2015 result indicates possible changes to the redox condition of BH3 due to drought conditions. Prior monitoring data for BH3 for the period 2006 to 2014 records a range of 0.002 – 0.086 mg/L, $\bar{x}$= 0.012 mg/L, median=0.008 mg/L, n=19. Further, with reference to the arsenic time series graph for associated bores (see Figure 35) no concentrations above 0.05 mg/L had been previously recorded.

Sulphate and Fluoride

Sulphate and fluoride concentrations at bores BH5 and BH7 exceeded the contaminant limits during the reporting period. Sulphate and fluoride concentrations observed at bores BH5 and BH7 have approximately flat trends when viewed over the period for which data is available (Figure 35). Consequently, the contaminant limit exceedance for sulfate and fluoride at monitoring bores BH5 and BH7 is as per previous reporting periods and not an emergent issue.

Previous discussion regarding electrical conductivity of groundwater at the Golden Butterfly Waste Rock Dump Monitoring Bores showed that the bores are categorised into two groups (bores BH4, BH5 and BH7 [possible confined aquifer] and bores BH3 and BH6 [potential shallow, unconfined surface aquifer]) by consideration of both groundwater levels and water quality data. Further, that the Golden Butterfly Waste Rock Dump, which was built on the existing ground surface, is not the source of elevated electrical conductivity in bores BH4, BH5 and BH7.

Since sulphate and fluoride constitute the major anions contributing to the observed electrical conductivity of the bore water, the sulfate and fluoride contaminant limit exceedance at bores BH5 and BH7 is the result of local geology. Similar to the discussion in the previous sections, the sulfate and fluoride contaminant limit exceedance at bores BH5 and BH7 is more indicative of inappropriate limits, lack of suitable reference sites and or baseline data.

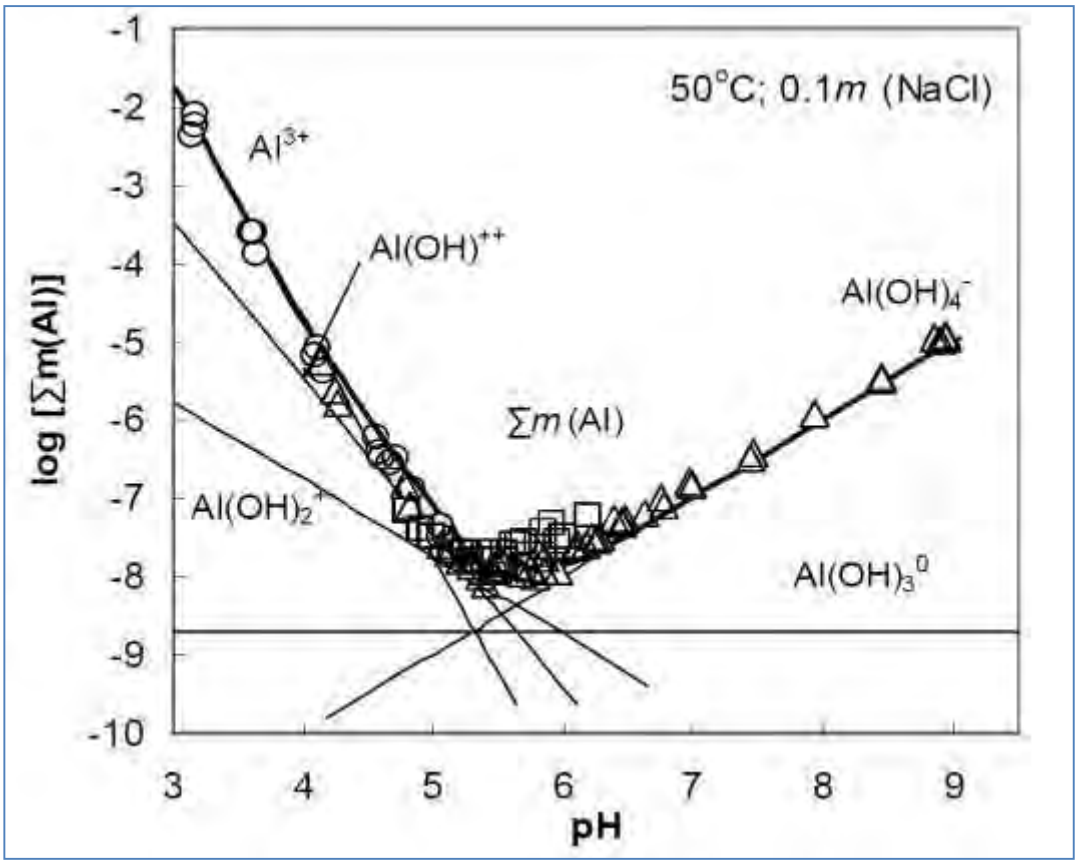


Figure 23: Aluminium Soluble Species versus pH
From Moller et al.

Groundwater Level

Details of the dimensions of the various groundwater monitoring bores is given in Table 6.

The various groundwater monitoring bores (see Figure 26 and Figure 27) are strategically located to provide information about possible impacts from various geographical features on the mining lease such as the mining pits and waste rock dumps.

Consequently, groundwater level monitoring results are presented as time series graphs in the following groupings in Figure 31 to Figure 34:

1. Golden Butterfly Pit Monitoring Bores: BH1, BH2, GBMB1, GBMB3, GBMB6 and SY1
2. Golden Butterfly North Pit Monitoring Bores: BH8 and BH9
3. Content Pit Monitoring Bores: BH10, BH11 and BH12
4. Golden Butterfly Dump Monitoring Bores: BH3, BH4, BH5, BH6, BH7

Observed groundwater levels for the various monitoring bores is tabulated in Table 13.

Table 6: Groundwater monitoring bore details

Monitoring Bore	**Bore Depth** (m)	**Elevation** (AHD)	**Monitoring Bore**	**Bore Depth** (m)	**Elevation** (AHD)
BH 1	55	117*	BH 10	21	103.95
BH 2	26	112*	BH 11	36	104.13
BH 3	20	113*	BH 12	17	102.08
BH 5	16	114*	GBMB 1	17	109*
BH 7	16	116*	GBMB 3	49	113*
BH 8	29	123.92	GBMB 6	27	113*
BH 9	29	122.29	SY 1	17	107.48

Notes: AHD = Australian Height Datum, * Elevations derived from available topographic mapping and are therefore approximate

6.5 Surface Waters

Beneficial uses of surface waters (Section 3.15) associated with the mining lease area involve:

- Water quality in Belmore Creek being suitable for utilisation by cattle and has some “minimal” change to background water quality and or combination of these outcomes.
- On site storages being potentially suitable for cattle watering purposes

Applicable standards to a particular outcome may not allow simultaneous attainment of other outcomes. Generally, the standards that achieve the most stringent outcome are adopted overall.

The following sections present and discuss current surface water quality data from the Copperfield River and on-site water storages in terms of potential impact from mining associated landforms on:

1. stock (in particular cattle) drinking water
2. alteration to background water quality

Stock (Cattle) Watering Assessment

ANZECC (2011) Livestock Drinking Water Guidelines are used in the assessment of potential impact of CGM mining associated landforms on the suitability of the Belmore Creek and on-site water storages for cattle drinking water. The individual guideline values used are reproduced in Table 7. Note that the ANZECC (2011) Livestock Drinking Water Guidelines form the contaminant limits given in Schedule F Table 4 of the Croydon EA.

Figure 47 to Figure 70 provide time series graphs for the various sample sites listed in Schedule F Table 3 (receiving surface waters) and Table 7 (water storages). Sample sites SW3a (Figure 55 to Figure 58), SW4 (Figure 59 to Figure 62) and SW5 (Figure 63 to Figure 66) are of particular relevance, as these sites could possibly have stored water that may be used for stock watering. Sample site SW6 (Figure 67 to Figure 70) is an actual stock watering dam. However, this site is not on the mining lease area and is not hydrologically connected to discharges from the pit lakes. The various time series graphs show that all potential stock watering locations (SW3a, SW4 and SW5) on the mining lease area meet ANZECC (2011) Livestock Drinking Water Guidelines.

Table 7: ANZECC (2011) Guidelines for Livestock Drinking Water

Parameter	NHMRC Guideline Value (mg/L)	Comment
Aluminium	5	
Arsenic	0.5	Up to 5mg/L may be tolerated if not provided as food additive and natural levels in the diet are low
Cadmium	0.01	
Cobalt	1	
Chromium	1	
Copper	1	1 mg/L for cattle
Manganese	-	Not sufficiently toxic
Molybdenum	0.15	
Nickel	1	
Lead	0.1	
Zinc	20	
Sulfate	1000	
Electrical Conductivity	5970	Total Dissolved Solids – for beef cattle up to 4000mg/L no effect (up to 5000mg/L can be tolerated with no loss of production); EC (uS/cm) x 0.67 = TDS (mg/L)
pH	-	No guideline specified

Impact on Background Water Quality Assessment

There is no background water quality data available, that is, water quality before mining operations were performed during 1987 to 1990, with which to compare current monitoring data. Further, the entire area has been impacted by prior mining activities of various scales ranging back to the 1890's. Nevertheless, the existing monitoring data set can be usefully compared to applicable guideline values and assessed in terms of time series trends to give as assessment of impacts on background water quality and hence possible impacts on aquatic ecosystem function.

ANZECC (2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems are used as the Croydon receiving water trigger values in Schedule F Table 4 of the EA. Time series graphs of the various analytes listed in Schedule F Table 4 of the EA for surface water monitoring locations given in Schedule F Table 3 are provided in Figure 47 to Figure 70.

The various time series graphs show that the surface water monitoring locations do not in general exceed the trigger levels and over time there is indication of improving quality. Where trigger levels have been exceeded the absolute concentrations involved are in the parts-per-billion range and not of environmental toxicological significance. This indicates that the mining related landforms have not significantly affected likely background water quality and hence aquatic ecosystem function. This interpretation is likely to be conservative, as it is based upon trigger limits "indicative of slightly disturbed tropical Australian upland river ecosystems". It can be reasonably argued that the Croydon site does not fall under this categorisation, being impacted by prior anthropological activities since the 1890's.

7 MONITORING PROGRAM

7.1 Sediment

Sampling Location and Frequency

In accordance with EA Condition F5-1 sediment quality of receiving waters and reference waters is conducted at the locations defined in Schedule F - Table 5 of the EA (reproduced in Table 8).

Sediment sampling is conducted twice a year, once at the end of the wet season period (generally April or May) and once at the end of the dry season period (generally November or December).

Table 8: Sediment Sampling Sites

Sample Site Code	Latitude	Longitude	Sample Site Description
Slaughteryard Creek			
SW1	630350	7986405	Lower Slaughteryard Creek
SW2	630197	7987640	Slaughteryard West Tributary at ML Boundary
SW3	631080	7988157	Slaughteryard Creek upstream of Golden Butterfly WRD
SW6	627908	7989454	Belmore Creek borrow pit/stock dam
SW3b	626736.519	7989973.135	Slaughteryard Creek reference site
Belmore Creek			
BCDS	631208	7988220	Belmore Creek Downstream
BCUS	627895.251	7990122.388	Belmore Creek Upstream (reference site)

Monitoring Parameters and Methods

Sediment samples are analysed for the parameters identified in EA Condition F5-1 of the EA which include: aluminium, arsenic, boron, cadmium, chromium, cobalt, copper, mercury, nickel, selenium and zine.

The whole sediment sample is subject to “total metal” analysis involving digestion with strong mineral acids.

Sampling Method

The following procedure is to be used when collecting samples as is based upon the requirements specified in Australian/New Zealand Standard “Water Quality Sampling Part 12: Guidance on Sampling of Bottom Sediments” AS/ANS 5667.12.

Samples are to be collected into polypropylene bags supplied by ALS Laboratories. The sample bags are approximately 20 cm x 25 cm allowing approximately 500gm to 1000gm of sample to be collected.

A small plastic sample scoop is used to collect the actual sediment from the river bed as follows:

1. Approximately 500gm to 1000gm of sample is required from each of the sample sites.
2. Label each plastic sample bag with the following details using permanent marker:
    a. Client/Reference: – "Croydon"
    b. Sampled By: – initials of the person(s) performing the sampling
    c. Sample ID: – this is the site code from the sampling sheet (ie. Either SW1, SW2, SW3 etc)
    d. Date/Time: – the date of the sampling in the format dd/mm/yy (the time is not necessary)
3. Sediment is collected from the dried stream bed surface, while walking in a line at right-angle to the stream bank at the individual sample location. This will provide a composite sample representative of the entire stream bed at each location.
    a. Belmore Creek – at every approximately 10 (ten) steps, scoop approximately 100gm into the sample bag. This should result in approximately 10 scoops from the cross-section of the stream bed being placed into the sample bag forming a representative composite sample.
    b. Slaughteryard Creek – due to narrow water course, sampling is performed at the centre of the creek longitudinally. At every approximately 3 (three) steps, scoop approximately 100gm into the sample bag. Repeat this procedure for 10 scoops from the longitudinal-section of the stream bed being placed into the sample bag forming a representative composite sample.
4. After completing the collection of the composite sample from the cross-section of the stream bed in step 2, close the sample bag, and then by rolling the contained sediment around, thoroughly mix the sample contents.
5. The samples are to be sent to ALS Laboratory in a plastic sample esky for analysis.

7.2 Macro-Invertebrates

Macro-invertebrates are not monitored as part of the routine environmental monitoring programme. Macro- invertebrate sampling was conducted previously in response to the 2010/2011 wet season discharge from the Content Pit. However, with the subsequent limestone dosing of the Content Pit lake bringing contained water to below ANZECC (2000) stock water guidelines (and the draw-down of lake levels due to water abstraction by the local pastoralist) future discharges are a lower probability and highly likely to be of even lower impact. Consequently, macro-invertebrate monitoring is not likely to be warranted. In event that macro-invertebrate monitoring is performed the following sampling locations and method are recommended to enable comparison with existing data.

Sampling Location and Frequency

A total of ten sites are to be surveyed in Belmore Creek and its tributaries (see Figure 24):

- site SW7 – a comparative site, upstream of the mine, on a tributary of Belmore Creek, at a pre-existing water quality monitoring site
- sites BCUS1, BCUS2 and BCUS3 – three comparative sites on Belmore Creek, upstream of the mining lease
- site SW6 – a comparative site, upstream of the confluence between the Content Pit overflow and a tributary of Belmore Creek, at a pre-existing water quality monitoring site
- site DSDi – a potentially impacted site immediately downstream of the confluence between the Content Pit overflow and a tributary of Belmore Creek, and
- sites BCDS1, BCDS2, BCDS3 and BCDS4 – four potentially impacted sites on Belmore Creek, downstream of the confluence of the Content Pit overflow and a tributary of Belmore Creek.

Belmore Creek is ephemeral with a seasonal first flow generally within the period February to April. Flow within Belmore Creek is also controlled by potential releases from Lake Belmore (Croydon Township freshwater drinking supply) which is located upstream of the mine lease area. Variations in flow regime have marked effects on physical habitat and stream biota (Bunn and Arthington, 2002). Consequently, the macro-invertebrate sampling is opportunistic (and is also curtailed due to personnel safety considerations if river flow is above 10 cumecs).

Figure 24: Macro-invertebrate sampling locations

Sampling Method

The sampling protocol outlined in the Queensland AUSRIVAS manual (Department of Natural Resources and Mines, 2001) is adopted.

At each site three replicate kick samples were obtained in different riffle sections using a standard 250µm sampling net. Attention is paid to ensuring that the full range of substrates including edge substrates, and the range of current velocities represented in the riffle are sampled. Each replicate sample is obtained to cover approximately 10 square metres of riffle area.

The composition of sampled substrates is recorded. Samples are transferred to a bucket and live-picked from a white sorting tray for at least 60 minutes or until all visible macro-invertebrates had been picked from the sample. Individual rocks and coarse plant material in the sample are first removed and individually scrubbed to remove adhering animals. Forceps, probes and Pasteur pipettes are used to transfer animals from the sample tray to a sampling vial containing methylated spirits and a label detailing site number, date and replicate number. Invertebrate samples are returned to the laboratory for sorting, identification and data entry.

Laboratory Procedure

To minimise risks of data corruption individual replicate samples are treated sequentially and sorting, identification and data entry procedures relating to each individual sample are completed prior to commencing work on the next sample. Samples are transferred piece-wise from the sample vial to a Petri dish and examined under a zoom stereomicroscope. Individual animals are sorted into taxa and identified to family level prior to transferring them to a new labelled sample vial for storage. The primary identification keys used are the web-based Keys to Australian Aquatic Invertebrate Families hosted on the LUCID central web site (http://keys.lucidcentral.org/keys/lwrrdc/public/Aquatics) with reference to supplementary printed keys where necessary.

As each animal is identified it was entered on a tally sheet listing the number of individuals for all families present in the sample. At the completion of each sample the data from the tally sheet is copied into the data entry section of a spreadsheet model which is used to calculate various biotic indices:

- Abundance weighted SIGNAL-2 value
- Number of animals
- Number of families
- Shannon Diversity index at family level
- Shannon Evenness Value

Statistical analysis is performed using commercial software packages. Site data is grouped for analysis by nonparametric methods as the data is not normally distributed and the number of site replicates is limited for practical reasons. Paired site groupings are tested for statistically significant differences in each of the output variables using the Kolmogorov-Smirnoff test.

Data is exported in a format suitable for input to AUSRIVAS river health modelling software (AusRivAs Macroinvertebrate Predictive Modelling Ver 3.1.1, CRCFE/LWA 2003) and used to run the Queensland Regional / Western / Autumn riffle model.

7.3 Revegetation/Flora

Revegetation monitoring is performed as per the protocols in the Wilson standard methodology (see Appendix A).

Sampling Location and Frequency

As per the Wilson revegetation methodology, the Croydon site has been categorised into two “reclaimed units” defined based upon management criteria (e.g. areas with common revegetation/rehabilitation procedures, initiation times, defined land use function such as waste rock dump etc). These general “reclaimed units” encompass the Content Waste Rock Dump and the Golden Butterfly Waste Rock Dump. There are also two analogue sites (“Boiler Analogue Site” and the “V Analogue Site) selected with similar topographical and land use features with which to compare the mine site revegetation results

Within each defined “reclaimed unit” or analogue site a grid is used to determine the physical location of transects for groundcover and revegetation data collection as follows:

- A fixed point of reference is selected for each “reclaimed unit” to facilitate location of the systematic grid in the field.
- A systematic grid of appropriate dimensions (e.g., 100m x 100m) is selected to provide a minimum number (10, 18, or 20 depending on size of the “reclaimed unit”) for ground cover samples of coordinate intersections within the reclaimed unit that are then used for the initial set of sample sites.
- A scaled representation of the grid is overlain on computer-generated field maps of each facility extending parallel to major compass axes.
- Unbiased placement of this grid is controlled by selection of two random numbers to be used as coordinates to establish a sampling starting point.
- Utilizing a handheld compass and handheld GPS, all of the initial sample points for each area are located in the field.

Sampling frequency is annual, targeted to coincide with the flowering period to facilitate floristic identification.

Sampling Method

Ground cover at each sampling site is determined utilizing the point-intercept methodology as follows:

- A transect of 10 m length is extended generally along the contour from the starting point of each sample site.
- At each one-metre interval along the transect, a “laser point bar” is situated above and parallel to the ground surface, and a set of 10 readings recorded as to hits on vegetation (by species), litter, rock (>5mm), or bare soil.
- Hits are determined at each metre interval by activating a battery of 10 specialized lasers situated along the bar at 10 cm intervals and recording the variable intercepted by each of the narrow (0.5 mm) focused beams

A total of 100 intercepts per transect are recorded resulting in 1 percent cover per intercept. This methodology and instrumentation facilitates the collection of the most unbiased, repeatable, and precise ground cover data possible.

Ground cover comprised of perennial and annual species exhibiting greater than two percent relative ground cover (composition) are identified and enumerated.

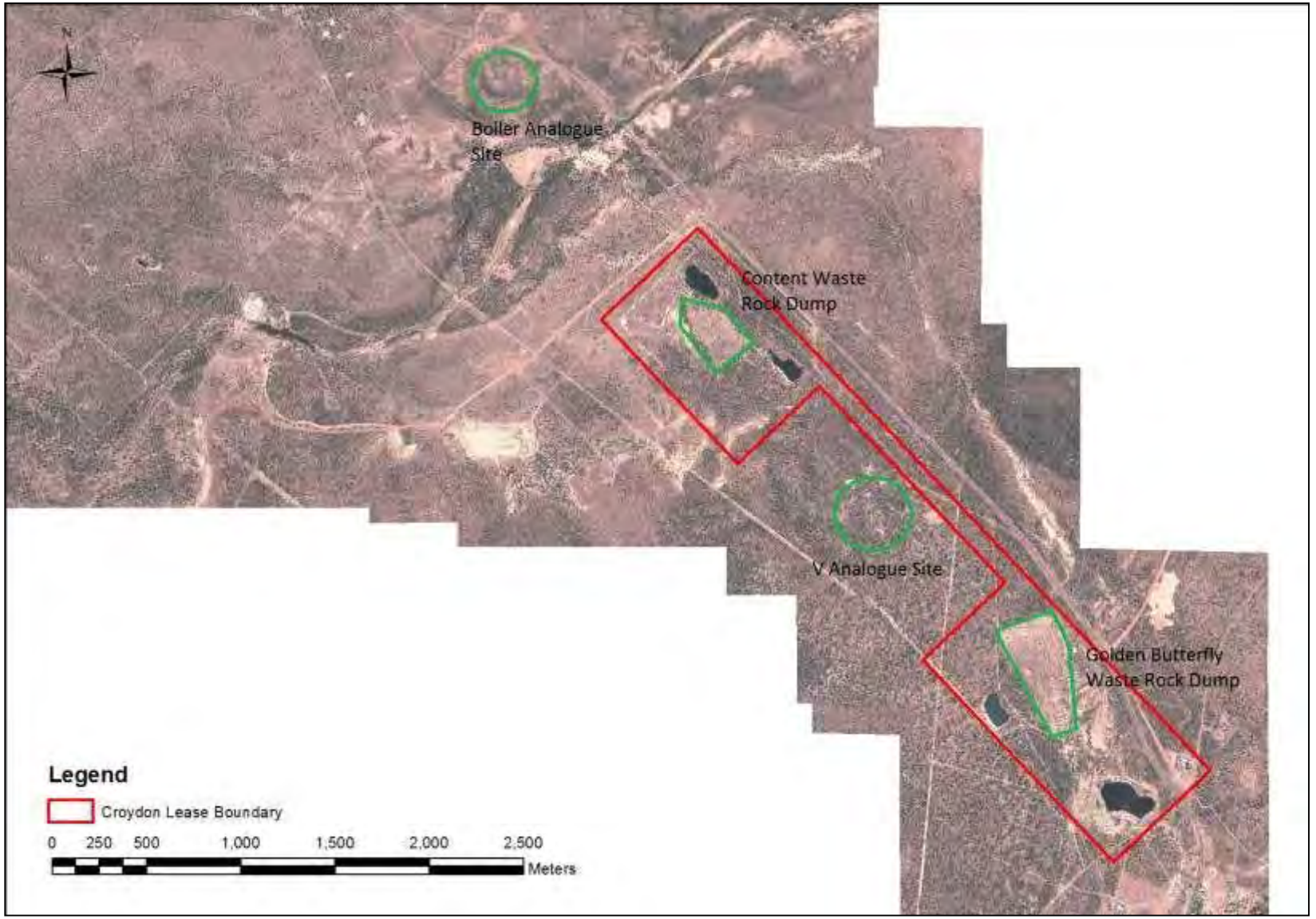


Figure 25: Location Map of Revegetation Monitoring Areas

Ground cover sampling is conducted to a minimum of 20 transects for rehabilitation areas and 10 or 18 transects for analogue areas. From these preliminary efforts, a sample mean and standard deviation for total non-overlapping vegetation ground cover is calculated. These parameters are calculated in the field to insure collection of an adequate sample and once again by computer during final data analyses for each area.

Sampling continues until an adequate ground cover sample, $\mathbf{n_{min}}$, has been collected in accordance with the Cochran formula (below) for determining sample adequacy, whereby the population would be estimated to within 20% of the true mean (μ) with 80% confidence.

When the inequality ($\mathbf{n_{min} \leq n}$) is true, sampling is adequate and $\mathbf{n_{min}}$ is determined as follows:

$$\mathbf{n_{min} = (t^2 s^2) / (0.2\ x)^2}$$

where:

n = number of actual samples collected (initial size = 10, 18, or 20)
t = value from the two-tailed t distribution for 80% confidence with n-1 degrees of freedom;
s^2 = the variance of the estimate as calculated from the initial understory samples;
$\boldsymbol{x}$ = the mean of the estimate as calculated from the initial samples.

If any of the initial ground cover sampling efforts from each reclamation area had not provided a suitable estimate of the mean (i.e., the inequality was false), additional samples would have been collected until the inequality ($\mathbf{n_{min} \leq n}$) became true.

Revegetation Standards

Rehabilitation success in reclamation units will be assessed against performance standards for 1) vegetative ground cover, 2) soil surface stability, and 3) biodiversity.

1. Vegetative Ground Cover Standard

The total vegetative ground cover (exclusive of exotic species) in the revegetated unit must equal or exceed 75 percent of the approved analogue area's total vegetative ground cover (exclusive of exotic species), using a direct mathematical comparison of the sampled means (assuming a statistically adequate sampling effort).

2. Soil Surface Stability Standard

A potential soil erosion value “A” in tons/acre/year of growth medium loss will be estimated by the RUSLE model. This value can then be compared to any one of three options (i, ii, or iii):

i) Soil loss value (A) determined by RUSLE for the reclaimed unit is equal to or less than the "T" value (effectively the soil genesis rate) appropriate to the site and the “trend” analysis detailed in Section 3.2 of the Reclamation Monitoring & Final Relinquishment Protocol indicates stable or positive results.

ii) Soil loss value determined by RUSLE for the reclaimed unit is less than 110%1 of an established soil loss baseline value determined by RUSLE for the mine area (prior to disturbance) and the “trend” analysis detailed in Section 3.2 of the Reclamation Monitoring & Final Relinquishment Protocol indicates stable or positive results.

iii) Soil loss value determined by RUSLE for the reclaimed unit is less than 110% of a soil loss value from a reference (analogue) area as determined by RUSLE and the “trend” analysis detailed in Section 3.2 of the Reclamation Monitoring & Final Relinquishment Protocol indicates stable or positive results.

3. Species Diversity Standard

Species diversity addresses biodiversity and must meet at least one of the following two tests:

a) Provide at least 3 non-exotic species with ≥ 2% composition.

b) Provide 50% of the number of non-exotic species found in the analogue area with ≥ 2% composition.

7.4 Groundwater

Sampling Location and Frequency

In accordance with EA Condition F7-1 groundwater monitoring is conducted at the locations and frequencies defined in Schedule F - Table 9 of the EA (reproduced in Table 9).

Table 9: Groundwater Monitoring Programme

Monitoring Location[1]	Frequency	Parameters[2]
BH1 – west of Golden Butterfly Pit	Annually	pH
BH2 – east of Golden Butterfly Pit		EC
BH3 – east of Golden Butterfly WRD		Sulphate
BH5 - east of Golden Butterfly WRD		Fluoride
BH7 - east of Golden Butterfly WRD		Aluminium
BH8 - east of Golden Butterfly WRD		Arsenic
BH9 - east of Golden Butterfly WRD		Boron
BH10 – west of Content WRD		Cadmium
BH11 – west of Content WRD		Chromium (Cr^{VI})
BH12– west of Content WRD		Cobalt
GBMB1 – Slaughteryard Creek		Copper
		Mercury (inorganic)
GBMB3 – Slaughteryard Creek		Nickel
		Selenium (total)
GBMB6 – Slaughteryard Creek		Zinc
SY1 – Slaughteryard Creek		

1. See Figure 26 for locations
2. Metals and metalloids are analysed for total dissolved fraction (filtered <0.45µm)

Monitoring Parameters and Methods

Groundwater samples are analysed for the parameters identified in Schedule F7-1 - Tables 10 of the EA. A summary of the groundwater monitoring is provided in Table 9.

In addition, groundwater levels are recorded in all monitoring bores defined Schedule F - Table 9 of the EA approximately quarterly.

Sampling Method

1. Upon arrival at a sample site use the water level dip meter to measure the water depth in the bore and record this in the appropriate column of the field data sampling sheet. The water depth is recorded as from the top of the bore casing.
2. Insert the submersible pump into the bore approximately 25 centimetres from the bottom or to the limit of the plastic tubing and connect the portable power supply.
3. Begin pumping and every six minutes using the pH/EC field meter record the pH and EC of the flow (also transcribe this data onto the Field Data Sampling Sheet).
    a. When three (3) consecutive readings are stable (pH within ±0.1 and EC within ±2%) samples can be collected.
    b. If the bore runs dry, stop pumping and allow the bore to recharge after which samples can be collected without further six (6) minute readings.
4. Using the flow directly from the submersible sample pump plastic tubing fill the following sample bottle types if required. Note: bottle types (c) to (e) have preservative chemicals added and must

not be allowed to overflow. Further, lids from these various bottles must not be swapped as this will introduce contamination.

a. 1L green labelled plastic sample bottle
b. 50ml red/green labelled sample bottle for “total” metal analysis
c. 250ml blue labelled sample bottle for cyanide analysis
d. 50ml blue labelled sample bottle for chromium analysis
e. 50ml clear sample bottle for arsenic analysis

5. A 50ml red/green sample bottle for “filtered” metal analysis is required as follow:
    a. Submerge the syringe a minimum depth into the 1L green plastic sample bottle, draw back the plunger to remove ~10ml of sample. Remove the syringe, draw back the plunger to rinse the entire inside of the syringe barrel, then discard the 10ml of sample. Repeat this twice to ensure the syringe has been thoroughly rinsed.
    b. With a syringe full of water sample as per step 5a, rinse the outside of the syringe and your gloved hands with rinse water. Then gently shake the syringe and your gloved hands to remove as much adhering water droplets as possible. This is to ensure no unfiltered droplets of water containing sediment/soil are accidently allowed to enter the 50ml red/green sample bottle for “filtered” metal analysis.
    c. Remove a 0.45µm filter disc from the wrapper and attach the filter disc to the bottom of the syringe prepared in step 5b. Press the plunger to filter the sample allowing the first approximately ten (10) drops to be discarded onto the ground. Filter the remaining volume in the syringe into the 50ml red/green sample bottle for “filtered” metal analysis. The syringe/filter disk is then discarded (do not reuse between sites).
    d. Using a permanent ink marking pen, place a “tick” in the “Dissolved Metals” box on the red/green sample bottle label.
6. Once all the necessary bottles have been filled, each is to be externally washed with rinse water to ensure any adhering soil or sediment is removed. Gently shake to remove as much adhering water droplets as possible, and then return to the sample bottle to zip-lock plastic bag.
7. The samples are to be sent to ALS Laboratory in a plastic sample esky for analysis as soon as possible after collection.

Figure 26: Location of Groundwater Bores (SE locations)

Figure 27: Location of Groundwater Bores (NW locations)

7.5 Surface Water

Routine Sampling Location and Frequency

In accordance with EA Condition F4-1 surface water monitoring is conducted at the locations defined in Schedule F - Table 3 of the EA (reproduced in Table 10).

Routine sampling frequency is defined in Schedule F - Table 3 of the EA as one sample must be taken during the wet season (January – March) and one sample must be taken during the dry season (July – September).

On-site water storages listed in Schedule F - Table C7 of the EA (reproduced in Table 11) are monitored on a twice yearly basis (wet season period, January – March; dry season period, July – September).

Discharge Event Sampling Location and Frequency

In addition to routine surface water sampling, “event based” sampling (defined as a surface water release from on-site water storages or contaminated areas within the mining lease) is to be conducted as follows:

- Samples from locations specified in Schedule F - Table 3 of the EA (reproduced in Table 10) to be taken within twenty-four (24) hours of the release event
- Another round of samples are to be taken between twenty-four (24) and forty-eight (48) hours after the release event
- If the release event has a duration of greater than twenty-four (24) hours, samples from locations specified in Schedule F - Table 3 of the EA (reproduced in Table 10) are to be taken daily for one week, and then weekly thereafter until the release event ceases

Additional sample sites in the event of discharge are required to provide information to enable interpretation of possible environmental impact of the discharge. The location of these samples sites is shown in Figure 30 and listed in Table 12.

Monitoring Parameters and Methods

Surface water samples are analysed for the parameters identified in Schedule F - Tables 4 of the EA. These parameters are as follows:

pH , Electrical Conductivity, Turbidity , Sulphate , Fluoride , Aluminium , Arsenic , Boron , Cadmium , Chromium (CrVI) , Cobalt , Copper , Mercury (inorganic) , Nickel , Selenium , Zinc.

All analyses must be performed by a NATA registered laboratory. All metals and metalloids must be measured for total (unfiltered) and dissolved (passing a 0.45um filter).

EA Condition F11-2 (e) requires the inclusion of dissolved oxygen saturation and temperature. However, there are no mining landform related processes that can affect dissolved oxygen or water temperature. Belmore Creek, Slaughteryard Creek and the other water bodies associated with the mine lease area are ephemeral, and in particular for sample locations on the mining lease, generally have a maximum depth below 0.5m. Therefore, incident rainfall runoff, cloud cover, seasonal weather conditions etc are the dominant factors affecting dissolved oxygen and temperature of water bodies on the mining lease. Dissolved oxygen and temperature data does not assist in interpretation of the results obtained from the other analytes stipulated in the monitoring programme. Therefore, the time, effort and expense of obtaining dissolved oxygen data is not warranted and is not included in the routine monitoring programme.

Sampling Method

1. Upon arrival at a sample site, turn on the pH/EC field meter and place the probes in the stream, pond etc to be sampled. This will allow the probes to equilibrate with the sample conditions while performing the other sampling tasks. Once having completed all other sampling tasks and just prior to leaving the site, record the pH/EC reading.
2. Using a new pair of disposable plastic gloves, open the zip-lock plastic bag containing the sample bottles and write the necessary details on the bottle label.
3. While still wearing the disposable plastic gloves and using the green labelled 1L plastic sample bottle, without removing the lid submerge the bottle into the stream or pond to a depth of approximately 10-15 cm (half-way up the forearm). While facing upstream, ensuring the bottle is upstream of your body or any disturbance caused to the stream bottom by your presence, open the lid with the other hand and allow the bottle to fill and then close the lid whilst still under water. Withdraw the sample from the water.
4. This same procedure in step 3 is to be followed with the 50ml red/green bottle for "total" metal analysis. However, using a permanent ink marking pen, place a "tick" in the "Total Metals" box on the red/green sample bottle label.
5. The following sample bottle types contain preservative chemicals and or have been specially treated and must **not** be used as in step 3:
    a. 50ml red/green sample bottle for "filtered" metal analysis
    b. 250ml blue sample bottle for cyanide analysis
    c. 50ml blue sample bottle for chromium analysis
    d. 50ml clear sample bottle for arsenic analysis
6. If one of the bottle types from (b) to (d) listed in step 5 is required, while still wearing the disposable plastic gloves, remove the lid from the bottle and place it thread facing up on the ground (to avoid any soil/sediment etc entering the bottle when the lid is later replaced). With the sample collected in the green labelled 1L plastic sample bottle from step 3, carefully fill the bottle to nearly full but ensuring that the bottle does not overflow. Since bottle types from (b) to (d) listed in step 5 have various chemical preservatives added, if the lids from these bottles are swapped this will introduce gross contamination. Ensure that the correct lid from each bottle is used when being replaced. After filling any necessary bottles, step 3 is to be repeated with the green labelled 1L plastic sample bottle.
7. If a 50ml red/green sample bottle for "filtered" metal analysis is required, while still wearing the disposable plastic gloves, with a new 50ml plastic syringe:
    a. Submerge the syringe into the stream or pond to a depth of approximately 10-15 cm (half-way up the forearm). While facing upstream, ensuring the syringe is upstream of your body or any disturbance caused to the stream bottom by your presence, draw back the plunger to fill the syringe. Remove the syringe from the stream or pond and dispose of the sample downstream. Repeat this twice to ensure the syringe has been thoroughly rinsed.
    b. With a syringe full of water sample as per step 7a, rinse the outside of the syringe and your gloved hands with rinse water. Then gently shake the syringe and your gloved hands to remove as much adhering water droplets as possible. This is to ensure no unfiltered droplets of water containing sediment/soil are accidently allowed to enter the 50ml red/green sample bottle for "filtered" metal analysis.
    c. Remove a 0.45µm filter disc from the wrapper and attach the filter disc to the bottom of the syringe prepared in step 7b. Press the plunger to filter the sample allowing the first approximately ten (10) drops to be discarded onto the ground. Filter the remaining volume in the syringe into the 50ml red/green sample bottle for "filtered" metal analysis. The syringe/filter disk is then discarded (do not reuse between sites).
    d. Using a permanent ink marking pen, place a "tick" in the "Dissolved Metals" box on the red/green sample bottle label.
8. Once all the necessary bottles have been filled, each is to be externally washed with rinse water to ensure any adhering soil or sediment is removed. Gently shake to remove as much adhering water droplets as possible, and then return to the sample bottle to zip-lock plastic bag.
9. The samples are to be sent to ALS Laboratory in a plastic sample esky for analysis as soon as possible after collection.

Table 10: Receiving Water Monitoring Sites

Site Code	Latitude	Longitude	Sample Site Description
Slaughteryard Creek			
SW1	630350	7986405	Lower Slaughteryard Creek
SW2	630197	7987640	Slaughteryard West Tributary at ML Boundary
SW3	631080	7988157	Slaughteryard Creek upstream of Golden Butterfly WRD
SW6	627908	7989454	Belmore Creek borrow pit/stock dam
Belmore Creek			
BCDS	631208	7988220	Belmore Creek Downstream
BCUS	627895	7990122	Belmore Creek Upstream (reference site)

Table 11: On-site Water Storage Monitoring Sites

Site Code	Latitude	Longitude	Sample Site Description
	631140	7987525	Golden Butterfly Pit
	630545	7987921	Golden Butterfly North Pit
	629473	7990023	Lady Isabella Pit
	629048	7990435	Content Pit
SW3a	6309133	7988253	Golden Butterfly WRD
SW4	631049	7987892	Stock Water Dam
SW5	628691	7990012	Sediment Dam at Lease Boundary

Table 12: Discharge Event Sampling Sites

Site Code	Latitude	Longitude	Sample Site Description
BCDS	-18.1756	142.1983	Belmore Creek Downstream
BDUS	-18.1741	142.2092	Belmore Creek Upstream
SW8	-18.1772	142.2025	Belmore u/s
SW9	-18.1769	142.2018	Belmore d/s
SW10	-18.1642	142.2194	Belmore u/s 1
SW11	-18.1678	142.2145	Belmore u/s 2
SW12	-18.1741	142.2092	Belmore u/s 3
SW13	-18.1756	142.1983	Belmore d/s 2
SW14	-18.1786	142.1941	Belmore d/s 3
SW15	-18.179	142.1886	Belmore d/s 4
SW18	-18.1665	142.2166	Belmore Crk Bridge

Figure 28: Location of Surface Water Sample Sites (SE locations)

Figure 29: Location of Surface Water Sample Sites (NW locations)

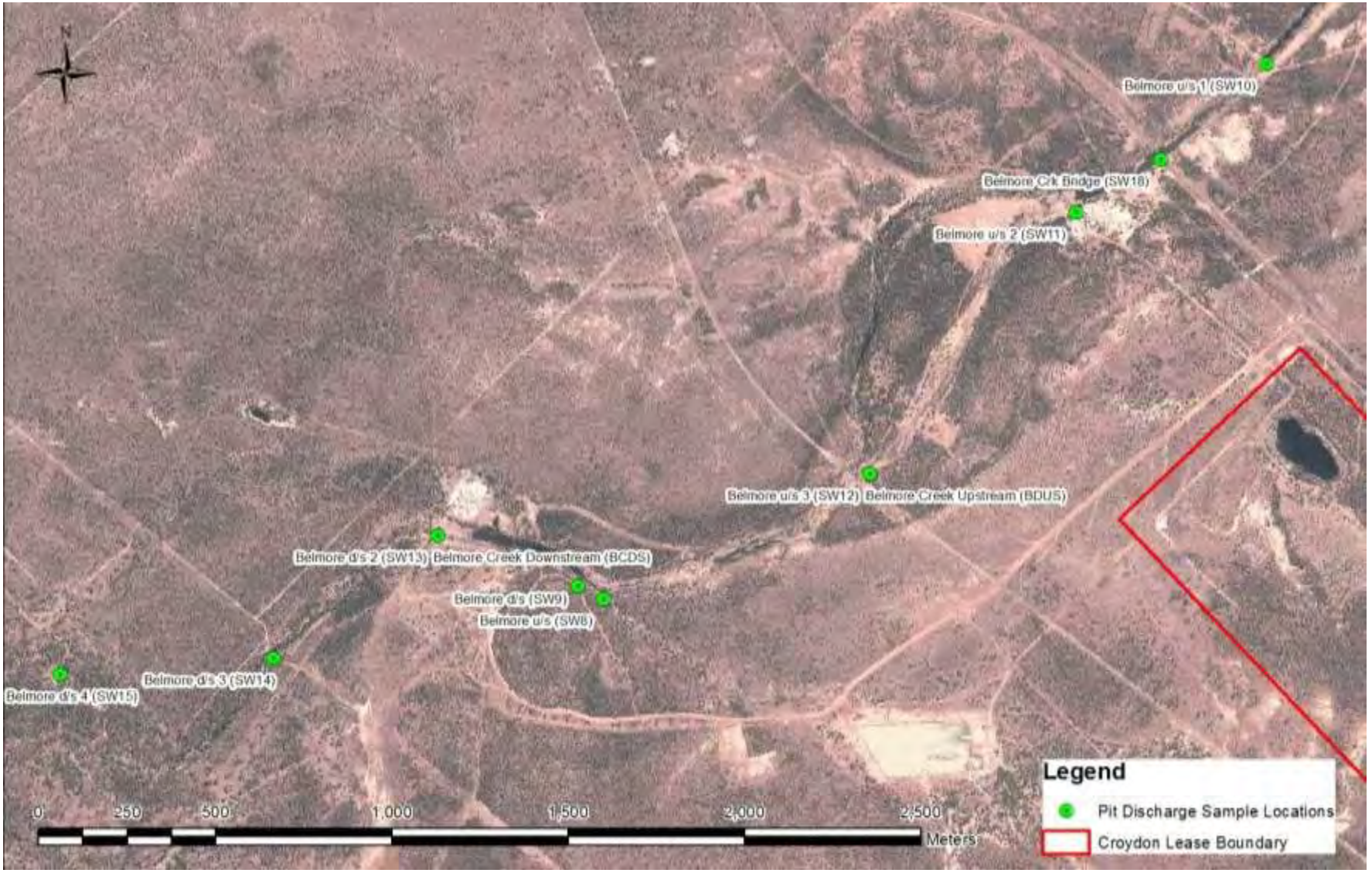


Figure 30: Location of Additional Sample Sites in Event Pit Discharge

8 REFERENCES

AUSRIVAS Manual: http://ausrivas.canberra.edu.au/Bioassessment/Macroinvertebrates/Man/Pred

Australian Accounting Standards Board (2006) AASB 137 Provisions, Contingent Liabilities and Contingent Assets Standard, Australian Govt, Canberra.

Australian and New Zealand Minerals and Energy Council (ANZMEC) and Minerals Council of Australia (MCA) (2000) *Strategic Framework for Mine Closure*. Australian and New Zealand Minerals and Energy Council, Canberra, and Minerals Council of Australia, Canberra.

Wilson Gold (2006). *Mine Closure Planning and Cost Estimation Guideline*. Unpublished report.

Wilson Gold (2009) Mine Closure Standard Unpublished report

Batley, G.E., Collection, Preparation, and Storage of Samples for Speciation Analysis, Ch 1, in *Trace Element Speciation: Analytical Methods and Problems*, CRC Press, 1989.

Cedar Creek (2011) Croydon Mine 2010 Revegetation Monitoring.

Commonwealth Department of Industry, Tourism and Resources (2006a) *Mine Closure and Completion*, Commonwealth of Australia, Canberra.

Commonwealth Department of Industry, Tourism and Resources (2006b) *Mine Rehabilitation*, Commonwealth of Australia, Canberra.

Department of Natural Resources and Mines, 2001, Queensland Australian River Assessment System (AusRivAS) Sampling and Processing Manual August 2001. Queensland, Department of Natural Resources and Mines, Brisbane.

Environment Australia (1997) *Hazardous Materials Management, Storage and Disposal*. Commonwealth of Australia.

Fawcett Mine Rehabilitation Services (2001) Report on Croydon Rehabilitation Works 1996/1997.

HLA - Envirosciences (2001) *Water Level Analysis of Golden Butterfly Pit – Croydon Gold Mine*. Report prepared for Goldfields Ltd, May 2001.

Moller, N., Christov, C., Weare, J., *Thermodynamic Models of Aluminium Silicate Solubility for Application to Enhanced Geothermal Systems*, Proceedings of the 31st Workshop on Geothermal Reservoir Engineering, Stanford University, 2006

New Zealand Ministry for the Environment (1999) *The Use of Macroinvertebrates in Water Management*, Ministry for the Environment, Wellington, New Zealand.

Popek, E.P., p.142, *Sampling and Analysis of Environmental Chemical Pollutants*, Academic Press, 2003

Queensland Environmental Protection Agency (2003a) *Final Rehabilitation Report and Audit Statement for Non-Standard Mining Lease Projects*.

Queensland Environmental Protection Agency (2003b) *Financial Assurance for Mining Activities.*

Queensland Environmental Protection Agency (2006) *Guideline 18: Rehabilitation Requirements for Mining Projects.*

Queensland Mining Council (2001) *Guidelines for Mine Closure Planning in Queensland*.

Singhal, B.B.S., Gupta, R.P., p. 211, *Applied Hydrogeology of Fractured Rocks*, 2nd Ed., Springer, 2010

Tongway and Hindley (2004) *Landscape Function Analysis: Procedures for Monitoring and Assessing Landscapes with Special Reference to Minesites and Rangelands.*

Williams, P (2013) Croydon Mine Rehabilitation Assessment 2013

USEPA (1997) *Monitoring Water Quality: A Methods Manual, EPA 841-B-97-003.*

APPENDIX A

Rehabilitation/Revegetation Monitoring Method

INTRODUCTION

Reclamation monitoring accounts for several mine closure elements including: vegetation establishment, plant community composition, and soil quality / stability that are critical to replacement of a productive post-mine land use. Relinquishment addresses processes, requirements, and milestones that assure stakeholders with a high degree of probability that the reclaimed land will not be problematic to the future "well-being" of the local environment. This document describes the soil surface and reclamation evaluation procedures to be used by Wilson Gold Corporation (Wilson) held mines for monitoring and analysis of reclamation performance in accordance with Wilson's Environmental Management Systems (EMS). These procedures have been developed in accordance with Wilson's EMS and Corporate Closure Group in Salt Lake City, Utah, USA. Unless superseded by site-specific permitting requirements, these procedures also support the process leading to eventual financial guarantee or assurance release in accordance with reclamation permit requirements for documentation of successful reclamation. Two important side-benefits of these procedures will be: 1) the timely detection of latent reclamation issues or problems along with recommendations for corrective action, and 2) a standardized means of recording information that will help preclude loss of such information due to staffing changes / turnover.

In this regard, this document details the step-wise procedures for evaluating final reclamation / revegetation of lands disturbed by mining operations under Wilson direction. This document is based on procedures developed in the United States and Australia that concentrate: first, on information control; second, on an evaluation of soils; third, on an evaluation of soil stability; fourth, on performance of revegetation (given that reclamation is designed to return the land to a productive post-mine land use); fifth, on consistent and meaningful reporting; and finally, development of and compliance with release criteria to facilitate relinquishment of any regulatory mandated financial assurances and/or liability. Key to the success of these components is the fifth step providing an effective feedback loop that conveys pertinent and/or corrective information to site managers or their successors. Once reclaimed surfaces have achieved satisfactory results, final bond relinquishment evaluations can then occur. In this regard, this document is divided into six (6) sections that address the aforementioned topics as follows: 1) Organization of existing information; 2) Evaluation of growth media; 3) Site-specific procedures for evaluating soil stability; 4) Site-specific procedures for monitoring reclamation/revegetation; 5) Reporting of findings; and 6) Procedures and criteria for a determination of final reclamation success.

It is the intent of Wilson to establish a reasonable, effective, and statistically defensible program to track the progress of soil stabilization and reclamation on areas generally closed to active mine operations. This program will track progress both during the period of vegetation establishment and development (typically 3 to 5 years after planting) and during the period that follows (after 5 years) until the financial assurance or liability is released. When implemented, this "program" will provide a scientifically defensible means to determine when units of reclaimed land will meet reclamation success criteria and can be identified as "ready for surety and liability release" (releasable). These procedures will also identify those areas, or substantive portions of areas, that are not responding sufficiently to be releasable. This latter point is one of the critical components of the monitoring program. If potentially problematic areas are not identified early in the reclamation process, the costs to Wilson in terms of both time and financial commitment will become excessive. Properly designed monitoring procedures will shed light on potentially problematic areas as well as provide a forum for the determination of corrective measures.

Step 1 Organization of Existing Information

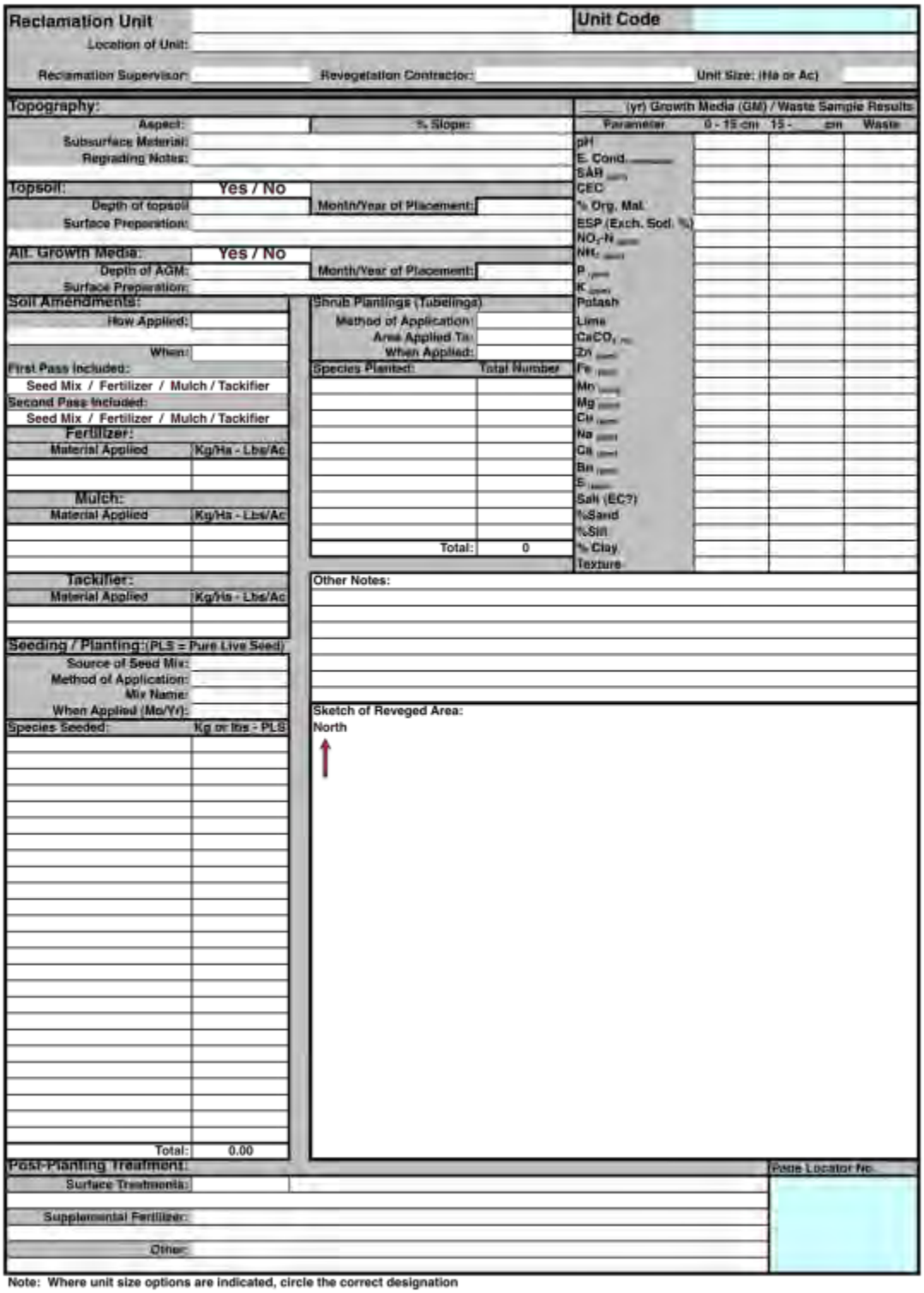
The first step in the overall monitoring process is to collect and organize any and all existing information regarding each unit of currently reclaimed land and then complete an "as-built" sheet for those units. A reclaimed unit (or management unit) consists of a defined area based on management criteria (e.g., areas with common reclamation procedures, initiation times, defined functions such as a waste rock

area, or areas with other unique designations or segregation). Often, segregation can be made based on slope, aspect, change of reclamation technique or practice, perceived problem or other informational basis, or based on land use management. Necessary information includes detailed mapping of the “unit(s)”, to document the areal extent of applied procedures with respect to the permit area and all applied reclamation metrics (procedures) as indicated on the “as-built” sheet (illustrated below). Once all currently existing reclaimed units have been documented in this manner, an “as-built” sheet should be completed for each new reclaimed unit forward in time. Copies of “as builts” should be maintained in the environmental offices, preferably at multiple locations.

The “as-built” sheet is designed as a “check sheet” to facilitate recording of the most pertinent data from a unit of reclaimed land that may be necessary to facilitate a determination of problematic conditions, or simply to document the reclamation metrics that occurred. This sheet contains places for generic identifying information, person(s) responsible for final reclamation, the size of the area, pertinent physical parameters such as topography, growth media and depth, amendments, soil sample results, live shrub or tree planting information, seed mix and method of application, post-planting treatments, etc., and a place to sketch the unit along with any miscellaneous notes. Given such information, the number of “unknowns” is minimized thereby leading to a more rapid determination of the best reclamation metrics for any given site, or sub-site. Also, such an information base facilitates more rapid isolation of problematic circumstances at any given site or sub-site.

A managerial unit should not be defined too broadly. Eventual sampling will provide detailed findings on the unit and if it has not been defined properly, the utility of resulting information will be compromised. For example, if a unit is defined too broadly and contains multiple growth media types, reseeding mixes, and/or amendments, it will be difficult to isolate problematic or outstanding reclamation components. To the contrary, if a unit is defined too narrowly, monitoring budgets will be excessively high. An example of a reasonable definition would be a waste dump, covered with the same growth media, to approximately the same depth, reseeded with the same mix of species and using the same reclamation metrics, but perhaps across two separate years. In this case, any observed differences between the two years would most likely be related to precipitation and not consequential to the overall program. However, if two different growth media were utilized, segregation of the two units would be appropriate. Similarly, if five different small areas were reclaimed using the same metrics, seed mixes, etc. there would be little need to separate them as five segregate units.

Managerial units should also be represented in two additional summary formats, among others, to assist both mine and corporate management with decision-making. The first of these formats is “spatial” (map) similar to the example provided below as Map 1. Pertinent detail such as the location, relative size, year of reclamation, etc. can be presented in a readily comprehensible format. It would be most helpful to provide such mapping in a digital format, especially using software such as ArcView, but paper copies are valuable as well. The second format is a spreadsheet summary of all reclamation along with pertinent notes and schedules. An example of such a summary is provided as Table RS below where each unit is represented along with the year of reclamation, name of the unit, location and size of each unit, method of reclamation, current status, monitoring schedule, and any additional pertinent notes. When remediation is necessary, such summary information becomes highly valuable.



Reclamation Unit | **Unit Code**

Location of Unit:

Reclamation Supervisor: | Revegetation Contractor: | Unit Size: (Ha or Ac)

Topography:

Aspect: | % Slope:

Subsurface Material:

Regrading Notes:

Topsoil: Yes / No

Depth of topsoil: | Month/Year of Placement:

Surface Preparation:

Alt. Growth Media: Yes / No

Depth of AGM: | Month/Year of Placement:

Surface Preparation:

Soil Amendments:

How Applied:

When:

First Pass Included:

Seed Mix / Fertilizer / Mulch / Tackifier

Second Pass Included:

Seed Mix / Fertilizer / Mulch / Tackifier

Fertilizer:

Material Applied	Kg/Ha - Lbs/Ac

Mulch:

Material Applied	Kg/Ha - Lbs/Ac

Tackifier:

Material Applied	Kg/Ha - Lbs/Ac

Seeding / Planting: (PLS = Pure Live Seed)

Source of Seed Mix:

Method of Application:

Mix Name:

When Applied (Mo/Yr):

Species Seeded:	Kg or lbs - PLS
Total:	0.00

Shrub Plantings (Tubelings)

Method of Application:

Area Applied To:

When Applied:

Species Planted:	Total Number
Total:	0

_____ (yr) Growth Media (GM) / Waste Sample Results

Parameter	0 - 15 cm	15 - ___ cm	Waste
pH			
E. Cond. _____			
SAR _____			
CEC			
% Org. Mat.			
ESP (Exch. Sod. %)			
NO_3-N _____			
NH_4 _____			
P _____			
K _____			
Potash			
Lime			
$CaCO_3$ _____			
Zn _____			
Fe _____			
Mn _____			
Mg _____			
Cu _____			
Na _____			
Ca _____			
Bo _____			
S _____			
Salt (EC?)			
%Sand			
%Silt			
% Clay			
Texture			

Other Notes:

Sketch of Reveged Area:

North

Post-Planting Treatment:

Page Locator No.

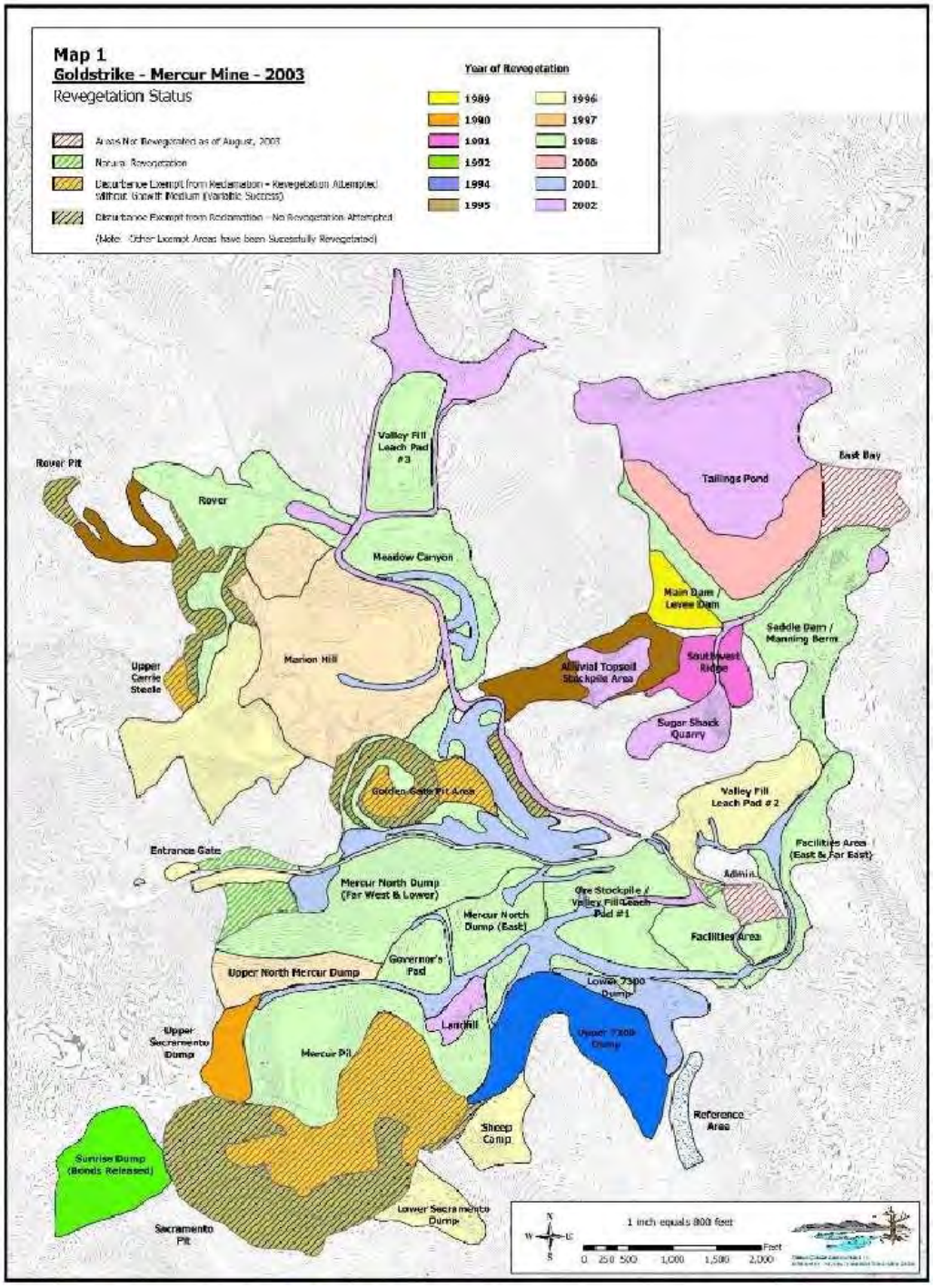
Surface Treatments:

Supplemental Fertilizer:

Other:

Note: Where unit size options are indicated, circle the correct designation

Reclamation "As Built" Sheet



Demonstration of Spatial Reclamation Data within a Mined Area for Ease of Reference

Demonstration of a Spreadsheet Summary to Track Reclaimed Managerial Units

Table RS (Continued)

							Vegetation Monitoring (By Cedar Creek)																	
Year	**Treatment Area**	**Description**	**Location**	**Acres**	**Seeding Method**	**Status**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
1995	AA_C	West End	AA Tails Dam - South Face	13.1	Hydro	Final		X	X	X	X	X	X	Gone in 2002										
1995	AA_D	Middle	AA Tails Dam - South Face		Hydro	Final		X	X	X	Rerved. In 1998. Gone in 1999													
1995	AA_E	East End	AA Tails Dam - South Face		Hydro	Final		X	X	X	Rerved. In 1998. Gone in 1999													
1995	AB_{1-3}	1 - North End to 3 - South End	AA Tails Dam - West Face	10.0	Hydro	Final		X	X	X	X	X	X	Rerved. - See AB 2003										
1995	AC_{1-3}	1 - North End to 3 - South End	Lower Portion of South Block RDA (East Face)	7.3	Broadcast	Final		X	X	X	X	X	X	X	X	Exchanged to Revernont								
1995	AD_{1-5}	Truck Shop, Crusher, Admin., Bas and Berms	Main Facilities Area	22.0	Hydro	Final					Most of this revegetation is gone													
1995	AE	Meikle Bowl Area	Circa - Meikle Mine facilities	0.4	Hydro	Final																		
1995	AF	Meikle North Slope	Circa - Meikle Mine facilities	10.0	Broadcast	Final																		
1996	AG	Dewatering Shop Slope	West of the Guard Shack	0.4	Hydro	Final																		
1996	AH	AA Southwest Area	Northwest of the Guard Shack	0.5	Broadcast	Final									Gone									
1996	AI	Heliport Pad	North Block - SE of Meikle Facilities	7.0	Broadcast	Final				Gone														
1996	AJ	Pipeline Corridor	North of AA Block to No. Block Tailings Imp.	3.0	Hydro	Final			X	X	X	X	X	X										
1996	AK	Containment Pond - S	Near Pipeline from AA Block to No. Block Tailings Imp.	0.4	Broadcast	Final			X	X	X	X	X	X										
1996	AL	Canyon Road Cut Banks	Access Road By Newmont's Carlin Facilities	10.0	Hydro	Final																		
1997	AM_{1-2}	1 - East End, 2 - West End	Below Pipeline - North Block Tails - S. Dam Face	6.6	Hydro	Interim				X	X	X	X	X	X									
1997	N_4	Formerly a portion of N3 - redisturbed	South Meikle Area	7.0	Broadcast	Interim				X	X	X	X	X	X									
1997	AJ	Pipeline Corridor **(2nd time)**	North of AA Block to No. Block Tailings Imp.	1.5	Hydro	Interim				X	X	X	X	X										
1997	AN_{up}	Discharge Pipeline/Canal (Upper Pipeline)	Boulder Valley (from TS Reservoir to Humboldt River)	58.0	Broad. & Harr.	Final				Vis.	X	Visual												
1997	AN_{can}	Discharge Pipeline/Canal (Canal Area)	Boulder Valley (from TS Reservoir to Humboldt River)	154.0	Broad. & Harr.	Final				Vis.	X	Visual												
1997	AN_{lp}	Discharge Pipeline/Canal (Lower Pipeline)	Boulder Valley (from TS Reservoir to Humboldt River)	34.0	Broad. & Harr.	Final				Vis.	X	Visual												
1998	AA_C	S Face AA Tails Dam **(2nd Time)**	AA Block, Tailings Facility	5.5	Broad. & Harr.	Final					X	Covered by Ore Stockpile in Late 1999												
1998	AA_D	S Face AA Tails Dam **(2nd Time)**	AA Block, Tailings Facility		Broad. & Harr.	Final					X													
1998	AO_{1-5}	1 - East End to 5 - West End	Above Pipeline - N. Block Tails - S. Dam Face	29.5	Broad. & Harr.	Interim					X	X	X	X	X	X	X							
1998	AP_{1-3}	North Face of South Block RDA	South Block Waste Disposal Area	25.0	Broad. & Harr.	Final					X	X	X	Mass failure destroyed this area in Feb 2001										
1998	AP_{3-6}	North Face of South Block RDA	South Block Waste Disposal Area		Hydro	Final					X	X	X											
1999	AO_{6-7}	Disturbed areas of AO_{1-2}	Above Pipeline - North Block Tails - South Dam Face	8.0	Broad. & Harr.	Interim						X	X	X	Merged with AO_{1-5}									
Jan 2000	AQ_{1-2}	Bell Creek Diversion	North of North Tailings Facility - Bell Creek Diversion	11.0	Hydro	Final						X	X	X	X	Photographic Monitoring								
Dec 2000	AR_{1-2}	1 - West End, 2 - East End (Carlin)	North Bazza - North Face	42.1	Broad. & Harr.	Final							X	X	X				O					
Dec 2000	AR_3	North Face - Topsoil	North Bazza - North Face	2.7	Broad. & Harr.	Final							X	X	X				O					
Dec 2000	AS_{1-2}	1 - West Face, 2 - South Face (Carlin)	West 9 Dump Area below test plots	20.6	Broad. & Harr.	Final							X	X	X	X			O					
Mar 2001	H_{1-3}	SW Portion - Topsoil	AA Leach Pad	250.0	Broad. & Harr.	Final							X	X	X	X	X	X	O					
Mar 2001	H_{4-8}	Central Portion - Carlin	AA Leach Pad		Broad. & Harr.	Final							X	X	X	X	X	X	O					
Mar 2001	H_9	North Corner - Topsoil / Carlin Mix	AA Leach Pad		Broad. & Harr.	Final							X	X	X	X	X	X	O					
Fall 2001	AR_4	Upper N. Face - Middle 1/3 - Carlin	North Bazza	4.9	Broad. & Harr.	Final								X	X	X	?		O					
Fall 2001	West 9 TPs	Carlin Test plots - Flat	West 9 Dump Area	20.0	Broad. & Harr.	Test								Removed in late 2002										
Dec 2002	AB_{1-2}	1- North End, 2 - South End (Carlin)	AA Tails Dam - West Face	19.7	Broad. & Harr.	Final									X	X	X	X	O					
Dec 2002	AT_{1-2}	1 - North Face, 2 - West Face (Topsoil)	North Block Tails Dam - Lower Portion	28.3	Broad. & Harr.	Final									X	X	X	X	O					
Dec 2002	AU_{1-3}	1 - SE, 2 - SW, 3 - North Flat (Carlin)	South Block WRDA	15.0	Broad. & Harr.	Final									X	X	X	X	O					
2002	AV	Topsoil Stockpile	SWE - South of Meikle Area along Haul Road	1.8	Broad. & Harr.	Interim																		
2002	AX	Topsoil Stockpile	North Block Tails Dam - West Face	4.3	Broad. & Harr.	Interim																		
Dec 2002	West 9 TPs	Carlin Test plots - Flat	West 9 Dump Area	20.0	Drill	Test									X	X	X	X	O					
2003	AY	Carlin - B units	South Block WRDA	89.8	Drill & Broadcast	Final										X	X	X	O					
2004	AZ	Carlin AZ2 - Topsoil AZ1	North Block Tails Dam - Lower Portion	10.4	Broadcast	Final											X	X	O					
2004	BA	Carlin	South Block WRDA	15.2	Drill & Broadcast	Final											X	X	O					

Step 2 Site-Specific Procedures for Evaluating Growth Media on a Managerial Unit of Reclaimed Land and Selection of Reference Areas

2.1 Introduction

Among other factors, successful reclamation is highly dependent upon the quality of growth media and occasionally the underlying material (spoil, tailings, etc.). If a soil has to develop under the conventions of primary succession, desirable vegetation establishment and growth may take many decades if not centuries. To the contrary, if the highest quality locally available growth media is utilized for reclamation, the conventions of secondary succession will be triggered and desirable vegetation establishment and growth will only take a few years. This factor alone will have the greatest impact on closure costs or savings. Occasionally, high quality growth media can be found at depth within overburden materials (e.g., buried alluvium).

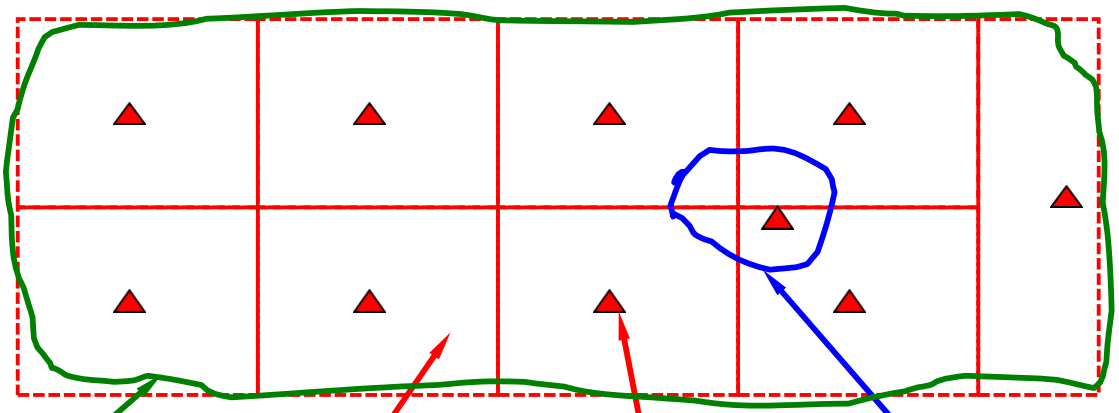
It is strongly recommended that in situ growth media be sampled and evaluated for quality prior to recovery in advance of operations. Furthermore, unless growth media to be used for reclamation is known to be adequate and non-problematic (e.g., from borrow or salvage sources that have already been validated by sampling as acceptable), then reclamation monitoring must necessarily begin with an initial evaluation of the growth media that has been distributed across the surface of a managerial unit of reclaimed land. Such an evaluation would be designed to provide data and information necessary to the development of appropriate reclamation metrics, plans, seed mixes, etc. to optimize opportunities for successful reclamation. This one-time evaluation (unless problematic pockets are found) ideally would occur prior to development of reclamation plans, but lacking such activity must occur immediately following lay-down of the material and prior to any seedbed preparation for a given unit of land.

2.2 Establish a Grid for Soil Sampling

Following lay-down and prior to any seedbed preparation, the placed growth media should be sampled on a systematic basis to determine suitability and/or need for remediation or special procedures. This process would require establishment of a grid and one sample point or composite sample per grid interval (polygon). The size of the grid polygon to be used would be determined based on the overall size of the managerial unit to be reclaimed. A typical minimum grid would be as follows:

- Units 10 hectares or less 1 sample pt. or composite sample per 5 hectare polygon
- Units between 10 and 60 hectares 1 sample pt. or composite sample per 10 hectare polygon
- Units between 60 and 300 hectares 1 sample pt. or composite sample per 15 hectare polygon
- Units larger than 300 hectares 1 sample pt. or composite sample per 20 hectare polygon

In addition to this systematic distribution of sample points, any notable areas of aberrant growth media should be identified and sampled as well. Such areas might include low points that accumulate water, demonstrate salt accumulations, exhibit potential acid generating materials, appear to be comprised of poor-growth media, exhibit excessive coarse fragment levels, etc. An illustration of this grid distribution for soil sampling is presented below along with an area of aberrant material.



Example of a Systematic Grid Distribution for Sampling Growth Media

2.3 Collect Growth Media Samples

At each sample point, a total of 2 or 3 soil samples should be collected from the vertical soil profile (solum). These would correspond to the following depths: one sample from the uppermost 15 cm of material (0 – 15 cm depth); a second sample taken across the range of the lower portion of the applied growth media (below 15 cm but above the underlying waste material); and a third sample taken from below the growth media and within the underlying waste material unless the applied growth media is greater than 60 cm in depth. If the total depth of applied growth media is about 20 cm or less, the second sample can be deleted but the waste material sample is still necessary. If the total amount of applied growth media is less than 15 cm, only the depth of growth media expressed in the profile should be collected for the upper sample (e.g., 0-10 cm for 10 cm depth). If the contact between applied growth media and underlying waste material cannot be determined with certainty, then samples should be collected from the 0 - 15 cm interval, the 15 – 30 cm interval and from the 30 – 60 cm interval or the point of auger refusal (due to rock). Individual samples should be collected across the vertical extent of the interval using a tile spade, auger, or similar instrument and placed within clean heavy-duty polyethylene bags. Each bag should be marked with indelible ink as to the mine name, reclaimed unit, grid polygon number, GPS coordinates, sample depth increment, date, collector, and any other pertinent managerial information. Additional observational data (e.g., soil structure, coarse fragment content from sieving, salt crusting, etc.) should be recorded as well. The total amount of sample material collected from each depth increment should be at least 0.5 liter, or more appropriately 1.0 liter. In addition, the depth increments for all samples / observations should be recorded for each sample site.

Prior to sieving, soil structure of the reapplied growth media should be noted for possible use with the RUSLE evaluation in Step 3. Soil structure is defined as the arrangement of soil particles into aggregates that form structural units. Soil structure can be determined by collecting a small excised sample from the uppermost 10 cm of the exposed soil profile. Careful examination of the soil particles as they are gently reviewed in the hand will result in one of the following four classifications:

1) Very fine granular < 1 mm
2) Fine granular, 1-2 mm
3) Medium to coarse granular, 2-5 mm
4) Blocky, platy, or massive, > 5 mm.

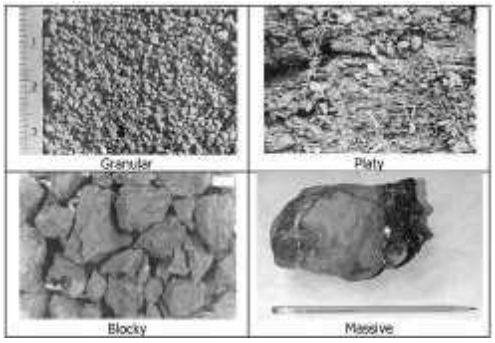
Definitions and photo examples of these terms is as follows:

Granular - This type of structure consists of small, porous aggregates that tend to be somewhat rounded in shape.

Platy - This type of structure consists of aggregates that have longer horizontal faces than vertical faces. The fragments are flat and thin.

Blocky - This type of structure consists of aggregates clinging together in nearly square or angular blocks having sharp edges. Large blocks normally do not allow rapid entry of water into the soil. This condition is mainly found in the subsoil.

Massive - This represents a soil condition where there is no evidence of aggregation. The soil particles tend to stick together in no definite pattern or arrangement.



Following an evaluation of soil structure, samples should be sieved in the field with a screen allowing passage of material less than about 5 mm (~ coarse fragment limitation). Where sieving occurs, the percent of coarse fragment content should be estimated to the nearest 5% or 10% by comparing the two piles of material (sieve passage vs. sieve collected). If ¼ of the initial sample volume is retained in the sieve, then coarse fragment content would be recorded as 25%; ½ of the initial sample volume would be recorded as 50%; and so on. This estimate should then be recorded for future analyses and the coarse fragment fraction can be discarded. If the remaining small gravel fragments are excessively sharp (e.g., chert), then the sample should be double bagged to help prevent loss of fines.

Collected samples should then be air-dried before sealing and shipment to a qualified laboratory. Shipment to the lab should occur at the soonest practicable time after collection and drying to avoid degradation of samples or false readings. Variables to be evaluated should include: **pH**, **EC** (for saline soils), either **SAR** or **CEC / ESP** (for potentially sodic soils), **texture** (laboratory method), and basic fertility components (**N**, **P**, **K**, and percent **OM** (organic matter)). **Soil permeability** may also be requested to facilitate classification into one of six categories to aid in the RUSLE analysis. These categories are: 1) Rapid, 2) Moderate to Rapid, 3) Moderate, 4) Slow to moderate, 5) Slow, and 6) Very slow. However, this tends to be an expensive test and an alternate determination of this parameter can be estimated with fair accuracy by evaluating soil texture in conjunction with soil structure (see section **2.4** below). It can also be estimated by performing a “percolation test” in the field. Additional variables as appropriate can include: **carbonates**, **base saturation**, **water saturation percentage**, and **potentially problematic elements** (e.g., selenium, boron, etc.) where such have been indicated as problematic in the region.

If requested, certain laboratories will provide an interpretation of the results with regard to suitability as a growth media. If such an assessment is not available, laboratory results should be reviewed by a soil professional or other professional familiar with parameter ranges necessary for material to service as an adequate growth media. In certain instances, “out-of-bounds” parameters may be compensated by application of amendments (e.g. lime application for low pH soils.). If one or more samples result in overly problematic findings, the target polygon(s) can be sub-sampled using a smaller grid interval to isolate the offending source (assuming the identified problem is sufficiently severe or extensive to warrant the effort). Given these additional data, appropriate remediation can be designed and implemented as necessary with the help of either a soil or reclamation professional. One note of particular importance with regard to amendments is pertinent. If annual weeds are potentially problematic in the vicinity of the operation, amendments containing nitrogen should **NOT** be used, or should be used only under the careful supervision of a qualified professional. (Nitrogen strongly encourages weedy annuals that can then be detrimental to the establishment of desirable plants. Species native to the area are typically well adapted to deal with poor soil fertility.)

In many circumstances, offending or problematic materials can simply be buried under an adequate depth of more conducive material. In other circumstances, especially where surface drainage considerations will be impacted, problematic materials may have to be excavated and transported elsewhere for burial.

2.4 Determination of Permeability

Soil permeability is defined as the rate at which water moves through the soil, and factors affecting soil permeability include; soil compaction, soil structure, and soil texture. As indicated above, a direct determination of soil permeability can be an expensive parameter to measure in a lab, but can be determined in a more practical manner based on less expensive laboratory data using certain guidelines as presented below for selecting a suitable permeability class for reclaimed soils. For the purposes of the RUSLE application (Step 3), permeability will be classified into one of the six classes used in the RUSLE application:

1) Rapid
2) Moderate to rapid

3)	Moderate
4)	Slow to moderate
5)	Slow
6)	Very slow

Soil compaction is the first factor to consider. Compaction is typically not an issue on reclaimed soils, unless the land use has caused heavy compaction following soil lay down (such as excessive grazing by large ungulates) or on haulage roads that were not ripped before reclamation activities. Therefore, soil compaction can generally be ignored unless circumstances arise in which severe compaction has occurred. In these circumstances, permeability would be reduced by at least one classification.

Soil structure is the next factor to be considered. Soil structure on mine sites is typically granular, however, sometimes a more developed structure can be observed, especially in older reclaimed areas. If an encountered growth medium can be characterized as having a platy, blocky, or massive structure, it will shift the permeability class downward (slower) by one classification. This is a general guideline and may need to be re-evaluated at the site scale if conditions dictate.

Finally, soil texture is the variable most affecting soil permeability. Lab results from the soil texture analysis will be used in this regard for a determination of soil permeability class. The texture of soils is an indication of the different particle sizes of clay, silt, and sand that greatly impact the rate at which water moves through the profile. The table below demonstrates the permeability of different soil "separates". However, this table represents each soil separate in its pure form, a condition that effectively does not occur on reclaimed land. Therefore, interpretation of the soil texture analysis is required. For example, if a soil texture analysis indicates that the soil is 70% silt and 30% sand, then the observer would likely classify the soil as moderately slow as opposed to slow. It must be emphasized that these are guidelines for evaluating soil permeability into classes. If aberrant conditions occur, then special considerations should be applied to address those circumstances to facilitate an accurate classification of soil permeability; and/or a professional soil scientist should be consulted[2].

Soil Separate	Particle size Diameter (mm)	Permeability
Clay	Below 0.0002	Very slow
Silt	0.05-0.002	Slow
Very fine sand	0.10-0.05	Moderately slow
Fine sand	0.25-0.10	Moderate
Medium sand	0.5-0.25	Moderately rapid
Coarse sand	>0.5	Rapid

2.5 Selection of Reference Areas

Although it may seem to be out of sequence, the selection of reference areas must necessarily occur very early in the reclamation process and certainly before stability and / or vegetation evaluations are implemented. Therefore, this discussion is placed here to emphasize that the selection of appropriate reference areas should occur at this time in the process.

Reference areas may also be termed "analog" areas or "comparison" areas, but effectively the three terms should be considered synonymous. The selection of reference areas must occur with great care and should be performed by a well-experienced reclamation specialist. Reference areas should be selected from undisturbed (by mining operations) and representative examples of local vegetation communities and physical topography that support the land use that is the target of post-mining reclamation. If the selected reference areas exhibit excessive or dense vegetation in comparison to the

[2] This procedure for collecting information on soil permeability is based on general guidelines and should be considered for adaptive development. Improvements to the protocol should be implemented on a regular basis to further refine and develop the accuracy and use of these guidelines.

norm for the area, then the standard will be artificially elevated. If the selected reference areas exhibit overly sparse or disclimactic vegetation in comparison to the norm for the area, then the standard will be artificially reduced and the potential for acceptance by oversight agencies will be compromised.

At least one reference area should be selected for each separate reclaimed vegetation community that targets a specific land use. For example, if the post-mining land use (PMLU) includes grazingland for livestock on rolling topography, then a reference area should be established on rolling topography that supports palatable native grasslands. If the PMLU is heavily managed livestock grazing (pasture-rotation, etc.), then a reference area should be established on a unit of "managed pastureland". If the post-mining land use includes wildlife habitat or open (undeveloped) rangeland (wildland), then a reference area should be established in an area supporting native grassland / shrub steppe communities (or similar), which tend to be the early seral stages of the eventual desirable community. In this latter case, care must be taken to avoid reference areas that exhibit overly disclimactic or dense stands of shrubs and trees as these life forms often take decades to mature and/or evolve (hence the need for an early seral equivalent).

The selected reference area(s) should be as "ecologically and topographically similar" to the pre-mining area, surrounding area, or area representing the desired PMLU as possible, and be based on five main considerations, as follows:

1. The reference areas should be representative of the desired PMLU or vegetation community supporting the PMLU.
2. The reference areas should occupy topography and aspects that are representative of the majority of reclaimed areas, especially with regard to slopes that may be subject to erosion.
3. The reference areas should exhibit similar physical soil conditions as reclaimed areas and therefore, should be an "approximate ecological equivalent".
4. Excepting managed pasturelands and/or occasional invasive weeds, the reference areas should support native tree/shrub/grass plant communities similar in structure to what can be obtained on reclaimed areas in the short term (e.g. 5 – 8 years).
5. The plant communities selected for comparison should provide an appropriate and logical target for reclamation efforts.

Once reference areas have been selected, adequately sampled, and found to be appropriate by Wilson and/or their reclamation consultants, they should be submitted for approval to oversight agencies as appropriate. A field review of the selected reference areas should then be scheduled with the oversight agencies at the earliest opportunity to obtain "formal" approval. However, it is recommended that site reviews of reference areas (as well as reclaimed areas up for bond / liability relinquishment) be scheduled during the late Spring / early Summer to avoid the visual complications of litter and standing dead vegetation.

Step 3 Site-Specific Procedures for Evaluating Soil Stability

3.1 Introduction

Following Step 2, evaluations of soil stability should occur to document this parameter and collect data necessary for remediation or relinquishment. Two types of monitoring will occur for this variable, one that can be used to show trend and provide insight regarding problematic circumstances and a second that will provide increased defensibility, especially for relinquishment evaluations.

The first type of monitoring (trend) will occur coincidentally with vegetation monitoring and will be co-located with vegetation transects. Such annual monitoring is designed to provide easily collected data that can be used to show erosional stabilization trends or lack thereof as well as provide information that will indicate solutions for problematic circumstances.

The second type of monitoring (two options possible) is designed to detect problems related to relinquishment as well as to provide for a means to document erosional stability and therefore, facilitate

bond relinquishment and liability release. Depending on site-specific circumstances or local preferences, the two options that could be selected are 1) Landscape Function Analysis (LFA) and 2) the Revised Universal Soil Loss Equation (RUSLE).

The annual use of LFA procedures (only the portion that addresses soil stability) or RUSLE are encouraged until site-specific data are developed that will help to shed light on the efficacy of emplaced growth media with regard to erosion / stability issues. If latent soil or stability issues remain a potential concern (following Step 2 work on soils and in association with the erosional trend monitoring), then implementation of either LFA or RUSLE procedures should continue to help determine any necessary remediation and/or help to show that stability is progressing in a positive direction where proof of such may be necessary.

The first option is an evaluation of soil stability utilizing a subset of the LFA procedure that was developed in Australia. The subset of this procedure would typically be used only in the first 2 to 4 years after seeding and would be subsequently abandoned once adequate vegetation had established to warrant implementation of Step 4. If proof of stability is then necessary for regulatory compliance or relinquishment at a later date, the necessary data will have been collected to facilitate appropriate calculations.

The second option will be an evaluation of soil stability utilizing RUSLE procedures developed over the last 6 decades in the USA, specifically version 1.06c designed for construction and mining disturbances. This procedure utilizes the most pertinent and applicable site-specific information to perform a reliable and cost-effective evaluation of erosional stability across the most potentially problematic portions of a reclaimed unit. Most of the input parameters are very easy to collect, or in many cases, are collected during other field monitoring procedures and can be used for both applications.

If option two is selected for use, documentation of soil stability need only occur at the time of bond relinquishment sampling unless stability issues are detected during interim periods. If stability issues arise, option two should be implemented annually to provide necessary data for the development of remedial measures.

3.2 Erosion Monitoring for Trend Analysis

Trend monitoring for erosional stability will be comprised of two observational procedures, one that is co-located with each vegetation sampling transect (Step 4) and one that is established and monitored independently. The first of these annual monitoring procedures (co-located with each vegetation monitoring transect) will be comprised of a ten-meter transect extended along the contour and starting at the vegetation transect starting point. Along this transect, all rills and gullies that cross the transect will be enumerated and data about each recorded. Data to be collected for all observed rills and gullies include: width (in cm), depth (in cm), current status (“active”, “healing”, or “indeterminate”), and if “healing”, the evidence so indicating. Such evidence may include: caving sidewalls, deposition within the channel of small fraction sediments, litter accumulation, and/or plant establishment within the cross-section. In addition, the percent slope will be recorded perpendicular to the contour.

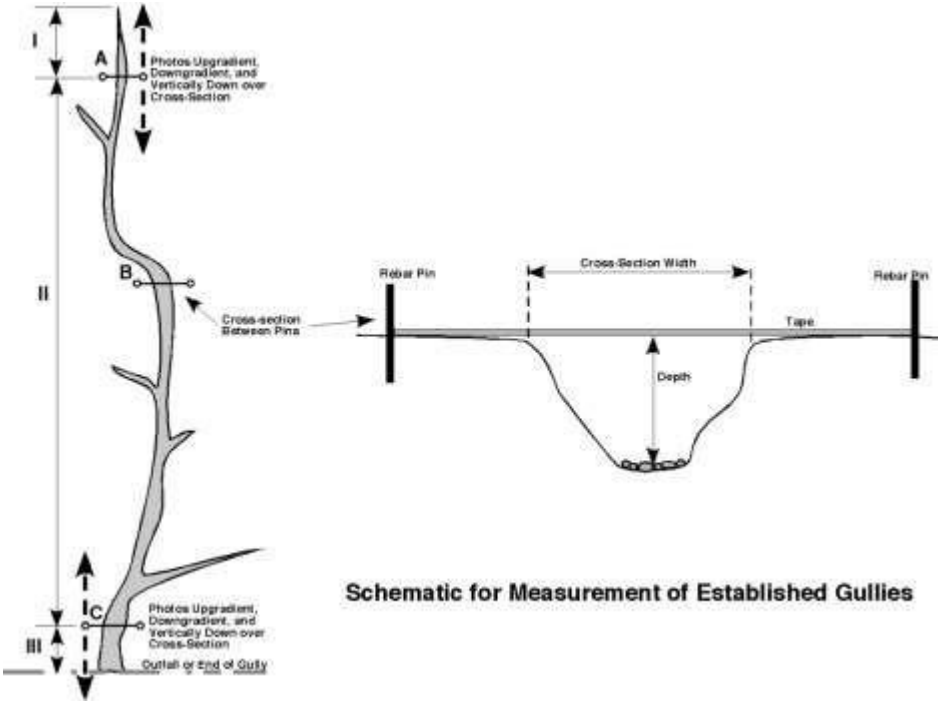
When compared over time and coupled with rock, litter, and vegetation cover data from the vegetation transect, this information will provide a strong indication of trend and factors contributing to erosional progression or stabilization. An analysis of such data will aid determination of corrective measures necessary to stabilize the soil surface or to preclude such problems by correct construction techniques for future facilities. Corrective measures may include: reduced slope angle; increased surficial rock cover (rock mulch); increased vegetation cover; need for mechanical techniques such as contour furrowing, pitting, etc.; or need for improved surface water control measures such as berms, benches, reinforced water courses, etc. Although the need for such measures may fall under the category of “common sense”, the threshold at which they become necessary given site-specific circumstances is typically an unknown without such empirical data.

The second erosional observation procedure to be utilized is independent of the vegetation monitoring transects. This procedure should be used in arid environments where episodic precipitation following soil lay-down leads to gully formation before vegetation can become established (e.g. Western Australia). Once formed, regardless of "healing status", these gullies can become the focus of regulatory scrutiny. Without trend information, there is little opportunity to counter "negative opinion" without expensive mitigation.

In this regard and depending on the size and revegetated status of a target reclaimed unit, one to several gullies should be located (following an episodic event), permanently marked, and monitored once per year. If a reclaimed unit vegetates quickly and gully formation does not occur, this procedure can be omitted. To the contrary, where revegetation is slower and gullies do form early in the revegetation sequence, the following minimum number of gullies should be identified for monitoring.

- 1 gully per 10 hectares up to units 40 hectares in size;
- Units 40 to 100 hectares – 5 to 6 gullies should be identified for monitoring;
- Units larger than 100 hectares – 7 to 8 gullies should be identified for monitoring.

Once gullies are located and permanently marked in the field (including GPS coordinates), the slope (percent) should be recorded and three sets of cross-sections (A, B, & C) need to be established as indicated in the schematic below:



Schematic for Measurement of Established Gullies

The endpoints of each cross-section should be permanently marked with a length of rebar driven into the ground sufficiently distant from the edge of the gully to allow for possible changes with time (at least 0.5 meter from either edge should be sufficient for most gullies). A tape stretched across the gully as indicated in the schematic will facilitate a determination of width and depth at each location. Any other pertinent observations such as healing and the evidence thereof, should also be recorded at this time. Such evidence may include: caving sidewalls, deposition within the channel of small fraction sediments, litter accumulation, and/or plants establishing within the cross-section.

In addition, at cross-sections A and C, three photos should be exposed, one upgradient, one downgradient, and the third vertically downward over the gully from a height of about 1.5 meters. Finally, three linear distances represented by lengths I, II, and III should be recorded. The linear distance from

the start of the gully to cross-section A (I) is the most likely distance to change from year to year. The distance from A to C (II) should not change, and the distance from C to the end of the gully (III) may change if the gully extends downgradient. If the gully is tributary to a collection ditch, mid-slope bench, or some other similar structure, this final distance may remain constant as well.

Special care must be taken during the collection of these measurements and photos to not step near the edge of the gully and cause the sides to collapse, especially in the vicinity of the cross-sections. Such action will adversely impact future measurements or conclusions drawn. Assuming such annual monitoring can indicate that early reclamation formed gullies tend to heal rather than remain active as vegetation establishes, then the “proof” will be available to counter negative opinion.

3.3 Erosion Monitoring for Relinquishment - Option 1 - Soil Stability Monitoring Using LFA Procedures

When using LFA procedures, use would be limited to the first few years of reclamation for a given managerial unit until sufficient vegetation has emerged to warrant the shift to vegetation monitoring and RUSLE monitoring procedures (Option 2). In most cases, LFA protocols would be implemented for a period of 2 years following seeding. If proof of increasing stability is necessary to address agency mandates or concerns LFA protocols could continue to be implemented for another 2 years coincidentally with vegetation monitoring protocols to lay the groundwork needed to document increasing stability. Another circumstance where LFA protocols would be extended for more than 2 years is where precipitation events are so intermittent or minimal that plant emergence from seed is delayed.

Finally, LFA procedures may be implemented where there is regulatory need. An example of such need would be at the time of final relinquishment on a unit of land to document (in comparison to early LFA data) that stability has been achieved.

3.3.1 Soil Stability Using Landscape Function Analysis (LFA) Procedures

Landscape Function Analysis is a procedure for the assessment of rangeland function, and is comprised of three components: a conceptual framework, a field methodology, and an interpretive framework. The conceptual framework treats landscapes as systems: defining how landscapes work in terms of sequences of processes regulating the availability of scarce resources. The field methodology uses “indicators” at landscape and patch scale to provide and structure information to satisfy the needs of the conceptual framework. The interpretational framework provides a process to identify critical thresholds in landscape function and thus provide a function-based state and transition landscape assessment.

This procedure has largely been developed by Mr. David Tongway in conjunction with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia. LFA evaluates soil surface data that are combined in different groupings to reflect three major soil habitat quality indices: stability, infiltration, and nutrient cycling. However, for the purposes of this procedure, stability will be the only index addressed because if a system is stable and is exhibiting reasonably desirable vegetation, the other two parameters (infiltration and nutrient cycling) can be assumed to be occurring. Soil surface data included in stability are soil cover, litter cover, cryptogam cover, crust brokenness, erosion type & severity, deposited materials, surface resistance to disturbance, and a slake test. David Tongway and CSIRO have provided a succinct summary of Landscape Function Analysis (Tongway, 2005), much of which is presented below. In addition, a field methodology developed by Tongway and CSIRO is presented as Appendix B.

3.3.1.1 LFA – Method of Operation.

"Landscape organization" is the coarsest form of LFA data and is the first step in data collection. Data are collected on a line transect oriented in the direction of resource flow (usually down slope, but aeolian

landscapes would use wind direction). Landscape features that interrupt, divert or absorb run-off and transported materials are recorded according to protocols outlined in the technical methods manual (Tongway 1994, Tongway and Hindley 1995, 2000) and the field methodology (Appendix B). Typically, zones of resource loss (source or runoff zones) are distinguished from zones of resource gain (sink or run-on zones) and their relative sizes are measured. Several indices of landscape organization can be deduced from these data. In addition, these data provide a "map" of the transect. In the second step, each zone type, a total of 10 soil surface variables, plus soil texture are assessed using the methods described in the manuals. These observations are both simple and quick after a little practice, but training from someone competent in the technique is necessary for reliable data.

3.3.1.2 LFA – Calculation of Indices.

The collected soil surface data are grouped in different combinations to reflect three major soil habitat quality indices: 1) stability or resistance to erosion, 2) infiltration/water holding capacity and 3) nutrient cycling (Figure 1). However, as stated previously, the stability index is the most useful and the only index needed for this application. Collected soil surface data are entered into pre-formatted Excel spreadsheets that generate final values that can then be interpreted (interpretive framework).

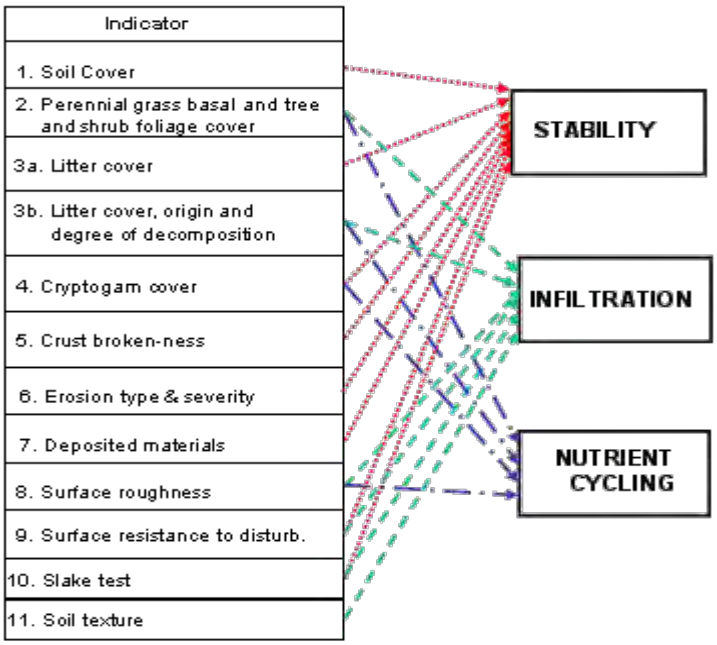


Figure 1: The combination of Soil Condition Classes to derive indices of Stability, Infiltration, and Nutrient Cycling.

3.3.1.3 LFA – Interpretational Framework.

The tabulated values need to be interpreted in the landscape context to make the most use of their information potential. With extensive experience, one might be able to place useful interpretations on each of the index values, but this is a complicated process. The most recent development in LFA is the process whereby a response surface in the form of a sigmoid curve is generated from field data (Tongway and Hindley 2000). The curve relates functional status with regard to stress and disturbance. To fit this curve, one needs data from both extremes of the available data space. The response surface (Figure 2) recognizes the upper asymptote as the potential (reference area) of the site limited by climate and parent material and the lower asymptote as the lower limit of function typically observed under first year reclamation conditions.

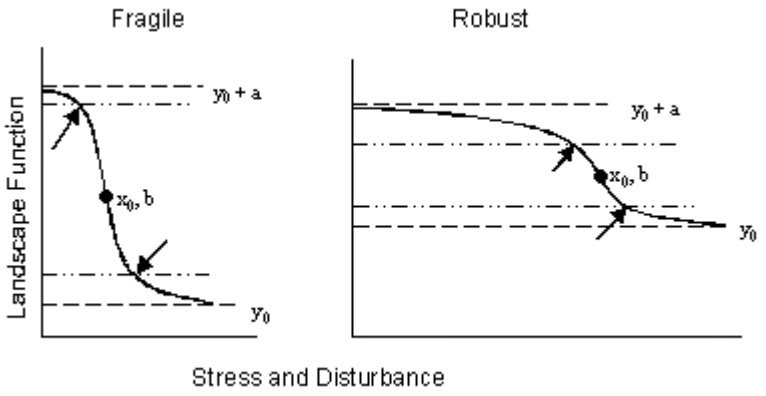


Figure 2. Examples of response curves for fragile and robust landscapes.

3.3.2 Use of Landscape Function Analysis for Success Evaluation

Landscape Function Analysis will be used for success evaluation in its typical form. The potential of the site will be established by selecting a reference area as indicated in Step 2 and obtaining data from that area. Once the reference area has been selected and deemed appropriate, then soil stability using LFA should be implemented with two transects placed in representative areas. The value obtained from these transects will be considered the goal of reclamation and the potential of the reclamation site.

The starting point (the lower asymptote as presented on Figure 2 above) should be represented by reclamation immediately after topsoiling. LFA should be implemented on a new unit of reclamation with at least two transects placed in representative areas to establish a time-0 value (t_0). Once these values have been defined, they can be fit to a sigmoid curve with each value at one of the extremes, t_0 at the bottom and the reference area at the top.

The inflection point of the sigmoid curve (represented as X_0 on Figure 2) can be calculated as approximately one-half of the difference between the two calculated LFA values (t_0 and Reference Area). A value slightly greater than this inflection point will be set as the standard or minimally acceptable level of soil stability. Monitoring of the same transects established at t_0 on a reclamation unit will provide progression along the sigmoid curve in relation to the standard. Once a unit of reclamation has passed the inflection point, it can be considered to be heading towards the potential of the site (reference area). **Therefore, the standard will be met if the soil stability index value determined by LFA for the reclaimed unit is greater than the calculated inflection point on the sigmoid curve.**

3.4 Erosion Monitoring for Relinquishment - Option 2 - Soil Stability Monitoring Using RUSLE Procedures

The RUSLE protocol will be used to determine whether the potential for soil erosion is sufficiently low, and for surface stability sufficiently high, to conclude that stability has been achieved. This protocol employs site-specific climatic, edaphic, topographic, and vegetation data to identify erosion potential. For practical use of this procedure, it must be applied after growth media characterization (Step 2) has been completed and in conjunction with vegetation monitoring (Step 4).

3.4.1 Background

Efforts to predict soil erosion from croplands mathematically were initiated in the USA approximately 60 years ago. A variety of factors were considered in attempting to develop prediction equations. All of these earlier equations were essentially regional in nature and were applicable only under limited

climatic/edaphic conditions. These equations were considered useful, however, and an effort was initiated to develop an equation that would be applicable nationally under a variety of site conditions.

Work on this was begun in the mid-1950's by the Agricultural Research Service. From this work the Universal Soil Loss Equation (USLE) was developed and refined during the 1960's and 1970's. Continued refinements were made to the equation and the associated parameters based on site-specific research and general use by the public. Additional data was continually gathered in an effort to update the equation and make it more useful (Renard et al. 1992).

Based on this additional data and refinement, the RUSLE equation was developed. Though still influenced by basic agronomic values in some instances, and using the same overall parameters as the USLE, the RUSLE equation is considered to be a significant step forward in more accurately predicting the potential for erosion under a variety of conditions. Where the original USLE arrived at a potential soil erosion value through simple multiplication of selected parameter values, the RUSLE employs a computer-based model that involves sub-routines for various parameters to ultimately predict potential soil erosion.

Revisions and improvements in assessing values for the parameters that are used in RUSLE have also been made which render the model more useful. Once believed applicable only to agronomic situations, RUSLE is now considered to be applicable to disturbed lands and mine sites as well. A RUSLE application was developed specifically for use on mining reclamation (RUSLE 1.06c).

3.4.2 Application

RUSLE 1.06c is a powerful program that is capable of predicting soil loss from fields or hillslopes that have been subjected to a full spectrum of land manipulation and reclamation activities. RUSLE 1.06c can accommodate undisturbed soil, spoil, and soil-substitute material (growth medium), percent rock cover, random surface roughness, mulches, vegetation types, and mechanical equipment effects on soil roughness, hillslope shape, and surface manipulation including contour furrows, terraces, and strips of close-growing vegetation and buffers.

Though a reasonably advanced tool, it should be noted that there are limits with respect to the applicability of the model. This model predicts erosion potential as a result of sheet, rill, and inter-rill erosion. Gully erosion is not a part of the predicative capability of RUSLE. Where gullying may occur, the bearing that this type of erosion would have on soil stability must be judged independently. RUSLE also does not, in and of itself, predict potential sedimentation. Soil loss is predicted, but not the eventual fate of the eroded material. RUSLE is a predictive model and must be used as such in the comparative sense against values that exhibit the same level of potential accuracy. This is the intent of the application of this model as a part of the overall reclamation success protocol discussed in this document.

The RUSLE model is based on six parameters utilized to estimate or quantify the factors that affect the potential for soil erosion. The RUSLE model is as follows (Renard et al. 1992):

$$\mathbf{A = R \bullet K \bullet L \bullet S \bullet C \bullet P}$$

Where:

A = Soil loss in tons / acre / year

R = Rainfall/runoff erosivity factor
K = Soil erodibility factor
LS = Hillslope length and steepness factors (combined as one)
C = Cover-management factor
P = Support practice factor

"R" represents the rainfall-runoff erosivity factor. The effects that climate, in terms of amount of incident precipitation, storm intensity, etc. have on erosion are accounted for by this factor. Values for this factor are developed using site-specific climatic data. Data needs for calculating the "R" factor in RUSLE 1.06c are presented by collection location.

Office Data Collection:

Site-Specific Climatic Data - Local monthly precipitation (in inches) and temperature (°F) data must be collected from either an onsite weather station or available internet resources for areas with published data that are in close proximity to the site. Larger data sets with a longer period of record will increase the accuracy of the soil loss prediction. Ideally, 30 years of monthly precipitation and temperature data will provide a strong data set. Data must be compiled by a qualified professional for entry into the RUSLE application. At present, data inputs must be in English units as opposed to Metric owing to the model's input requirements.

Field Data Collection:

None – other than from site-specific meteorological station.

The "**K**", or soil erodibility, factor is related to the integrated effect of rainfall, runoff, and infiltration on soil loss. It is typically considered to be the soil loss rate/unit for a specified soil as measured on a standard plot experimentally. K-factors to be used for this protocol may be taken from a standard nomograph developed for this purpose (NRCS 1993) since the surface growth medium may not directly correspond to any recognized soil series. The factors to be considered in developing the appropriate K-factor are texture, percent organic matter, soil structure, and permeability. Data needs for calculating the **"K"** factor in RUSLE 1.06c are presented by collection location.

Office Data Collection:

None, unless a detailed soil survey has been completed for the project area and the soil utilized for the target location can be correlated to that survey.

Field Data Collection:

Soil Texture (% sand, % silt, and % clay)

Collected as part of the growth media analysis described in Step 2. All samples collected in the growth media analysis are averaged to allow for one set of values to be entered into the RUSLE application.

Soil Organic Matter (%)

Collected as part of the growth media analysis described in Step 2. All samples collected in the growth media analysis are averaged to allow for one value to be entered into the RUSLE application.

Soil Structure

Soil structure is defined as the arrangement of soil particles into aggregates that form structural units. Collected as part of the growth media analysis described in Step 2. For the purposes of the RUSLE application soil structure is classified into one of four classes:

1) Very fine granular, <1 mm
2) Fine granular, 1-2 mm
3) Medium to coarse granular, 2-5 mm
4) Blocky, platy, or massive, >5 mm

Soil Permeability

Soil permeability is defined as the rate at which water moves through the soil and is strongly correlated with the soil texture that is collected as part of the growth media analysis described in Step 2. For the purposes of the RUSLE application permeability will be classified into one of six classes used in the RUSLE application as described elsewhere in this document: 1) Rapid, 2) Moderate to Rapid, 3) Moderate, 4) Slow to Moderate, 5) Slow, 6) Very Slow.

Percent Rock

Percent of the surface covered by rock (>5mm), collected as part of the vegetation monitoring protocol described in Steps 4 and 6. An average across the entire unit will be used to allow for one value to be entered into the RUSLE application.

Slope length (L) and gradient (S) will be combined into one factor using charts developed for this purpose. Data have shown that this method offers the best means of integrating the effects of these two factors into the equation. Slope length accounts for the effect topography has on erosion potential. Lengths should be measured in the field to supply the correct data for the L-factor and compound slopes will be defined if existing. Slope steepness, or gradient, measured as a percent, is a representation of the slope and will also typically be determined in the field to supply the most relevant data. Slope lengths and percents may also be taken from post-reclamation contour maps if the maps accurately represent site conditions. Data needs for calculating the **"LS"** factor in RUSLE 1.06c are presented by collection location.

Office Data Collection:

None - unless data are taken from detailed and accurate "as builts" of reclamation features.

Field Data Collection:

Slope length (in feet) and gradient (%) should be measured in the field. The slope should be divided into segments in such a way that each segment can be considered uniform. A measuring tape or similar should be used to determine the length of each segment and a clinometer to measure the gradient (in percent or degrees but if in degrees must be converted to percent). This process should be executed on what is perceived as an average slope on the reclamation unit following an extended reconnaissance effort. The selected slope must be representative of the slopes and lengths found on the unit.

Alternately, at least five typical slopes should be measured as described above and then averaged. If one particular area exhibits excessive slope gradient or length, it may be isolated and separately analyzed to determine erosional stability.

The cover-management factor (**C**) reflects the effect of vegetation and related management practices on erosion rates. This factor will be based largely on site-specific data collected from, or which is estimated to be relevant to, each area for which reclamation success is being evaluated. The type of vegetation currently existing on site, estimated soil roughness, measured soil surface percent cover (vegetation, coarse fragments, litter, other non-erodible material) and height, measured plant canopy cover, and estimated below-ground plant biomass factors will all be used to develop the C-factor using a computer program sub-routine run. This factor may be the most influential factor in determining potential erosion from a site. Data needs for calculating the **"C"** factor in RUSLE 1.06c are presented by collection location.

Office Data Collection:

Effective root mass in the top 4 inches will be based on published life form ratios. Life form ratios will be separated by grasses, forbs, shrubs, trees, etc. The ratio of biomass to percent surface cover will be gathered from scientific literature and then weighted based on canopy cover for entry into the RUSLE application. Occasional circumstances may occur where a dominant plant does not fit into a typical life form. In such circumstances it can be researched separately and treated on an individual basis.

Field Data Collection:

% Canopy Cover

Canopy cover is the vegetative cover above the soil surface that intercepts raindrops (but does not contact the soil surface). Open spaces in a canopy, whether within the perimeter of a plant canopy or between adjacent plants, are not considered as canopy. It is for this reason, among others, that ground cover data are collected with point-intercept techniques as opposed to other techniques. These data are collected during the vegetation monitoring (Steps 4 and 6).

Average Fall Height (in feet)

Defined as the height within the canopy from which intercepted rain drops re-form into water droplets and fall to the ground; this fall distance is known as the "effective fall height." In plant communities that have more than one type of life form composing the canopy, such as on rangeland with a mixture of grasses, shrubs, and trees, a fall height should be determined for each life form. Collected as part of the vegetation monitoring protocol described in Steps 4 and 6. These fall heights will then be weighted using the canopy cover to establish an average fall height for entry into the RUSLE application.

Total % Ground (Basal) Cover (Rock and Litter)
Basal cover is material in contact with the soil that both intercepts raindrops and slows surface runoff. It includes all types of cover, such as mulches and rock fragments, live vegetation in contact with the soil surface, cryptogamic crusts (which are formed by mosses or fungi in the soil), and plant litter. Collected as part of the vegetation monitoring protocol described in Steps 4 and 6.

% Rock Cover
Collected as part of the vegetation monitoring protocol described in Steps 4 and 6. An average across the entire unit will be used to allow for one value to be entered into the RUSLE application.

% Plant Litter Surface Cover
Collected as part of the vegetation monitoring protocol described in Steps 4 and 6. An average across the entire unit will be used to allow for one value to be entered into the RUSLE application.

The "**P**", or support practice, factor takes into account the effects of mechanical practices applied to the surface of the growth medium to increase infiltration, reduce runoff, and decrease erosion. Such practices include ripping, pitting, and contour furrowing and result in a parameter value of less than 1.0. A value of 1.0 may be appropriate where no support practices have been employed on the reclaimed area. The effects that basic tillage or fertility practices have on erosion potential are included in the cover management factor of the equation. Data needs for calculating the **"P"** factor in RUSLE 1.06c are presented by collection location.

Office Data Collection:
Gather information on reclamation activities such as contour furrowing and terracing from reclamation records ("as builts").

Field Data Collection:
Make observations regarding procedures that may have been implemented should there be no file data available as to past practices.
Following data collection and parameter development, the RUSLE model will be engaged for each area requiring an evaluation. Implementation of the RUSLE model on reclamation units will occur as an average of the entire unit[3]. A potential soil erosion value "A" in tons/acre/year of growth medium loss will be estimated by the model. This value can then be compared to any one of three options (A, B, or C) for success evaluation:

> A) The standard will be met if the soil loss value (A) determined by RUSLE for the reclaimed unit is equal to or less than the "T" value (effectively the soil genesis rate) appropriate to the site and **the "trend"** analysis detailed in Section 3.2 indicates stable or positive results.

The "T" value will be assigned independently based on the limiting properties of the subsurface growth medium and/or geologic material present beneath the reclaimed units. Criteria for assigning a "T" value include the physical and chemical characteristics of subsurface layers and the properties of soil moisture and temperature as influenced by climate. This process accounts for the weatherability and suitability as a growth medium of the subsurface materials (i.e. rate of genesis of suitable sub-soils). A soil

[3] When applied in this manner this methodology does not account for small or isolated areas of potential reclamation failure. These areas must be identified and addressed separately by onsite personnel, or they can become individual units subject to investigation using the overall procedure.

scientist can be consulted to help calculate or determine the "T" values for the types of reclaimed sites to be evaluated if they are not already available in the literature or public domain.

In lay terms, the "T" value approximates the rate of soil genesis (tons/acre/year). If the potential loss of growth medium as predicted by the model ("A") is less than or equal to the "T" value, the area will be considered stable and the test passed. If the potential loss ("A") is greater than the "T" value, the area will not be considered sufficiently stable and the area will fail the success test. The addition of the need for a "stable" or "positive" trend from the analysis in Section 3.2 addresses the fact that RUSLE does not account for gully erosion.

B) The standard will be met if the soil loss value determined by RUSLE for the reclaimed unit is less than 110%[4] of an established soil loss baseline value determined by RUSLE for the mine area (prior to disturbance) and **the "trend"** analysis detailed in Section 3.2 indicates stable or positive results.

A baseline value (A_B) will be determined by implementing RUSLE using data from the baseline soil survey (prior to mining disturbance). This method accounts for site-specific conditions including similar vegetation type, growth media, and climate.

In effect, the baseline "A_B" value approximates the rate of soil loss on the ground before mining disturbance. If the potential loss of a reclamation unit as predicted by the model ("A") is less than 110% of the baseline "A_B" value, the area will be considered stable and the test passed. If the potential loss is greater than 110% the baseline "A_B" value, the area will not be considered sufficiently stable and the area will fail the success test. The addition of the need for a "stable" or "positive" trend from the analysis in Section 3.2 addresses the fact that RUSLE does not account for gully erosion.

C) The standard will be met if the soil loss value determined by RUSLE for the reclaimed unit is less than 110%[*] of a soil loss value from a reference (analog) area as determined by RUSLE and **the "trend" analysis detailed in** Section 3.2 indicates stable or positive results.

The reference value (A_{RA}) will be collected from a reference (analog) area in the same year as the reclamation unit sampled for comparison. The selected reference area(s) should be as "ecologically and topographically similar" to the pre-mining area, surrounding area, or area representing the desired post-mining land use (PMLU) as possible, and be based on five main considerations, as follows:

- The reference area(s) should be representative of the desired PMLU or vegetation community supporting the PMLU.
- The reference areas should occupy topography (slope) and aspects that are representative of the majority of reclaimed areas.
- The reference areas should exhibit similar physical soil conditions as reclaimed areas and therefore, should be an "approximate ecological equivalent".
- Excepting managed pasturelands and/or occasional invasive weeds, the reference areas should support native tree/shrub/grass plant communities similar in structure to what can be obtained on reclaimed areas in the short term (e.g. 5 – 8 years).
- The plant communities selected for comparison should provide an appropriate and logical target for reclamation efforts.

[*]Given the vagaries of biotic and edaphic systems, the vast majority of regulatory agencies have allowed a modest level of flexibility when comparing reclamation to native or undisturbed lands. In the more restrictive circumstances, this flexibility has been limited to a 10% variance.

The reference "A_{RA}" value approximates the rate of soil loss on a selected reference area adjacent to the mining disturbance. If the potential soil loss from a reclamation unit as predicted by the model ("A") is less than 110% of the reference "A_{RA}" value, the area will be considered stable and the test passed. If the potential loss is greater than 110% the reference "A_{RA}" value, the area will not be considered sufficiently stable and the area will fail the success test. The addition of the need for a "stable" or "positive" trend from the analysis in Section 3.2 addresses the fact that RUSLE does not account for gully erosion.

These suggestions for success evaluation must necessarily remain dynamic as such testing for erosional stability is in its infancy. There are circumstances (e.g., the Outback of Australia) where the land surface has been subjected to the erosive forces of nature for so long a period that they are now extremely stable and the "T", "A_B", or "A_{RA}" values may not present a reasonable target for reclamation. In this regard, it may be possible to develop a standard similar to the "inflection point" concept presented for LFA analyses. Once several reclaimed units are sampled, data generated, and analyses made, the efficacy of the currently proposed standards versus the need for an alternate RUSLE success comparison will be further evaluated.

Step 4 Evaluate Establishing Vegetation Using Vegetation Measurement Protocols

4.1 Introduction

By using established, scientifically defensible procedures to track the progress of newly establishing vegetation communities, a determination of either latent problems or a prediction of future "releasability" will be reliably manifested. At some point, the reclaimed community will have progressed sufficiently to be "tested" and thereby trigger final bond and/or liability relinquishment on areas no longer potentially necessary for operations.
The initial stage (Stage I) of vegetation monitoring will occur concurrently with the implementation of LFA stability protocols or soil sampling protocols and will consist of two components: 1) a brief qualitative evaluation of the reclaimed surface and manifested physical and biotic attributes, and 2) a brief evaluation of emergent plant density. Following this initial stage of monitoring, units that appear to be advancing will be evaluated and assessed to determine progress toward "releasable" status and/or to determine if latent problems may need attention. In this regard, Stage II vegetation monitoring protocols will be implemented for all reclamation units that have achieved sufficient vegetation growth and development to warrant the effort.

For the vast majority of circumstances Stage II monitoring will target the vegetation variable of "Ground Cover", and because most vegetation used in reclamation does not or will not achieve heights in excess of approximately 1.5 meters over the short-term, a concentration on vegetation ground cover below 1.5 meters will be the primary emphasis. However, for older reclamation and other exceptions where ground cover due to vegetation exceeds 1.5 meters in height, a secondary procedure will be used to incorporate "overstory" cover. Additional rationale and attributes regarding the value of the ground cover variable is provided in Appendix A.

In typical circumstances, Stage II procedures would be implemented for a period of 1 to 3 years, assuming reclaimed communities are progressing as expected until either Stage III is reached or the area becomes "releaseable". Stage III is essentially a "holding" period where reclamation has achieved adequate parameters to be relinquished, but the area is not operationally ready to be released from the permit. In these instances, compliance monitoring would be initiated requiring an evaluation once every 3 years to insure that the reclaimed area has not regressed or otherwise developed any problems. In certain circumstances (such as poor growth media or rainfall), the progress of reclaimed communities may take a longer period of time and Stage II procedures may be scheduled for implementation on a biennial basis (once every two years).

4.2 Physical and Biotic Attributes and Emergent Plant Density Monitoring (Stage I)

4.2.1 Physical and Biotic Attributes

During the first growing season following seeding a reclaimed unit will be subjected to a relatively brief one-time evaluation to document plant establishment as well as other reclamation considerations. This evaluation consists of a qualified observer traversing the subject area and evaluating vegetation establishment and related physical and biotic conditions. Approximately 1 hour of qualitative review time per 20 hectares should be expended. During the traverses, the observer should note, among other items: 1) areas of poor seedling emergence, 2) pervasively weak or stressed seedlings, 3) indicators of soil fertility problems (e.g. certain anthocyanine colorations), 4) noxious weeds or invasive plant infestation, 5) evidence of unintended livestock grazing, 6) excessive erosion and type, 7) evidence of acid formation, 8) evidence of structural instability (stress fractures, piping, etc.), 9) evidence of hyper-saline soils, 10) "pockets" of the aforementioned, and 11) any other similar revegetation / reclamation related problems. Also at this time, any gullies that may have formed during rainfall events should be identified and subjected to the trend evaluation as indicated in Section 3.2.

To provide a framework for many of these observations, the qualitative data sheet on the following page could be utilized. It does not directly address all the points above, but provides a structured approach for making observations. This qualitative data sheet should also be utilized for all segregate-unit monitoring activities (Stage II and Stage III). It provides a structured checklist of additional observational attributes that often are not detected by quantitative evaluations.

4.2.2 Emergent Plant Density

In addition to the physical and biotic attributes evaluation, the surveying observer will collect semi-quantitative samples to document the emergent density of seeded species. This procedure will occur as follows. For areas up to 5 hectares in size, a total of 5 samples will be collected. For areas between 5 and 35 hectares in size, a total of 10 samples will be collected. For areas between 35 and 150 hectares in size, a total of 20 samples will be collected. Finally, for areas larger than 150 hectares in size a total of 30 samples will be collected. Each sample will consist of a group of five 0.1-m^2 quadrats distributed in an unbiased manner. The number of emergent plants rooted within the perimeter of each quadrat will be recorded accordingly into one of five classes: perennial grass, perennial forb, shrub/tree, annual grass, or annual forb. This procedure typically takes about 2 minutes per sample point (5 quadrats) yet yields valuable information on the success of the seeding effort. Efforts that result in fewer than 1 perennial emergent per 0.1-m^2 should be considered to be poor and a possible candidate for remediation. Efforts with 1 – 2 perennial emergents per 0.1-m^2 are considered to be fair, 2 - 3 perennial emergents per 0.1-m^2 are considered good, and 3 - 5 perennial emergents per 0.1-m^2 are considered to be very good. Finally, greater than 5 perennial emergents per 0.1-m^2 are considered to be excellent.

In certain droughty areas (e.g., Mojave desert of the U.S. or goldfields of Western Australia), quadrat size may need to be increased to 1-m^2 to facilitate emergent plant evaluation. In these areas, efforts with 1 – 2 perennial emergents per 1-m^2 are considered to be fair to good and 3 - 4 perennial emergents per 1-m^2 are considered very good to excellent.

In addition to the qualitative and emergent density surveys, the reclaimed unit should be circumnavigated on foot or with all-terrain vehicle utilizing a sub-meter GPS to field delineate the unit boundary. In this manner, any discrepancy between planned and actual area of reclamation will be documented. Such information becomes important during relinquishment activities.

RECLAIMED UNIT - QUALITATIVE OBSERVATIONAL DATA SHEET

YEAR = _____	Mine/Project:	Unit Name:	OBSERVER = _____
Steepest Slopes - Clinometer Angles (° of angle or %): / / / /		Date:	Photo - Y / N

QUALITATIVE PARAMETER	Excellent	Good	Average	Fair	Poor	N/A	COMMENTS (Especially for departures below average)
Overall Condition of Revegetation	5	4	3	2	1	X	
Quality of Growth Media (Texture / Organics / Salts)	5	4	3	2	1	X	
Plant Health and Vigor (e.g., Anthocyanine Coloration ?)	5	4	3	2	1	X	
Recruitment (e.g., Seed Production, tillering, etc.)	5	4	3	2	1	X	
Shrub Patch Diversity (Heterogeneity of Patches)	5	4	3	2	1	X	
Shrub Density (Within Patches)	5	4	3	2	1	X	
Diversity (of Species)	5	4	3	2	1	X	
Macro Diversity (Lifeform/Habitat/Layering)	5	4	3	2	1	X	
Cryptobiotic Development	5	4	3	2	1	X	
Litter Residue	5	4	3	2	1	X	
Evidence of Wildlife Use	5	4	3	2	1	X	

QUALITATIVE PARAMETER	None	Minor	Average	Major	Massive	N/A	COMMENTS (Especially for departures below average)
Noxious Weed Population Description (Indicate Sp.)	5	4	3	2	1	X	
Annual / Invasive Weed Population Description	5	4	3	2	1	X	
Erosion - Rills (Less than 15cm (USA) or 30cm (AUS) in depth)	5	4	3	2	1	X	Type / Active / Healing / Evidence of Healing / Etc.
Erosion - Gullies More than 15 cm (USA) or 30 cm (AUS))	5	4	3	2	1	X	
Erosion (Sheet, Aeolian, etc.)	5	4	3	2	1	X	
Soil Crusting	5	4	3	2	1	X	
Thin Areas (Cause, Amount, & Location)(1/2 acre minimum) Bare = 0-10% of Avg. Cover Thin = 10-33% of Avg. Cover	5	4	3	2	1	X	Percent Bare = _____ Percent Thin = _____

Other Comments:

Office Use:	Qualitative Parameters				Quantitative Samples			QA/QC Check By:
	Score		Total	Percent	Cover Ts	WPD Belts	Prod Quads	
		/		=				

4.2.3 Recommendations

The results of the qualitative, and semi-quantitative emergent density survey will form an initial basis for recommendations for future needs of the reclaimed unit. For most efforts it is anticipated that a recommendation to proceed to Stage II monitoring will be made. Other possible recommendations may include:

1. Allow additional time for seed to emerge and re-evaluate using Stage I Protocols. The amount of additional time may be one or two years.

2. Retreat all or parts of a unit by resoiling, reseeding, fertilizing, weed control efforts, addressing acid generation or stability concerns, etc. An important concept that must be taken into account is that precipitation is not always favorable for reclamation efforts in any given year or environment, just as occurs for agricultural practices. Also, species selected, growth form, depredation by granivores, and mold or fungus may impact emergence. Therefore, as indicated above, a second or third growing season is occasionally necessary to achieve the desired seedling emergence. If however, after three growing seasons emergence is still unsatisfactory, reseeding may be necessary to replenish the seed bank. If mitigation occurs, re-monitor the following growing season using Stage I Protocols.

Advancement to Stage II monitoring would be based on the estimated amount of expressed vegetation in the target reclamation unit(s). When the amount of vegetation cover visually exceeds an estimated 10 percent of the value expressed by the appropriate reference area, then Stage II activities should commence. For example, assume the reference area exhibits a value of 50% ground cover by live vegetation. Then Stage II activities would commence when absolute ground cover by live vegetation on the reclaimed unit is approximately 5% (50% x 10% = 5%).

At this time, stability monitoring with LFA procedures can cease unless an additional year or two of data are desired to help show positive trend toward stabilization of the soil surface.

4.3 Quantitative Vegetation Monitoring (Stage II)

4.3.1 Ground Cover

During Stage II vegetation monitoring, evaluation will consist of a reasonably rapid quantitative evaluation of ground cover (for most circumstances) to document the level of progress. This effort will entail a qualified observer systematically establishing “ground cover” sampling transects across the reclaimed unit (using a visually-based grid as opposed to a more formal measured grid) at the following sampling intensity:

- Units 5 hectares or less — 5 Transects
- Units between 5 and 35 hectares — 10 Transects
- Units between 35 and 150 hectares — 20 Transects
- Units larger than 150 hectares — 30 Transects

These transects will be systematically distributed as opposed to being randomly distributed. In this application a systematic distribution of samples is superior because it ensures sample representation from across the entire reclaimed unit (population). Also, this procedure better accounts for heterogeneous expressions of multiple seedings or reclamation conditions by "forcing" a patterned distribution of samples which minimizes sample bias resulting from vegetated pockets being either entirely missed or overemphasized. This “forced” distribution also facilitates a second overall look at the entire reclaimed unit for the qualitative parameters discussed for Stage I (physical attributes) monitoring.

Ground cover transects will typically consist of 10-meter long 100-intercept “line-point transects” (“point-intercept transects”). There may be some instances (elevated variability) where longer transects would be appropriate, and these circumstances can be addressed on a site-specific basis. The actual sampling methods are described in detail in Step 6. As routinely documented in the heavily regulated US coal industry, this methodology, using modern laser instrumentation, facilitates the collection of the

most unbiased, repeatable, precise, and cost-effective* ground cover data possible. As indicated in Section 3.2, a co-located erosion observation transect will occur with each vegetation transect.

4.3.2 Woody Plant Density

In certain circumstances, ground cover will not be the best variable to monitor for tracking the success of reclamation in the short-term. Instances where this may occur include environments not conducive to herbaceous specie reclamation and environments dominated by overstory forests (e.g., woodlands). In these circumstances, ground cover transects may be replaced, or reinforced, by woody plant density belts.

Woody Plant Density Belts will typically consist of 50-meter long by 2-meter wide belts whereby all live woody plants rooted within is enumerated by species. There may be instances where only the non-seedling categories of woody plants would be enumerated (seedlings tend to have high mortality rates) and these circumstances can be addressed on a site-specific basis. The actual sampling methods are described in detail in Step 6.

4.3.3 Recommendations

Depending on the results of data analyses from the quantitative surveys and interpretation of observations, appropriate management recommendations will be generated for the target unit. For most efforts on a reasonable path to growth and development, it is anticipated that a recommendation to proceed to Stage III or Bond Relinquishment (Step 6) will be forthcoming. Other possible recommendations include:

1. Allow additional time for the establishing community to mature and then re-evaluate using Stage II Protocols.

2. Retreat all or parts of a unit by reseeding, fertilizing, weed control efforts, addressing acid generation or stability concerns, etc. and continue monitoring using Stage II protocols as necessary.

Advancement to Stage III monitoring or Bond Relinquishment (Step 6) would be based on the estimated amount of expressed vegetation in the target reclamation unit(s) in comparison to the success criterion based on the appropriate reference area. When the amount of vegetation cover / density approaches (and is expected to exceed the following year) or presently exceeds the appropriate success criterion, then either Stage III or Bond Relinquishment activities may commence. Typically, a minimum period of three growing seasons is necessary before final relinquishment sampling could or should occur.

4.4 Compliance Monitoring for Units Not Operationally Ready for Release (Stage III)

Following passage of Stage II, many units of reclaimed land will not be operationally ready to be released by mine management (i.e., there may be potential need to reopen any given facility). As indicated above, if an area is not managerially or operationally ready for relinquishment, monitoring using Stage II protocols should continue to occur to validate the status of the unit and insure that no additional work or remediation is necessary. In this regard, compliance monitoring once every 3rd year should be completed until as such time as mine management indicates a particular facility is managerially or operationally ready to be released.

Step 5. Prepare Monitoring Report

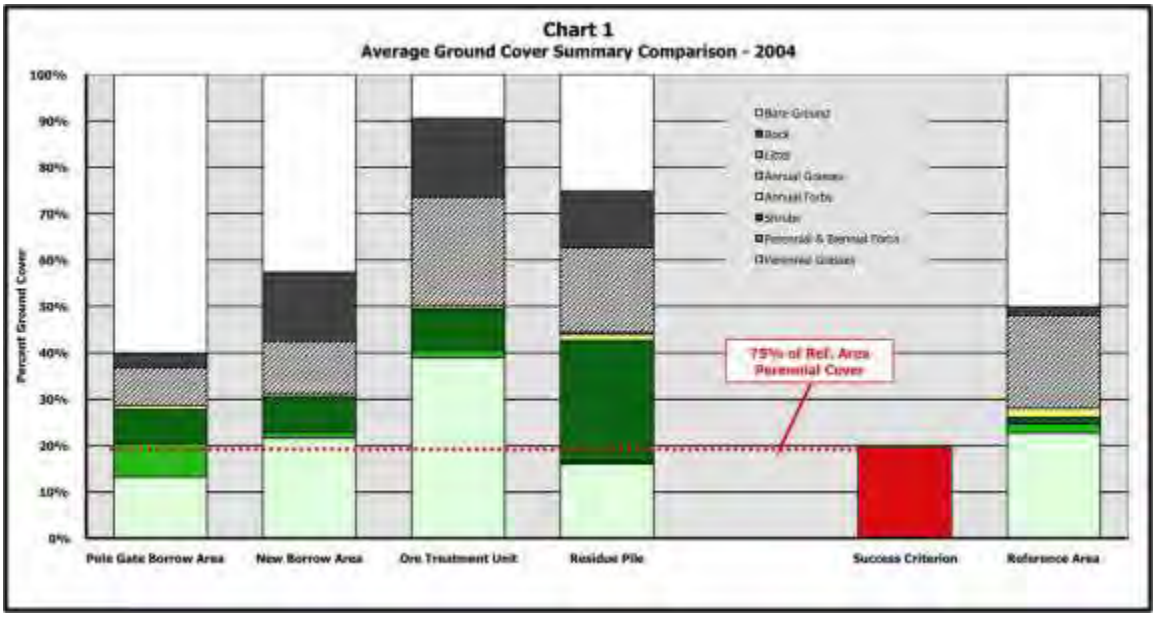
* In typical reclamation, transects completed with laser instrumentation can be implemented by an experienced observer at a rate of 6 or 7 transects per man-hour of effort with a range of 4 to 9 depending on the diversity of vegetation and size of the reclaimed unit. Addition of the co-located erosion observation transect will slow this rate of speed by 50% +/-.

Monitoring reports should consist of three levels of communication: 1) immediate, 2) short-term, and 3) standard longer-term documentation. Immediate reporting should be used for observations of conditions (or lack thereof) that need immediate attention from environmental or reclamation department staff. Such reporting would be verbal and may consist of a site review with appropriate staff either immediately (same day) or at the end of the field evaluation period (within a few days). If conditions requiring immediate attention are not observed, then immediate verbal feedback of "nil" circumstances should still occur at the end of the field evaluation period.

Short-term reporting should be used for observations of conditions that need attention during the current field season, but do not warrant "immediate" attention. For example, poor take by seeded species over a portion of a reclamation unit that would benefit from reseeding during the current field season. Such matters could be addressed by a brief, field report of only a few pages length utilizing sketches rather than computer generated mapping for spatial information. Short-term reports should be delivered to the appropriate department staff within a matter of weeks (less than 4 would be best). Furthermore, short-term "field" reports should also include documentation of any "immediate reporting" that occurred during field work.

The third level of reporting involves the standard longer-term documentation of field activities and findings that will be prepared during the non-field season. This report will present the results of monitoring data analyses and any management recommendations in a user-friendly format. Reporting will provide a detailed description and exhibition of the methodology utilized in a manner similar to that presented within a refereed journal article that would allow an independent 3rd party to repeat the work. Results will be presented and described, by segregate unit (treatments and/or reclamation units) in text, tabular, and as possible graphic form to aid interpretation by reviewers. For example, comparisons with reference / analog area data (shown as a "threshold value") will facilitate immediate comprehension of a reclaimed unit's status. An example of this type of graphic follows on the next page as Chart 1.

Each full report should present three levels of information: 1) an executive summary, 2) a detailed presentation of findings (including summarized data) that targets the technical reviewer such as the mine's reclamation staff or regulatory oversight personnel, and 3) an appendix that presents all raw data (tabulated and organized) and 1st order summaries to facilitate an independent corroboration of findings.



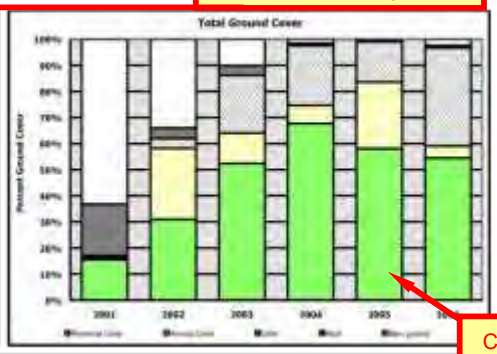
An executive summary with summary graphics (such as presented immediately above) should be developed to provide higher level management a quick synopsis of the most pertinent findings, especially with regard to reclamation units that have achieved sufficient status as to be "releasable" from the permit. All technical analyses, 2nd and 3rd order summary information, interpretation of findings, recommendations, etc. should be presented in the main body of the document along with supporting mapping and analyses. Included within this section of the report, or appended as appropriate, should be a detailed summary and compilation of all pertinent current and past data with regard to each unit of reclaimed land under investigation during that year.

These compilations ("Compendiums") are very useful to technical managers as they present a current "snapshot" of the status of reclaimed lands as well as all pertinent historic, background, and spatial data in a one page format (see Exhibit 2 on the following page). Finally, all supporting, but non-essential raw data for the technical component of the report should be tabulated and organized and presented in an appendix to the document (see Exhibit 3).

In this manner, all managerial needs and requirements of agency permitting documentation should be satisfied. In addition to recommendations relating to financial assurance relinquishment, additional recommendations resulting from the monitoring program may include: recommendations to modify reclamation procedures and/or seed mixtures for future reclamation areas, recommendation for weed control and recommendations regarding future grazing management. A summary section will be developed as a portion of the monitoring report that includes an overall summary table and map exhibiting the reclamation status of all reclaimed areas. (See the map and table presented for Step 1.)

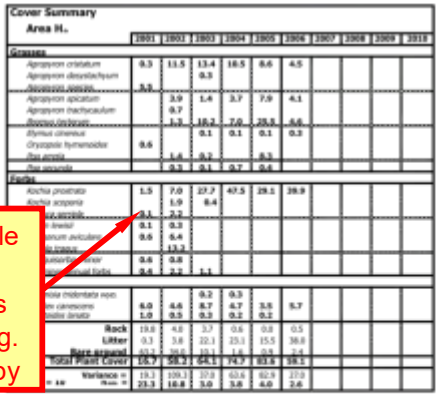
Exhibit 2 - Compendium – Summary of All Pertinent Data re: Each Segregate Reclamation Unit – 11x17 Format

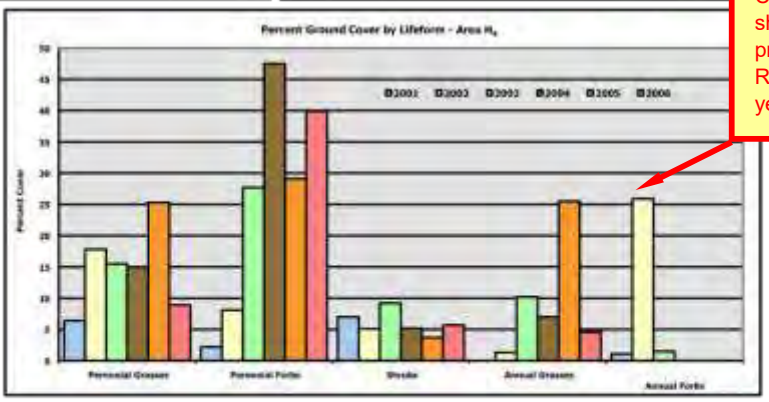
Map of Reclamation Unit showing most current distribution of samples.



Charts showing progress of Reveg. by year

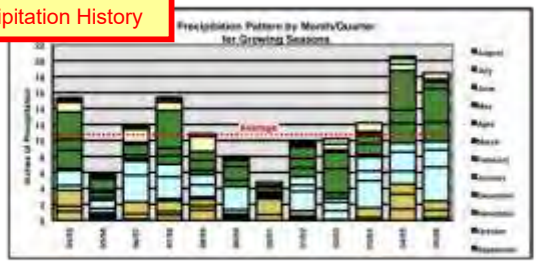
Table tracking specifics of Reveg. by





Current Photo

Precipitation History



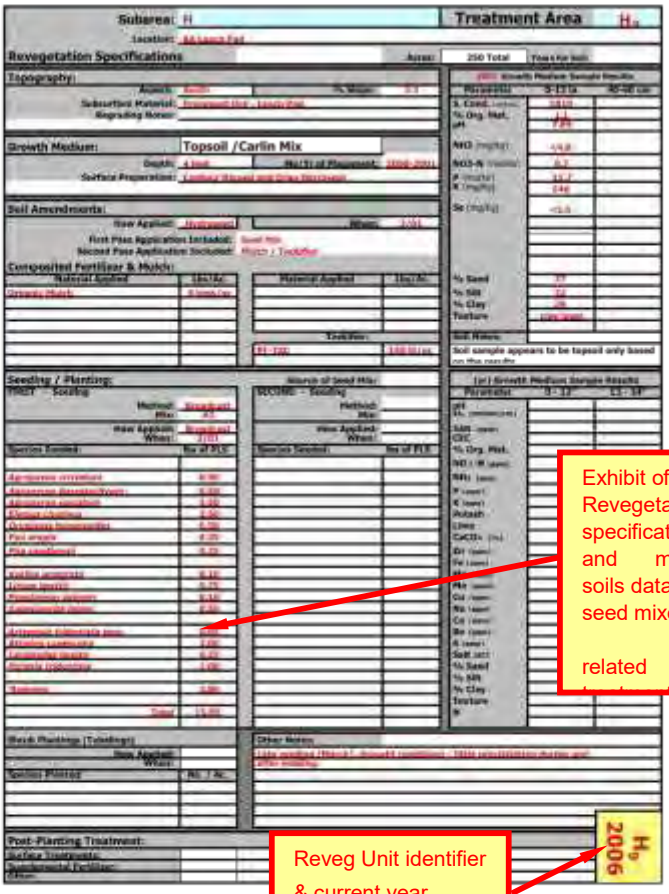


Exhibit of all Revegetation specifications and metrics, soils data, seed mixes, and related

Reveg Unit identifier & current year

Step 6. Development of Site-Specific Standards for Determination of Successful Reclamation and Subsequent Financial Guarantee or Assurance Relinquishment for Mined **or "Mine-Related"** Areas

6.1 Introduction

This section details sampling and analysis procedures and the final reclamation success criteria (standards) for evaluation of reclamation of mine-related disturbances. These criteria and protocols are developed in accordance with Wilson's Environmental Policies and will typically meet or exceed regulatory requirements in the U.S. and elsewhere in the world. This section does not include a separate analysis for Erosional Stability (see Step 3) because either of two options may be employed. However, a demonstration of Erosional Stability as detailed in Step 3 should occur for final relinquishment to document success with regard to this variable.

In addition to identified "standards" a set of "goals" may/will be identified to assist in the evaluation and interpretation of targeted reclamation efforts. However, it is important to understand the difference between goals and standards, especially within the context of their use in this document and the reclamation permit. A "standard" is a legally binding level of reclamation performance that must be attained to trigger release of financial sureties and future liability. A "goal" is a desirable result (level of reclamation) that serves to act as guidance for reclamation activities, but has no legal bearing on the release of financial sureties or liability if attainment is not achieved. In other words, goals help to guide reclamation in the desired direction, but standards offer the minimally acceptable level that must be achieved to have a legal consequence.

Consistent with the requirements of Reclamation Permitting, final reclamation success will be evaluated through three broad concepts:

- Documentation that erosional stability has been achieved as detailed in Step 3.
- Comparison to an adequate analog or reference area(s) representative of the pre-existing vegetation community(s) and/or desirable baseline / ecological conditions which will act as surrogate for the post-mining land use;
- Evaluation of plant species present in, and/or resulting from, the proposed (and planted) seed mixes.

Total vegetative cover and composition are important factors in determining the success of reclamation efforts. However, of equal importance to reclamation success is the achievement of soil stabilization. Without soil stability, reclamation efforts may regress along the successional continuum and thereby preclude the achievement of long-term land use goals. In this regard, prior to, or concurrent with vegetation, a determination of soil stability should be documented through procedures detailed under Step 3 of this document.

The long-term goal of reclamation efforts is to establish self-sustaining biotic systems with appropriate ecological resistance and resilience. This does not necessarily mean that the reclaimed area will exactly replicate the surrounding vegetation communities, but that it will successfully support the designated post-mining land uses. In general, it would be an undesirable condition that the reclaimed area match exactly the surrounding vegetation communities, since community diversity adds significantly to overall habitat diversity for an area. As appropriate, seed mixtures designated by the reclamation plan are largely composed of species native to the region. Also as appropriate, seed mixes contain a complement of grasses, forbs, shrubs and trees to provide establishment of a diverse plant community within reclaimed areas.

6.2 Proposed Reclamation Targets

6.2.1 Reclamation "Goals"

The Reclamation Plan establishes the goal of reclamation as follows:

- Perennial vegetative cover as close as possible to 100 percent of selected comparison (analog or reference) areas; or
- Perennial vegetative cover that is on a reasonable successional path to achieve as close as possible 100 percent of selected comparison (analog or reference) areas.

In certain circumstances, woody plant density may replace the term cover, and in other circumstances the term perennial may not be appropriate. However, the stated goals will suffice for most operations.

Although the goal of the reclamation program is to achieve "as close to 100% of the perennial plant cover as possible, success must be based on reasonably achievable standards that reflect the minimum levels necessary for return of the permit area to a self-sustaining ecosystem. Therefore, reclamation success will be assessed against a performance "standard" for vegetative ground cover. Reclamation efforts will be considered successful when standards have been met following at least three growing seasons since planting efforts.

6.2.2 Vegetative Ground Cover Standard (Success Criterion)

Vegetative ground cover should be utilized for the vast majority of reclamation circumstances and must meet the following criterion: The total vegetative ground cover (exclusive of annual species and litter) in the reclaimed unit equals or exceeds 60 percent of the total vegetative ground cover (exclusive of annual species and litter) of the analog or reference area.

In those environments where annuals form a significant component of the floral composition and cover, the 60 percent standard shall apply to all live (during the current growing season) vegetation (excluding noxious weeds).

6.2.3 Woody Plant Density Standard (Success Criterion)

For those circumstances where an evaluation of ground cover may be inappropriate (e.g., Death Valley, USA; tropical rainforest of Australia; or managed timberland anywhere), an alternate success criterion may be utilized as follows: The total density of woody plants in the reclaimed unit equals or exceeds 50 percent of the total density of mature age-class woody plants of the analog or reference area.

6.3 Reclamation Evaluation Procedures

Monitoring and eventual evaluation will typically involve sampling of ground cover within each reclaimed unit under consideration for financial guarantee or assurance relinquishment (and at least 3 years of age) and the appropriate analog or reference area. Species diversity information will be calculated from the ground cover data and presented for informational purposes to document goal-related composition that will then indicate ecological resilience and progress toward the desired land use. Sampling for ground cover will be accomplished utilizing the point-intercept procedure along transects of 100 intercepts each, preferably using modern instrumentation (e.g. lasers or optics).

6.3.1 Sampling

The first step of the vegetation sampling procedure is to obtain ground cover data from each reclaimed unit to be evaluated. A reclaimed unit consists of a defined area based on management criteria, such as areas with common reclamation procedures and initiation times, areas with a defined function such as a waste rock facility, or areas with other unique designations. Ground cover samples also will be obtained from the analog or reference area(s). Sampling will occur approximately during the peak

standing biomass period of the year (early- to mid-summer) and sampling locations will be determined utilizing a systematic (bias-free) method with a random start[5]. This systematic procedure also provides proportionate representation from across each reclaimed unit for additional characteristics such as aspect, slope, etc.

6.3.1.1 Sample Site Location.

The systematic procedure for sample location in both a reclaimed unit and the analog or reference area will occur in the following stepwise manner. First, a fixed point of reference will be selected for the area to facilitate location of the systematic grid in the field. Second, a systematic grid of appropriate dimensions will be selected to provide a reasonable number (e.g., 15 or 20) of coordinate intersections that could be used for the initial set of sample sites. Third, a scaled representation of the grid will be overlain on field maps of the target unit extending along north/south and east/west lines or other appropriate direction. Fourth, the initial placement of this grid will be implemented by selection of two random numbers (an X and Y distance) to be used for locating the first coordinate from a fixed point of reference, thereby making the effort unbiased. Fifth, where an excess number of potential sample points (grid intersections) is indicated by overlain maps, the excess will be randomly chosen for elimination unless it is later determined that additional samples are necessary to meet sample adequacy. If additional samples are needed, the eliminated potential sample sites will be added back in reverse order until enough samples have been collected. Sixth, utilizing compass and pace techniques or a handheld GPS, the sample points will be located in the field.

6.3.1.2 Ground Cover Determination.

Ground cover at each sampling site will be determined utilizing the point-intercept methodology as illustrated In Exhibit 1. This methodology will be applied as follows: First, a transect 10 meters in length will be extended from the starting point of each sample site toward the direction of the next site to be sampled. Then, at each one-meter interval along the transect, a “laser point bar”, “optical point bar” or 10-point frame will be situated vertically above the ground surface, and a set of 10 readings recorded as to hits on vegetation (by species), litter, rock (>5mm), or bare soil. Hits will be determined at each meter interval as follows:

1. When a laser point bar is used, a battery of 10 specialized lasers situated along the bar at 10-centimeter intervals will be activated and the variable intercepted by each of the narrow (0.02”) focused beams will be recorded (see Exhibit 1);

2. If an optical point bar is used, intercepts will be recorded based on the item intercepted by fine crosshairs situated within each of 10 optical scopes located at 10-centimeter intervals;

3. If a 10-point frame is used, sharpened needles will be used to determine intercepts at 10-centimeter intervals. Care will be taken to NOT record “side touches” on the pins as this will result in a significant overestimation error.

The following sampling rules should apply during data collection. Intercepts will be recorded by species for the first (typically highest below 1.5 meters) current annual (alive during the current growing season) plant part intercepted without regard to underlying intercepts or attachment to a living base. Otherwise, the intercept will be classified as litter, rock or bare soil. Rock intercepts are based on a particle size of 5 mm or larger to facilitate RUSLE evaluations, otherwise it would be classified as bare soil. To distinguish between current year senescent plant material and litter (including standing dead), the

[5] Systematic sampling (with random initiation) is superior to other sample distribution procedures because it forces representation from across the reclaimed unit. It accounts better for heterogeneous expressions of multiple seedings or reclamation conditions by "forcing" a patterned distribution of samples. This method thus minimizes the risk that significant pockets will be either entirely missed or overemphasized. However, in research applications statistical analysis methods may be limited.

following rule should apply: 1) if the material is gray or faded tan it should be considered litter; and 2) if the material is bright yellow or beige it should be considered current annual (alive) and recorded by species. On occasion, experience with non-conforming taxa may override this rule.

When using laser or optic instruments during windy field conditions, the observer should consistently utilize one of the following techniques for determining a hit: 1) record the first item focused upon that is intercepted by the narrow laser beam or cross-hair; 2) wait a few moments and record the item intercepted for the longest time, or 3) block the wind and record the intercept. When using a pin frame, the observer must wait for the wind to subside.

With regard to gaps in the overstory, the point-intercept procedure naturally corrects for overestimations created by 2-dimensional areal (quadrat) or 1-dimensional linear (line-intercept) techniques. In this regard, the 0-dimensional point is extended along a line-of-sight until it “intercepts” something that is then recorded. Frequently points simply pass through overstory gaps until a lower plant part, litter, rock or bare soil is encountered.

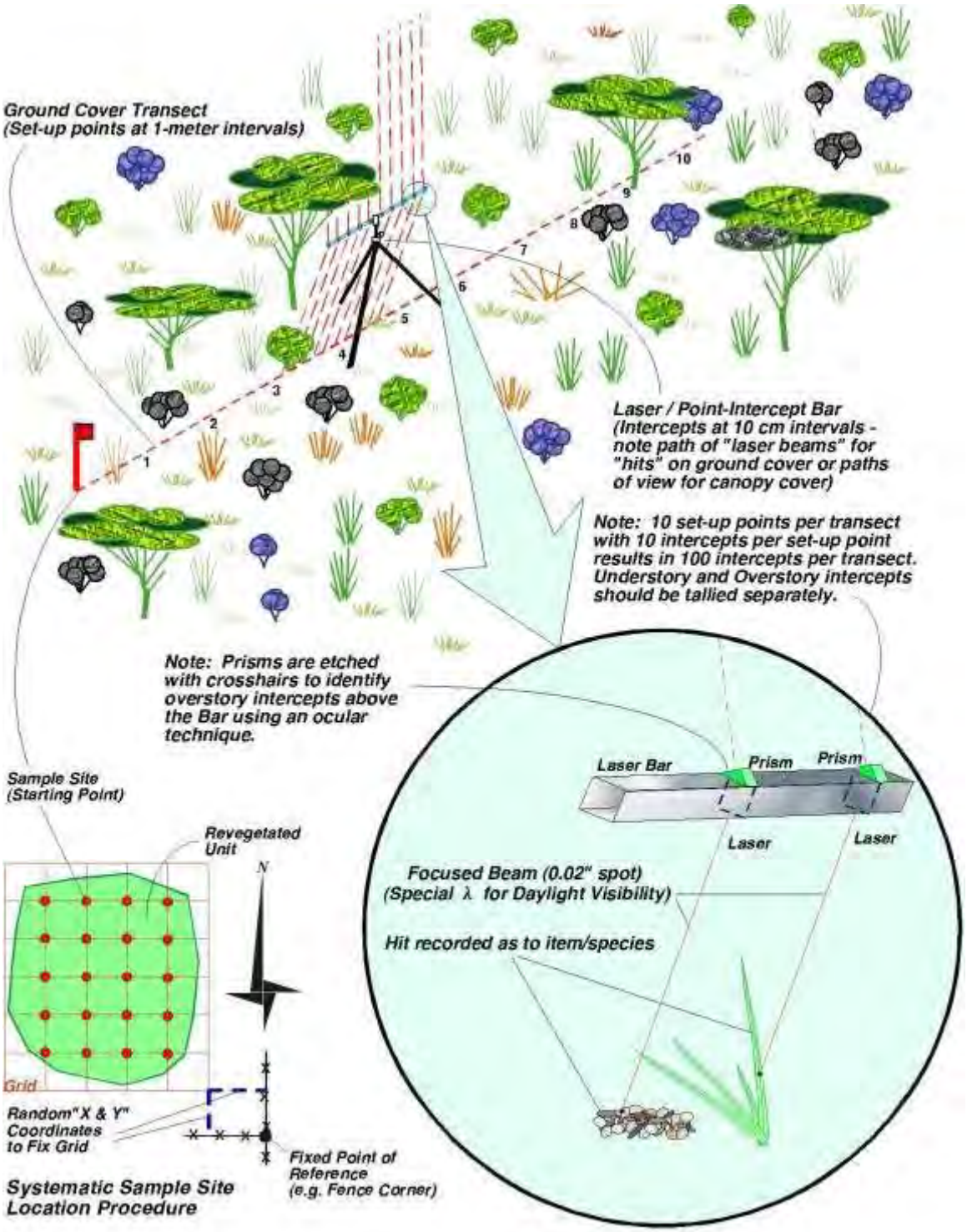


Exhibit 1

Sampling Procedure at a Systematic Sample Site Location

Regardless of instrument, a total of 100 intercepts per transect will be recorded resulting in 1 percent cover per intercept. This methodology and instrumentation (excepting the 10-point frame) facilitates the collection of the most unbiased, repeatable, precise, and cost-effective ground cover data possible.

Overstory Cover. In certain circumstances (e.g., various Acacia species in Australia), young reclamation can exceed 1.5 meters in height. In these instances, overstory cover should be recorded separately from the understory cover (below 1.5 meters). Point-intercepts can be collected above the ground cover equipment with the aid of prisms etched with cross-hairs (see Exhibit 1). In this regard, intercepts will be recorded by species, with all other intercepts being non-applicable (sky). The sampling rules indicated above should again be used as appropriate. To facilitate ground cover calculations, any understory hit that occurs concurrently with an overstory hit will be recorded as a 2nd intercept and will not be included in the total that must add up to 100%.

RUSLE-Specific Measures – Fall Height and Basal Cover. When a RUSLE evaluation is to occur, the following metrics will be included with the ground cover procedures to facilitate proper input variables. Following completion of each ground cover transect, an estimate of average fall height (closest 1/2 foot) and total percent basal cover should be recorded for the soil stability analysis using the RUSLE application. Average fall height is defined as the height within the canopy from which intercepted raindrops re-form into water droplets and fall to the ground; this fall distance is known as the "effective fall height." In plant communities that have more than one type of vegetation composing the canopy (e.g., both a shrub and tree stratum), a fall height should be determined for each life form. It is typically unnecessary to estimate an average fall height for grasses and forbs, as they are relatively close to the surface and rain droplets tend to follow the stems to the ground rather than reforming and falling. At the completion of each vegetation transect a visual estimate of the average fall height for shrubs encountered should be recorded as well as a separate estimate for any trees. Where necessary, a height measurement tool (rule, staff, etc.) may be utilized to obtain the estimate. The upper limit for the measurement should be the average height of the mid-point for the volume of canopy. For example, if the canopy where spherical in nature, the height would be estimated from the ground to the central radius point. If the canopy were pear shaped, the height would be determined from a point somewhat lower. Occasional circumstances may occur where a dominant plant that is not a shrub or tree would need an average fall height recorded. In such circumstances these can be recorded separately and treated on an individual basis. These fall heights will then be weighted based on canopy cover of each life form to establish an average fall height for the transect, and the fall heights for the total number of transects for a given unit will be averaged for entry into the RUSLE application.

Basal cover is the material in contact with the soil surface that both intercepts raindrops (thereby dissipating energy) and slows surface runoff. It includes all types of cover such as mulch, the living base of plants, rock fragments, plant litter (standing dead or detached vegetation) in contact with the soil surface, and cryptogamic crusts (which are formed by lichen, mosses, or fungi in the soil). In effect, it would be the surface material visible on the bare soil had a mower, set to a very low elevation, passed over the area removing all above ground biomass without disturbing the litter. Although all ground cover is determined by the point-intercept technique as described in this document, a very reasonable estimate of basal cover can be determined from the ground cover transect by using the following adjustment techniques. These techniques involve a determination of basal bare ground exposure, which is the inverse of basal cover (i.e., 100% minus the bare ground exposure results in a value for basal cover).

First, all bare ground hits along a ground cover transect would be included in this analysis.
Second, in portions of the transect dominated by grasses, especially sod-formers, and forbs, 10% of the hits would be assumed to encounter bare ground if the overstory were removed. The remaining hits would be assumed to encounter the living base of plants or ground-contact litter.
Third, the percent of exposed bare soil below shrubs and trees would be estimated following a quick visual review of the transect.

Fourth, the values from the first three steps would be tallied and subtracted from 100. This final value would be a reasonable estimate of basal cover for the transect.

An example of the aforementioned procedure would be as follows: First, the total bare ground hits observed along a given ground cover transect would be “X” (22 hits for example). Second, the grass and forb cover was determined to be “Y” (33 hits for example) but only 10% of “Y” would typically be bare ground if the overstory were removed so the value to be used would be 0.1Y (or 3.3 hits for this example). Third, a visual evaluation below the shrubs (and trees) reveals that “Z” % bare ground is visible (15% bare ground in this example).

If shrub and tree ground cover resulted in 20 hits along the ground cover transect, then bare ground would be 20 x 0.15 or 3 hits if the overstory were removed. The sum of X, Y, and Z hits in this example would be 22 + 3.3 + 3 or 28.3 (% bare ground exposure). Therefore, basal cover must be the inverse or 100 – 28.3 = 71.7 or rounded off to 72%. The 72% basal cover value would be tallied with all other transect basal cover values from the unit and the average would be used for RUSLE calculations.

6.3.1.3 Woody Plant Density Determination.

Where ground cover is inappropriate for use as a bond relinquishment mechanism, woody plant density can be determined from each sampling site through the use of large quadrats or belts. A belt should encompass at least 100 m2 and would typically be 2-meters wide by 50 meters long, but can be other dimensions such as 4m x 25m. Once a convention (dimension of quadrat) is started, it must be maintained until all samples in that unit have been collected to avoid violating sampling theory assumptions. The long axis of the belt should be extended in the direction of the next site to be physically sampled.

Then within each belt all woody plants (shrubs and trees) should be enumerated by species and age class. Determination of whether or not a plant may be counted will be dependent upon the location of its main stem or root collar where it exits the ground surface with regard to belt limits. A belt transect should be sampled for each identified sample point (grid intersection) as identified in Section 6.3.1.1 above. At least 20 and preferably 30 samples should be collected from each unique management unit or analog / reference area. In addition, sample adequacy will NOT be determined for woody density belts as indicated in the next section unless it is only for informational purposes (the state of art has not provided a procedure that adequately captures woody plant population variation, therefore, calculation of sampling adequacy is not possible). Age classes recorded for the belt transects include: 1) seedling (plant of the year), 2) young (typically 2-3 years of age for shrubs or pole size or smaller for trees), 3) mature, 4) decadent (plants with less than 25% live crown), and 5) dead (assuming species is still positively recognizable).

6.3.1.4 Sampling Adequacy.

Data collection will continue within each discrete sampling unit (reclaimed unit or analog / reference area) for ground cover until a statistically adequate sample has been obtained. Adequacy of sampling will be achieved when, for each discrete unit, the number of samples actually collected (n) provides a level of precision within 10% of the true mean with 90% confidence (n_{min}), i.e., when $n_{min} \leq n$, and n_{min} is calculated as follows:

$$n_{min} = (t^2 s^2) / (0.1 \bar{x})^2$$

where: n = the number of actual samples collected with a minimum of 10 in each unit;
t = the one-tailed value from the t distribution for 90% confidence with n-1 degrees of freedom;
s^2 = the variance of the estimate as calculated from the initial samples;
$\bar{x}$ = the mean of the estimate as calculated from the initial samples.

For environments that are arid and native vegetation is somewhat sparse (e.g., areas with less than 250 mm (10") of annual precipitation), sampling adequacy will be relaxed by sampling to within 20% of the true mean with 90% confidence. In this regard, the 0.1 in the denominator of the $\mathbf{n_{min}}$ equation above will be changed to 0.2.

For environments that are very arid and native vegetation is very sparse (e.g., areas with less than 150 mm (6") of annual precipitation), sampling adequacy will be further relaxed by sampling to within 20% of the true mean with 80% confidence. In this regard, the 0.1 in the denominator of the $\mathbf{n_{min}}$ equation above will be changed to 0.2, and the t value from the t distribution will be selected from the 80% confidence column with n-1 degrees of freedom (one-tailed distribution).

As indicated above for most circumstances, this formula provides an estimate of the sample mean to within 10% of the true population mean (μ) with 90% confidence. Calculations of the mean and variance will be based on "total vegetation ground cover" exclusive of litter, but including annuals. Furthermore, a minimum sample size of ten (10) samples (20 for units larger than 50 hectares) will be collected from each discrete reclaimed unit or the analog / reference area. If the initial ten (or 20) samples do not provide an adequate estimate of the mean (e.g., the inequality above is false), additional samples will be collected until the inequality is satisfied. However, in no case will more than 40 ground cover transects be collected in any given sampling unit.

6.4 Ground Cover Comparison Standard

After adequate sampling, the comparison process will be initiated by calculating the mean ground cover value for non-annual plants (non-annual ground cover, or "NAGC") for each reclaimed unit and analog / reference area. The test for reclamation success for ground cover will occur as follows.
Determine whether the mean NAGC of the reclaimed unit(s) ($\bar{x}_{(rv)}$) equals or exceeds 60 percent of the mean NAGC for the analog /reference area ($\bar{x}_{(co)}$). In other words, if the inequality $\bar{x}_{(rv)} \geq 0.6$ ($\bar{x}_{(co)}$) is true, then the ground cover test has been passed. In areas with less than 250 mm (10") of precipitation, annual ground cover shall not be excluded from the above comparison unless they are locally identified as noxious or invasive weeds.

6.5 Woody Plant Density Comparison Standard

For woody plant density sampling, the comparison process will be initiated by calculating the average density of woody plants for each reclaimed unit and analog / reference area. The test for reclamation success will occur as follows.
Determine whether the average woody plant density of the reclaimed unit(s) ($\bar{x}_{(rv)}$) equals or exceeds 50 percent of the average "mature" category plants from the analogue / reference area ($\bar{x}_{(co)}$). In other words, if $\bar{x}_{(rv)} \geq 0.5$ ($\bar{x}_{(co)}$), and $\bar{x}_{(co)}$ is comprised only of the mature category of plants, then the woody plant density test has been passed.

References Cited:

Bonham, Charles D. 1989. Measurements for Terrestrial Vegetation. John Wiley & Sons. 338 pp.

Renard, K. G., G. R. Foster, G. A. Weesies, D. K. McCool, and D. C. Yoder (Coordinators). 1992. Predicting soil erosion by water: a guide to conservation planning with the revised universal soil loss equation (RUSLE). U. S. Department of Agriculture. Washington, D C. 400 pp. + appendices.

Tongway, David. 1994. Rangeland soil condition assessment manual. (CSIRO Division of Wildlife and Ecology: Canberra)

Tongway, D. and N. Hindley. 1995. Manual for Soil Condition Assessment of Tropical Grasslands. (CSIRO Division of Wildlife and Ecology: Canberra)

Tongway, D. and N. Hindley. 2000. – See Appendix B.

Tongway, David. 2005. Landscape Function Analysis: a Systems Approach to Assessing Rangeland Condition. http://www.cse.csiro.au/research/efa/lfa_summary.htm

USDA-Natural Resource Conservation Service (NRCS). 1993. National soils handbook. Superintendent of Documents. U. S. Government Printing Office. Washington, D. C. Various pagings.

APPENDIX B

Monitoring Data and Graphs

Table 13: Groundwater levels in monitoring bores

Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)	Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)
BH1	117	1/03/2008	13.90	103.10	BH2	112	20/08/2015	8.05	103.95
BH1	117	2/04/2009	8.71	108.29	BH2	112	20/11/2015	8.15	103.85
BH1	117	10/08/2009	13.85	103.15	BH2	112	26/06/2016	7.60	104.40
BH1	117	29/03/2010	12.50	104.50					
BH1	117	11/07/2010	15.00	102.00	BH3	113	1/03/2008	1.10	111.90
BH1	117	13/08/2010	15.44	101.56	BH3	113	2/04/2009	0.05	112.95
BH1	117	18/10/2010	16.05	100.95	BH3	113	10/08/2009	1.53	111.47
BH1	117	20/11/2010	16.17	100.83	BH3	113	29/03/2010	1.45	111.55
BH1	117	29/03/2011	11.50	105.50	BH3	113	11/07/2010	3.95	109.05
BH1	117	22/08/2011	13.00	104.00	BH3	113	18/10/2010	4.35	108.65
BH1	117	10/03/2012	13.25	103.75	BH3	113	20/11/2010	4.39	108.61
BH1	117	8/07/2012	13.00	104.00	BH3	113	29/03/2011	1.25	111.75
BH1	117	8/09/2012	13.45	103.55	BH3	113	22/08/2011	2.82	110.18
BH1	117	24/06/2013	14.00	103.00	BH3	113	10/03/2012	0.95	112.05
BH1	117	29/09/2013	14.75	102.25	BH3	113	8/07/2012	3.70	109.30
BH1	117	7/12/2013	15.10	101.90	BH3	113	8/09/2012	4.02	108.98
BH1	117	23/03/2014	15.00	102.00	BH3	113	24/06/2013	4.20	108.80
BH1	117	14/05/2014	15.20	101.80	BH3	113	29/09/2013	4.38	108.62
BH1	117	31/07/2014	15.55	101.45	BH3	113	7/12/2013	4.55	108.45
BH1	117	20/10/2014	15.75	101.25	BH3	113	23/03/2014	2.10	110.90
BH1	117	4/02/2015	15.70	101.30	BH3	113	14/05/2014	4.55	108.45
BH1	117	11/04/2015	15.80	101.20	BH3	113	31/07/2014	4.90	108.10
BH1	117	21/06/2015	15.85	101.15	BH3	113	20/10/2014	5.00	108.00
BH1	117	20/08/2015	16.45	100.55	BH3	113	4/02/2015	3.60	109.40
BH1	117	20/11/2015	16.47	100.53	BH3	113	11/04/2015	3.55	109.45
BH1	117	26/06/2016	16.35	100.65	BH3	113	21/06/2015	4.65	108.35
					BH3	113	20/08/2015	5.15	107.85
BH2	112	1/03/2008	4.70	107.30	BH3	113	20/11/2015	5.20	107.80
BH2	112	2/04/2009	6.17	105.83	BH3	113	26/06/2016	4.20	108.80
BH2	112	10/08/2009	7.14	104.86					
BH2	112	29/03/2010	4.90	107.10	BH4	113	29/03/2010	4.60	108.40
BH2	112	11/07/2010	5.30	106.70	BH4	113	11/07/2010	4.50	108.50
BH2	112	13/08/2010	5.41	106.59	BH4	113	18/10/2010	4.80	108.20
BH2	112	18/10/2010	5.75	106.25	BH4	113	20/11/2010	4.85	108.15
BH2	112	20/11/2010	5.84	106.16	BH4	113	29/03/2011	4.60	108.40
BH2	112	29/03/2011	3.75	108.25	BH4	113	22/08/2011	4.70	108.30
BH2	112	22/08/2011	4.55	107.45	BH4	113	10/03/2012	4.25	108.75
BH2	112	10/03/2012	3.95	108.05	BH4	113	8/07/2012	4.20	108.80
BH2	112	8/07/2012	4.65	107.35	BH4	113	8/09/2012	4.40	108.60
BH2	112	8/09/2012	5.03	106.97	BH4	113	24/06/2013	4.80	108.20
BH2	112	24/06/2013	5.95	106.05	BH4	113	29/09/2013	4.85	108.15
BH2	112	29/09/2013	6.40	105.60	BH4	113	7/12/2013	5.00	108.00
BH2	112	7/12/2013	6.65	105.35	BH4	113	23/03/2014	4.90	108.10
BH2	112	23/03/2014	6.60	105.40	BH4	113	14/05/2014	5.20	107.80
BH2	112	14/05/2014	6.70	105.30	BH4	113	31/07/2014	5.50	107.50
BH2	112	31/07/2014	7.10	104.90	BH4	113	20/10/2014	5.60	107.40
BH2	112	20/10/2014	7.40	104.60	BH4	113	4/02/2015	5.50	107.50
BH2	112	25/01/2015	7.55	104.45	BH4	113	11/04/2015	5.50	107.50
BH2	112	4/02/2015	7.25	104.75	BH4	113	21/06/2015	5.65	107.35
BH2	112	11/04/2015	7.43	104.57	BH4	113	20/08/2015	5.85	107.15
BH2	112	21/06/2015	7.74	104.26					

Table 13 Continued: Groundwater levels in monitoring bores

Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)	Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)
BH5	114	1/03/2008	5.40	108.60	BH7	116	11/07/2010	4.60	111.40
BH5	114	2/04/2009	2.82	111.18	BH7	116	18/10/2010	4.65	111.35
BH5	114	10/08/2009	3.89	110.11	BH7	116	20/11/2010	4.60	111.40
BH5	114	29/03/2010	4.90	109.10	BH7	116	29/03/2011	4.10	111.90
BH5	114	11/07/2010	4.80	109.20	BH7	116	22/08/2011	4.30	111.70
BH5	114	18/10/2010	5.10	108.90	BH7	116	10/03/2012	4.20	111.80
BH5	114	20/11/2010	5.09	108.91	BH7	116	8/07/2012	4.15	111.85
BH5	114	29/03/2011	2.90	111.10	BH7	116	8/09/2012	4.30	111.70
BH5	114	22/08/2011	4.48	109.52	BH7	116	24/06/2013	4.40	111.60
BH5	114	10/03/2012	4.55	109.45	BH7	116	29/09/2013	4.45	111.55
BH5	114	8/07/2012	4.53	109.47	BH7	116	7/12/2013	4.65	111.35
BH5	114	8/09/2012	4.65	109.35	BH7	116	23/03/2014	4.55	111.45
BH5	114	24/06/2013	5.00	109.00	BH7	116	14/05/2014	4.70	111.30
BH5	114	29/09/2013	5.30	108.70	BH7	116	31/07/2014	4.95	111.05
BH5	114	7/12/2013	5.40	108.60	BH7	116	20/10/2014	5.10	110.90
BH5	114	23/03/2014	5.40	108.60	BH7	116	4/02/2015	4.95	111.05
BH5	114	14/05/2014	5.40	108.60	BH7	116	11/04/2015	5.00	111.00
BH5	114	31/07/2014	5.60	108.40	BH7	116	21/06/2015	5.12	110.88
BH5	114	20/10/2014	5.65	108.35	BH7	116	20/08/2015	5.20	110.80
BH5	114	4/02/2015	5.40	108.60	BH7	116	29/09/2013	4.45	111.55
BH5	114	11/04/2015	5.45	108.55	BH7	116	7/12/2013	4.65	111.35
BH5	114	21/06/2015	5.58	108.42	BH7	116	23/03/2014	4.55	111.45
BH5	114	20/08/2015	6.00	108.00	BH7	116	14/05/2014	4.70	111.30
BH5	114	20/11/2015	6.05	107.95	BH7	116	31/07/2014	4.95	111.05
BH5	114	26/06/2016	5.80	108.20	BH7	116	20/10/2014	5.10	110.90
					BH7	116	4/02/2015	4.95	111.05
BH6	114	29/03/2010	1.70	112.30	BH7	116	11/04/2015	5.00	111.00
BH6	114	11/07/2010	3.20	110.80	BH7	116	21/06/2015	5.12	110.88
BH6	114	18/10/2010	4.35	109.65	BH7	116	20/08/2015	5.20	110.80
BH6	114	20/11/2010	4.25	109.75	BH7	116	20/11/2015	5.18	110.82
BH6	114	29/03/2011	2.00	112.00	BH7	116	26/06/2016	5.20	110.80
BH6	114	22/08/2011	3.20	110.80					
BH6	114	10/03/2012	0.80	113.20	BH8	123.92	1/10/2008	17.12	106.80
BH6	114	8/07/2012	3.00	111.00	BH8	123.92	2/04/2009	12.20	111.72
BH6	114	8/09/2012	4.35	109.65	BH8	123.92	10/08/2009	16.70	107.22
BH6	114	24/06/2013	4.50	109.50	BH8	123.92	29/03/2010	13.55	110.37
BH6	114	29/09/2013	4.65	109.35	BH8	123.92	10/07/2010	12.50	111.42
BH6	114	7/12/2013	4.95	109.05	BH8	123.92	13/08/2010	12.50	111.42
BH6	114	23/03/2014	2.00	112.00	BH8	123.92	18/10/2010	12.60	111.32
BH6	114	14/05/2014	3.60	110.40	BH8	123.92	20/11/2010	12.57	111.35
BH6	114	31/07/2014	4.10	109.90	BH8	123.92	29/03/2011	8.75	115.17
BH6	114	20/10/2014	4.30	109.70	BH8	123.92	22/08/2011	9.28	114.64
BH6	114	4/02/2015	3.60	110.40	BH8	123.92	10/03/2012	10.10	113.82
BH6	114	11/04/2015	3.60	110.40	BH8	123.92	8/07/2012	9.95	113.97
BH6	114	21/06/2015	3.70	110.30	BH8	123.92	8/09/2012	10.32	113.60
BH6	114	20/08/2015	4.30	109.70	BH8	123.92	24/06/2013	11.70	112.22
BH6	114	20/11/2015	4.40	109.60	BH8	123.92	29/09/2013	11.90	112.02
					BH8	123.92	7/12/2013	12.10	111.82
BH7	116	1/03/2008	4.70	111.30	BH8	123.92	23/03/2014	12.20	111.72
BH7	116	2/04/2009	3.35	112.65	BH8	123.92	14/05/2014	12.50	111.42
BH7	116	10/08/2009	3.35	112.65	BH8	123.92	31/07/2014	12.50	111.42
BH7	116	29/03/2010	4.60	111.40	BH8	123.92	20/10/2014	12.60	111.32

Table 13 Continued: Groundwater levels in monitoring bores

BH8	123.92	25/01/2015	12.60	111.32	BH10	103.95	31/07/2014	7.75	96.20
BH8	123.92	4/02/2015	12.65	111.27	BH10	103.95	20/10/2014	7.85	96.10
BH8	123.92	11/04/2015	12.81	111.11	BH10	103.95	4/02/2015	7.80	96.15
BH8	123.92	21/06/2015	13.00	110.92	BH10	103.95	11/04/2015	7.85	96.10
BH8	123.92	20/08/2015	13.12	110.80	BH10	103.95	21/06/2015	8.00	95.95
BH8	123.92	20/11/2015	13.20	110.72	BH10	103.95	20/08/2015	8.10	95.85
BH8	123.92	26/06/2016	13.45	110.47	BH10	103.95	20/11/2015	8.15	95.80
					BH10	103.95	26/06/2016	8.23	95.72
BH9	122.29	1/10/2008	12.42	109.87					
BH9	122.29	2/04/2009	7.40	114.89	BH11	104.13	1/10/2008	7.60	96.53
BH9	122.29	10/08/2009	9.66	112.63	BH11	104.13	2/04/2009	5.51	98.62
BH9	122.29	29/03/2010	8.70	113.59	BH11	104.13	10/08/2009	4.73	99.40
BH9	122.29	10/07/2010	8.60	113.69	BH11	104.13	28/03/2010	4.26	99.87
BH9	122.29	13/08/2010	8.85	113.44	BH11	104.13	11/07/2010	3.75	100.38
BH9	122.29	18/10/2010	9.15	113.14	BH11	104.13	18/10/2010	3.70	100.43
BH9	122.29	20/11/2010	9.23	113.06	BH11	104.13	20/11/2010	3.75	100.38
BH9	122.29	29/03/2011	6.50	115.79	BH11	104.13	29/03/2011	2.25	101.88
BH9	122.29	22/08/2011	7.22	115.07	BH11	104.13	22/08/2011	2.75	101.38
BH9	122.29	10/03/2012	8.15	114.14	BH11	104.13	10/03/2012	2.75	101.38
BH9	122.29	8/07/2012	7.95	114.34	BH11	104.13	8/07/2012	2.65	101.48
BH9	122.29	8/09/2012	8.33	113.96	BH11	104.13	8/09/2012	2.80	101.33
BH9	122.29	24/06/2013	9.60	112.69	BH11	104.13	1/11/2012	3.00	101.13
BH9	122.29	29/09/2013	9.90	112.39	BH11	104.13	20/12/2012	3.00	101.13
BH9	122.29	7/12/2013	10.30	111.99	BH11	104.13	24/06/2013	3.45	100.68
BH9	122.29	23/03/2014	10.35	111.94	BH11	104.13	29/09/2013	3.70	100.43
BH9	122.29	14/05/2014	10.75	111.54	BH11	104.13	7/12/2013	4.05	100.08
BH9	122.29	31/07/2014	10.90	111.39	BH11	104.13	23/03/2014	4.25	99.88
BH9	122.29	20/10/2014	11.30	110.99	BH11	104.13	14/05/2014	4.35	99.78
BH9	122.29	25/01/2015	11.30	110.99	BH11	104.13	31/07/2014	4.55	99.58
BH9	122.29	4/02/2015	11.45	110.84	BH11	104.13	20/10/2014	4.80	99.33
BH9	122.29	11/04/2015	11.57	110.72	BH11	104.13	8/12/2014	4.90	99.23
BH9	122.29	21/06/2015	11.82	110.47	BH11	104.13	25/01/2015	4.85	99.28
BH9	122.29	20/08/2015	12.00	110.29	BH11	104.13	4/02/2015	4.90	99.23
BH9	122.29	20/11/2015	12.00	110.29	BH11	104.13	11/04/2015	5.02	99.11
BH9	122.29	26/06/2016	12.15	110.14	BH11	104.13	21/06/2015	5.18	98.95
					BH11	104.13	20/08/2015	5.40	98.73
BH10	103.95	1/10/2008	10.44	93.51	BH11	104.13	22/09/2015	5.50	98.63
BH10	103.95	2/04/2009	7.98	95.97	BH11	104.13	20/11/2015	5.55	98.58
BH10	103.95	10/08/2009	7.80	96.15	BH11	104.13	26/06/2016	5.85	98.28
BH10	103.95	28/03/2010	7.70	96.25					
BH10	103.95	11/07/2010	7.50	96.45	BH12	102.08	1/10/2008	7.46	94.62
BH10	103.95	18/10/2010	7.64	96.31	BH12	102.08	2/04/2009	7.22	94.86
BH10	103.95	20/11/2010	7.62	96.33	BH12	102.08	10/08/2009	7.02	95.06
BH10	103.95	29/03/2011	7.30	96.65	BH12	102.08	28/03/2010	6.90	95.18
BH10	103.95	22/08/2011	7.19	96.76	BH12	102.08	11/07/2010	6.82	95.26
BH10	103.95	10/03/2012	7.15	96.80	BH12	102.08	18/10/2010	6.87	95.21
BH10	103.95	8/07/2012	7.00	96.95	BH12	102.08	20/11/2010	6.83	95.25
BH10	103.95	8/09/2012	7.15	96.80	BH12	102.08	29/03/2011	6.50	95.58
BH10	103.95	20/12/2012	7.15	96.80	BH12	102.08	22/08/2011	6.42	95.66
BH10	103.95	24/06/2013	7.35	96.60	BH12	102.08	10/03/2012	6.35	95.73
BH10	103.95	29/09/2013	7.45	96.50	BH12	102.08	8/07/2012	6.25	95.83
BH10	103.95	7/12/2013	7.60	96.35	BH12	102.08	8/09/2012	6.40	95.68
BH10	103.95	23/03/2014	7.55	96.40	BH12	102.08	20/12/2012	6.40	95.68
BH10	103.95	14/05/2014	7.55	96.40	BH12	102.08	24/06/2013	6.55	95.53

Table 13 Continued: Groundwater levels in monitoring bores

BH12	102.08	29/09/2013	6.60	95.48	GBMB3	113	7/12/2013	7.00	106.00
BH12	102.08	7/12/2013	6.75	95.33	GBMB3	113	23/03/2014	5.65	107.35
BH12	102.08	23/03/2014	6.70	95.38	GBMB3	113	14/05/2014	6.20	106.80
BH12	102.08	14/05/2014	6.70	95.38	GBMB3	113	31/07/2014	8.20	104.80
BH12	102.08	31/07/2014	7.10	94.98	GBMB3	113	20/10/2014	8.35	104.65
BH12	102.08	20/10/2014	7.20	94.88	GBMB3	113	4/02/2015	8.40	104.60
BH12	102.08	4/02/2015	7.00	95.08	GBMB3	113	11/04/2015	8.40	104.60
BH12	102.08	11/04/2015	6.95	95.13	GBMB3	113	21/06/2015	8.45	104.55
BH12	102.08	21/06/2015	7.05	95.03	GBMB3	113	20/08/2015	8.55	104.45
BH12	102.08	20/08/2015	7.20	94.88	GBMB3	113	7/12/2013	7.00	106.00
BH12	102.08	20/11/2015	7.25	94.83	GBMB3	113	23/03/2014	5.65	107.35
BH12	102.08	26/06/2016	7.30	94.78	GBMB3	113	14/05/2014	6.20	106.80
					GBMB3	113	31/07/2014	8.20	104.80
GBMB1	109	1/03/2008	3.60	105.40	GBMB3	113	20/10/2014	8.35	104.65
GBMB1	109	2/04/2009	1.09	107.91	GBMB3	113	4/02/2015	8.40	104.60
GBMB1	109	10/08/2009	1.97	107.03	GBMB3	113	11/04/2015	8.40	104.60
GBMB1	109	29/03/2010	3.00	106.00	GBMB3	113	21/06/2015	8.45	104.55
GBMB1	109	11/07/2010	3.15	105.85	GBMB3	113	20/08/2015	8.55	104.45
GBMB1	109	18/10/2010	3.50	105.50	GBMB3	113	20/11/2015	8.65	104.35
GBMB1	109	20/11/2010	3.35	105.65	GBMB3	113	26/06/2016	8.30	104.70
GBMB1	109	29/03/2011	1.90	107.10					
GBMB1	109	22/08/2011	1.98	107.02	GBMB6	113	1/03/2008	11.70	101.30
GBMB1	109	10/03/2012	1.90	107.10	GBMB6	113	2/04/2009	10.73	102.27
GBMB1	109	8/07/2012	1.85	107.15	GBMB6	113	10/08/2009	13.14	99.86
GBMB1	109	8/09/2012	2.30	106.70	GBMB6	113	29/03/2010	10.05	102.95
GBMB1	109	24/06/2013	3.00	106.00	GBMB6	113	11/07/2010	9.55	103.45
GBMB1	109	29/09/2013	3.25	105.75	GBMB6	113	18/10/2010	9.85	103.15
GBMB1	109	7/12/2013	3.50	105.50	GBMB6	113	20/11/2010	10.20	102.80
GBMB1	109	23/03/2014	2.75	106.25	GBMB6	113	29/03/2011	7.10	105.90
GBMB1	109	14/05/2014	3.00	106.00	GBMB6	113	22/08/2011	8.00	105.00
GBMB1	109	31/07/2014	4.35	104.65	GBMB6	113	10/03/2012	7.85	105.15
GBMB1	109	20/10/2014	4.50	104.50	GBMB6	113	8/07/2012	7.50	105.50
GBMB1	109	4/02/2015	4.55	104.45	GBMB6	113	8/09/2012	7.60	105.40
GBMB1	109	11/04/2015	4.55	104.45	GBMB6	113	24/06/2013	8.10	104.90
GBMB1	109	21/06/2015	4.65	104.35	GBMB6	113	29/09/2013	8.20	104.80
GBMB1	109	20/08/2015	4.78	104.22	GBMB6	113	7/12/2013	8.55	104.45
GBMB1	109	20/11/2015	4.85	104.15	GBMB6	113	23/03/2014	8.10	104.90
GBMB1	109	26/06/2016	5.30	103.70	GBMB6	113	14/05/2014	8.00	105.00
					GBMB6	113	31/07/2014	8.55	104.45
GBMB3	113	1/03/2008	7.30	105.70	GBMB6	113	20/10/2014	8.70	104.30
GBMB3	113	2/04/2009	2.48	110.52	GBMB6	113	4/02/2015	8.70	104.30
GBMB3	113	10/08/2009	4.18	108.82	GBMB6	113	11/04/2015	8.85	104.15
GBMB3	113	29/03/2010	2.80	110.20	GBMB6	113	21/06/2015	8.85	104.15
GBMB3	113	11/07/2010	3.55	109.45	GBMB6	113	20/08/2015	9.00	104.00
GBMB3	113	18/10/2010	3.70	109.30	GBMB6	113	20/11/2015	9.05	103.95
GBMB3	113	20/11/2010	3.80	109.20	GBMB6	113	26/06/2016	8.16	104.84
GBMB3	113	29/03/2011	2.75	110.25					
GBMB3	113	22/08/2011	3.90	109.10	SY1	107.48	1/10/2008	10.62	96.86
GBMB3	113	10/03/2012	3.80	109.20	SY1	107.48	2/04/2009	8.09	99.39
GBMB3	113	8/07/2012	4.80	108.20	SY1	107.48	10/08/2009	10.47	97.01
GBMB3	113	8/09/2012	4.90	108.10	SY1	107.48	29/03/2010	7.10	100.38
GBMB3	113	24/06/2013	6.60	106.40	SY1	107.48	11/07/2010	6.75	100.73
GBMB3	113	29/09/2013	6.75	106.25	SY1	107.48	20/11/2010	8.10	99.38

Table 13 Continued: Groundwater levels in monitoring bores

SY1	107.48	29/03/2011	5.25	102.23					
SY1	107.48	22/08/2011	6.00	101.48					
SY1	107.48	10/03/2012	5.45	102.03					
SY1	107.48	8/07/2012	5.10	102.38					
SY1	107.48	8/09/2012	5.90	101.58					
SY1	107.48	24/06/2013	5.50	101.98					
SY1	107.48	29/09/2013	5.55	101.93					
SY1	107.48	7/12/2013	6.00	101.48					
SY1	108.48	23/03/2014	5.00	103.48					
SY1	108.48	14/05/2014	5.00	103.48					
SY1	108.48	31/07/2014	5.10	103.38					
SY1	108.48	20/10/2014	5.15	103.33					
SY1	108.48	25/01/2015	5.10	103.38					
SY1	108.48	4/02/2015	5.08	103.40					
SY1	108.48	11/04/2015	5.15	103.33					
SY1	108.48	21/06/2015	5.24	103.24					
SY1	108.48	20/08/2015	5.65	102.83					
SY1	108.48	20/11/2015	5.70	102.78					
SY1	108.48	26/06/2016	5.45	103.03					

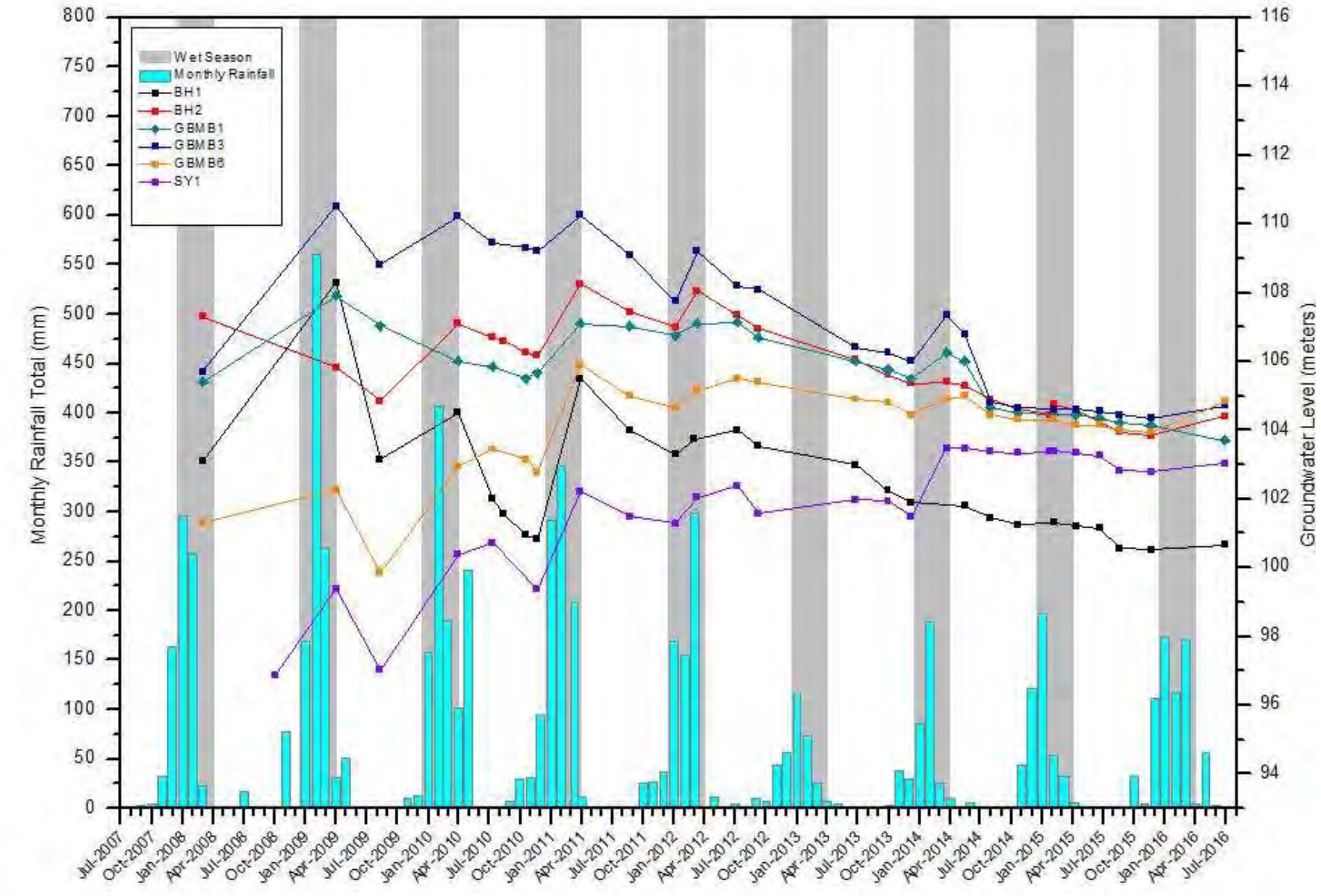


Figure 31: Water Levels - Golden Butterfly Pit Monitoring Bores

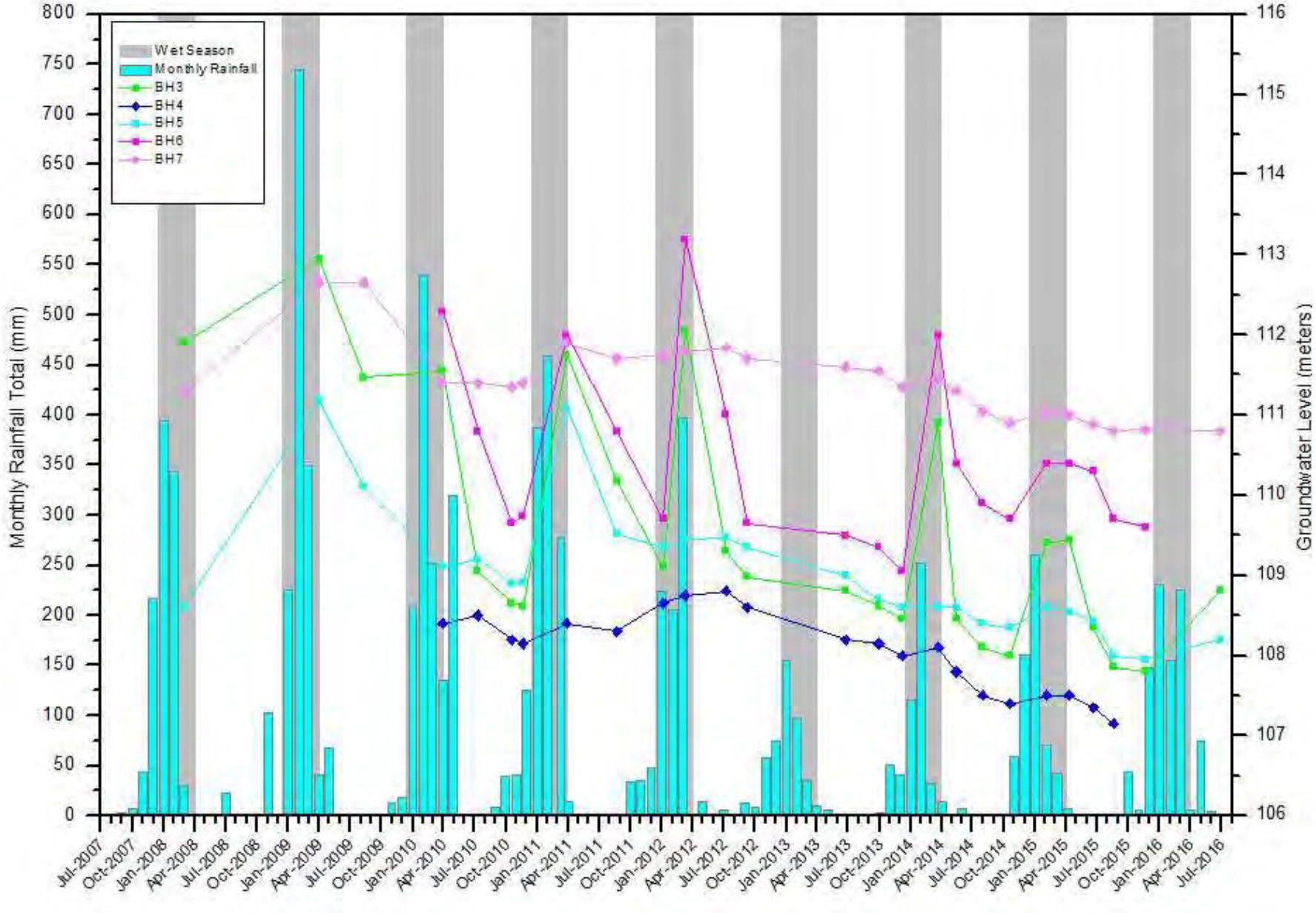


Figure 32: Water Levels - Golden Butterfly Dump Monitoring Bores

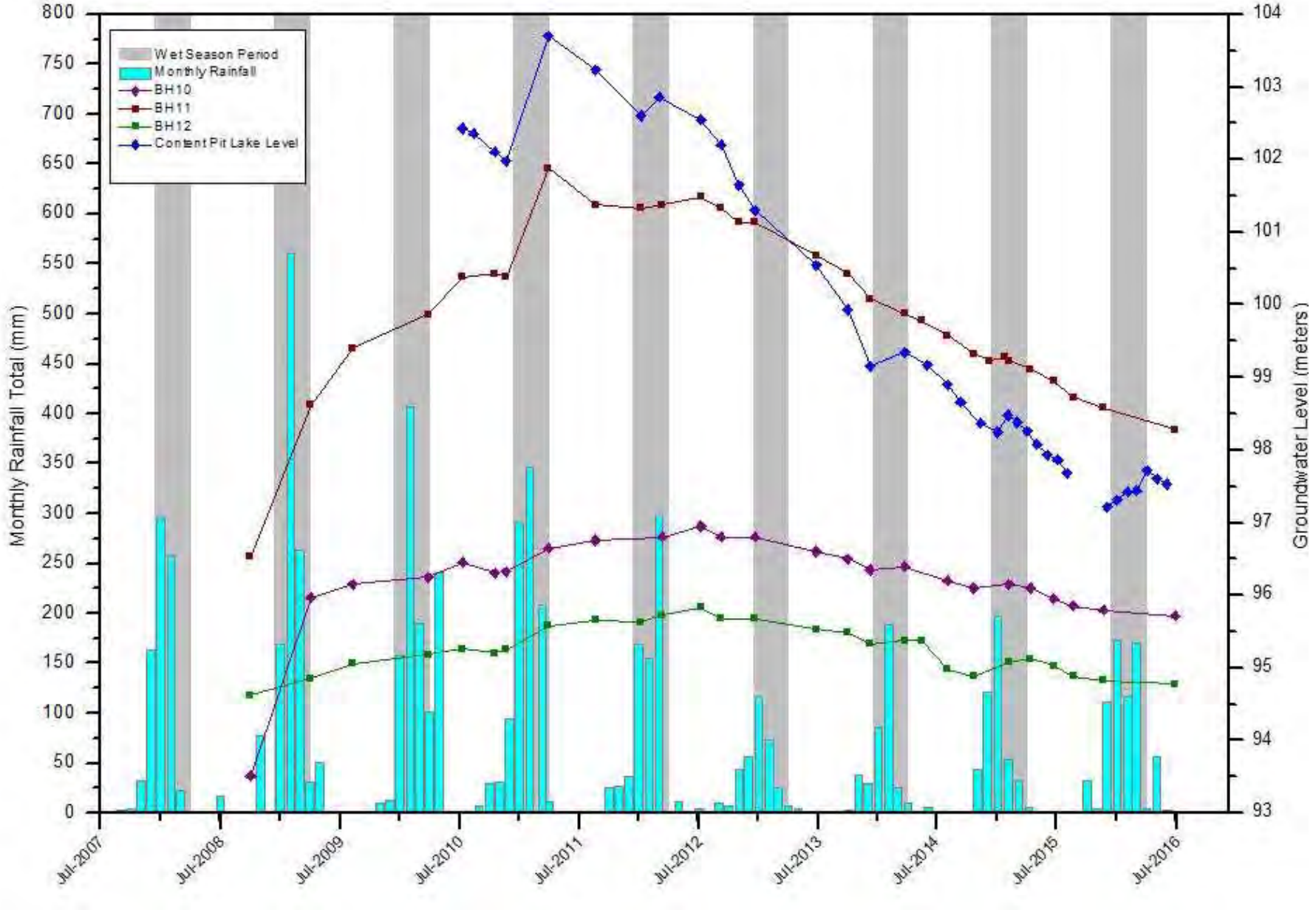


Figure 33: Water Levels - Content Pit Monitoring Bores

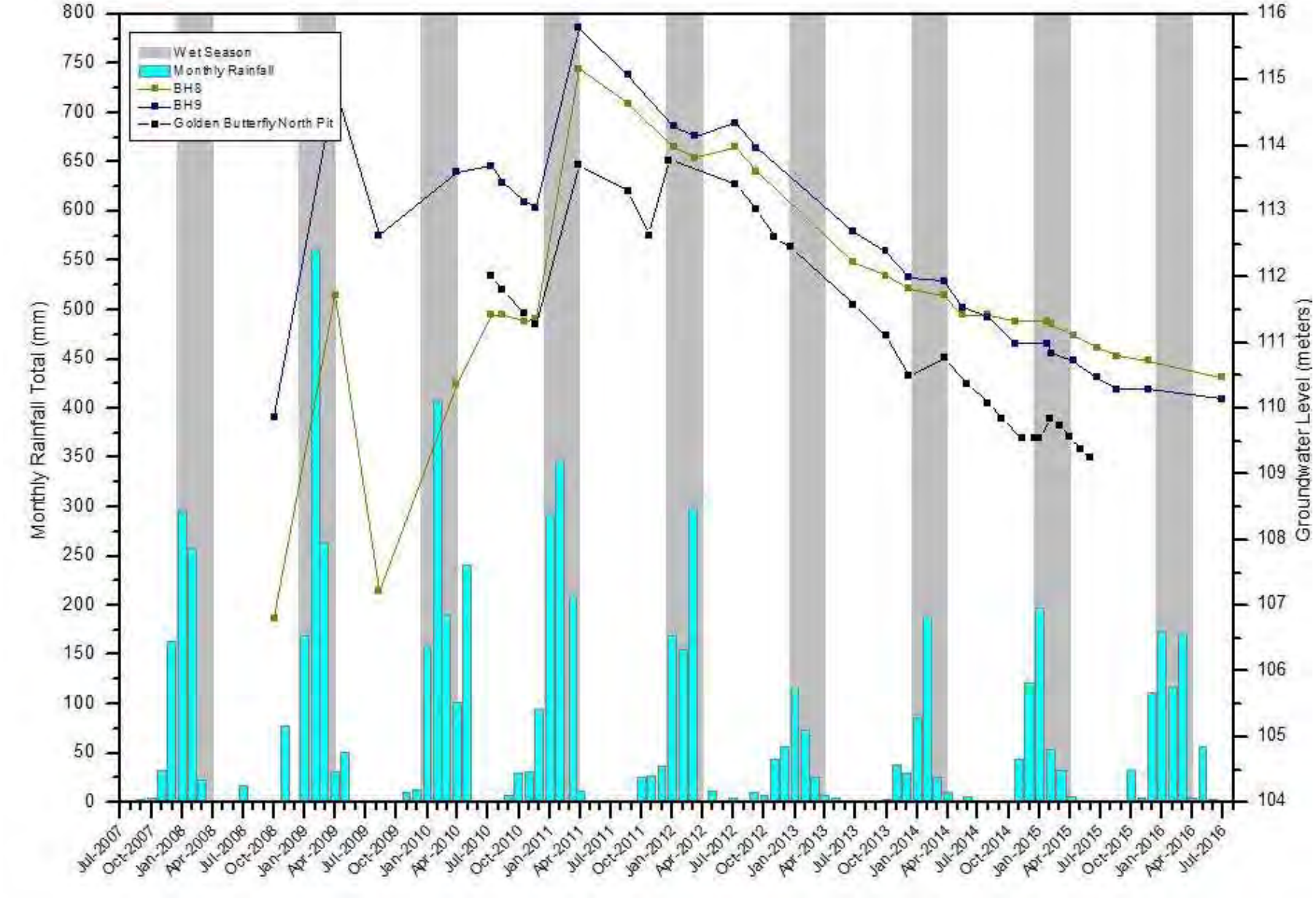


Figure 34: Water Levels - Golden Butterfly North Pit Monitoring Bores

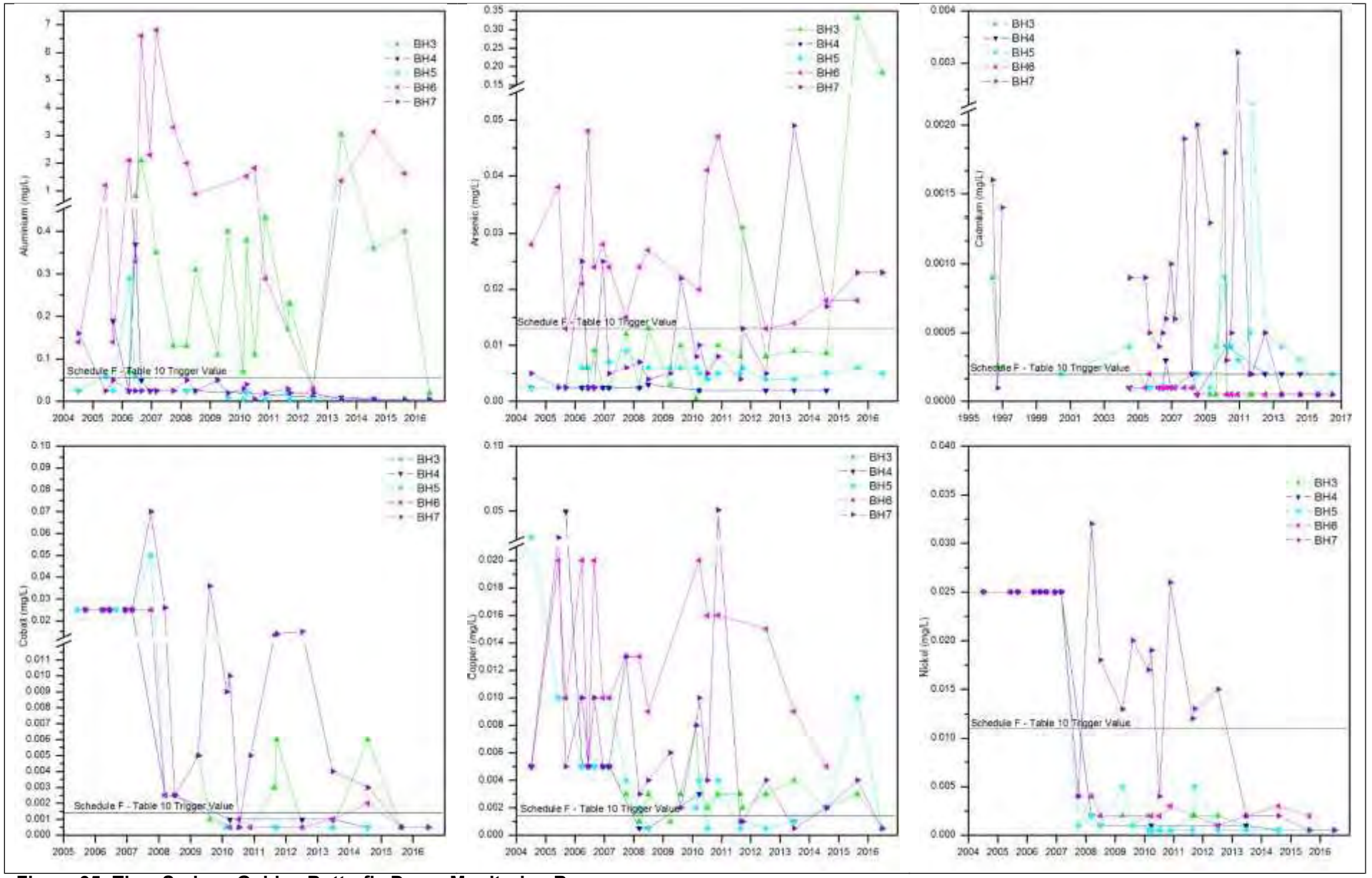


Figure 35: Time Series - Golden Butterfly Dump Monitoring Bores

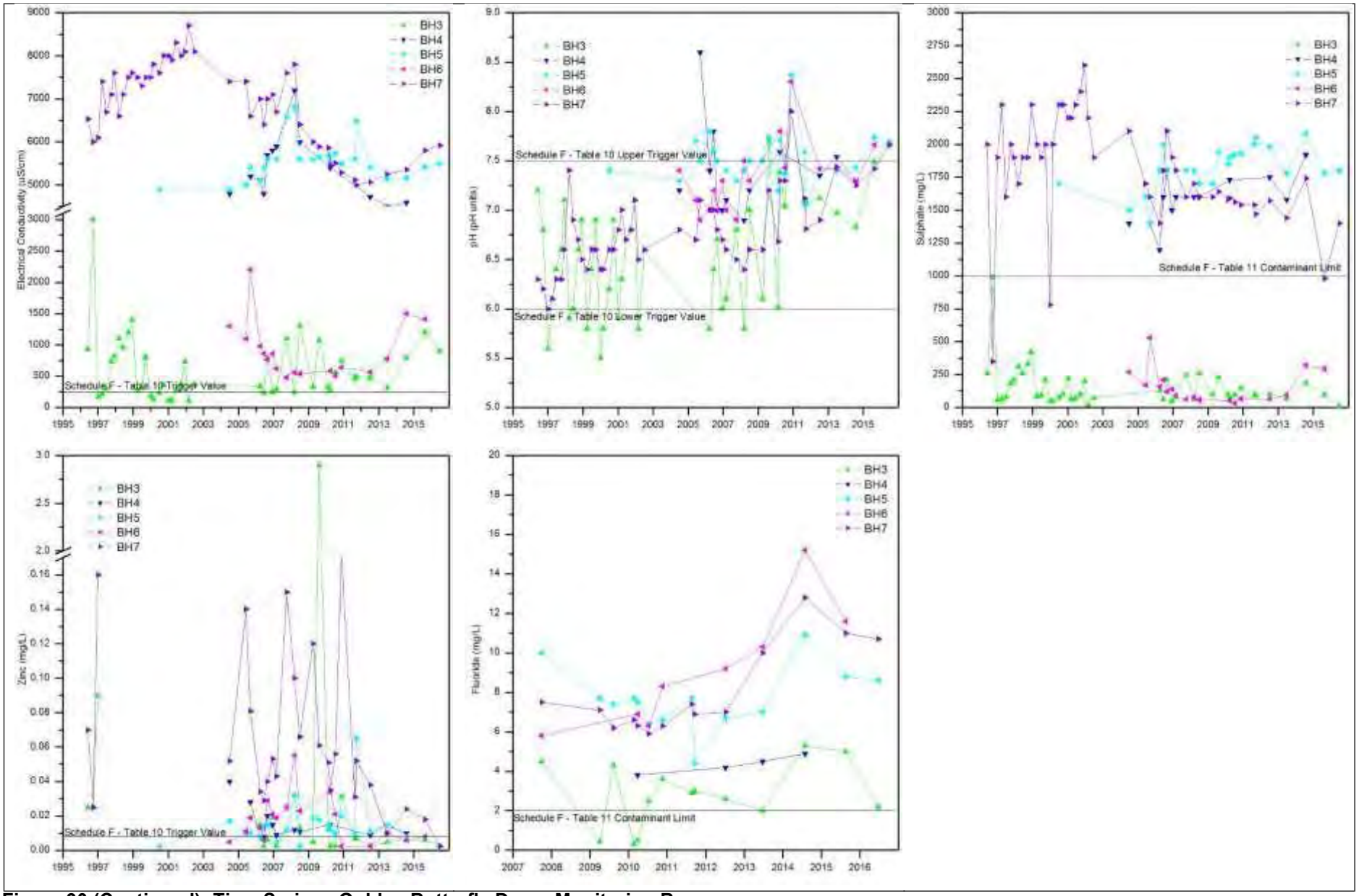


Figure 30 (Continued): Time Series - Golden Butterfly Dump Monitoring Bores

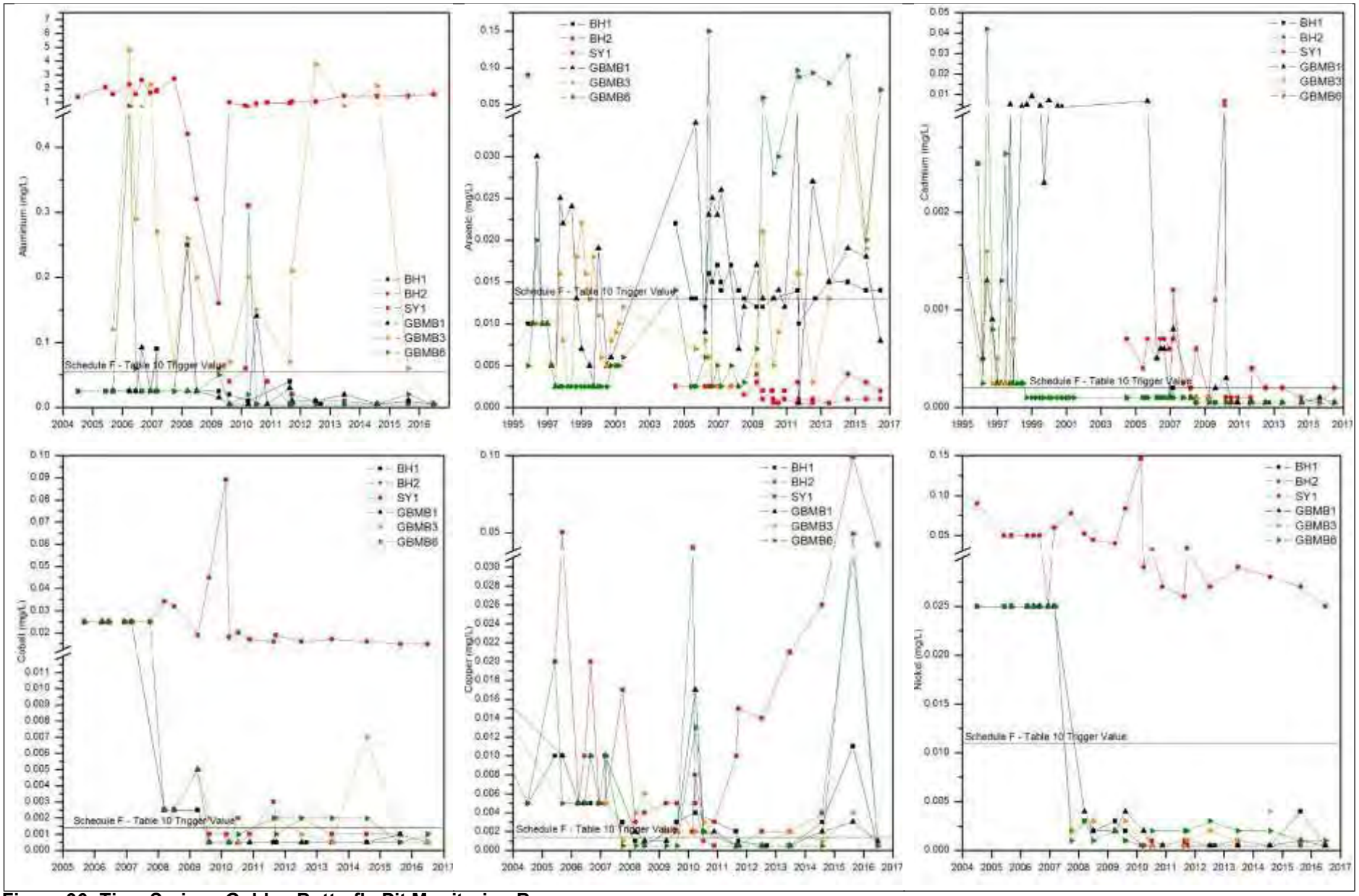


Figure 36: Time Series - Golden Butterfly Pit Monitoring Bores

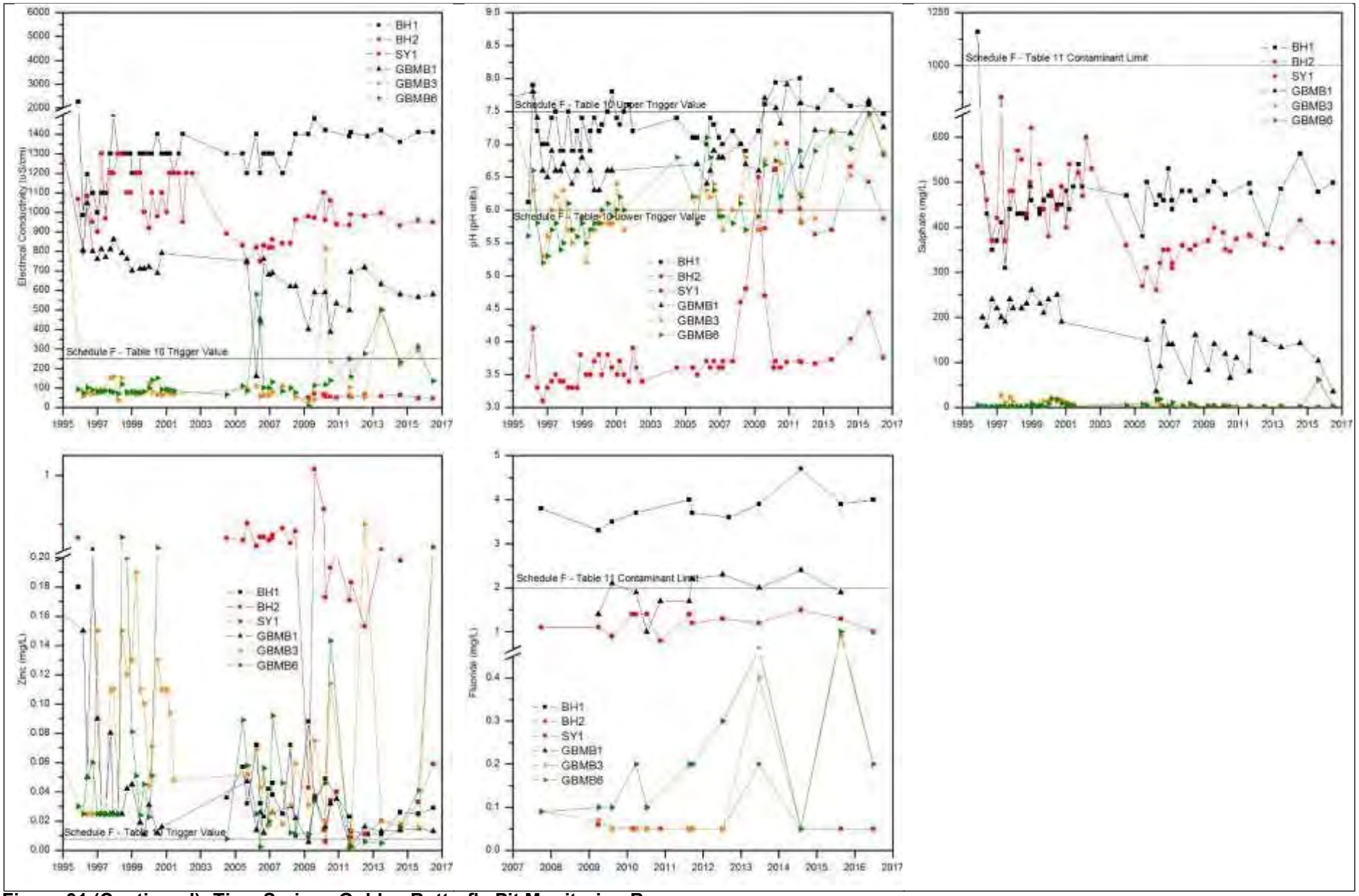


Figure 31 (Continued): Time Series - Golden Butterfly Pit Monitoring Bores

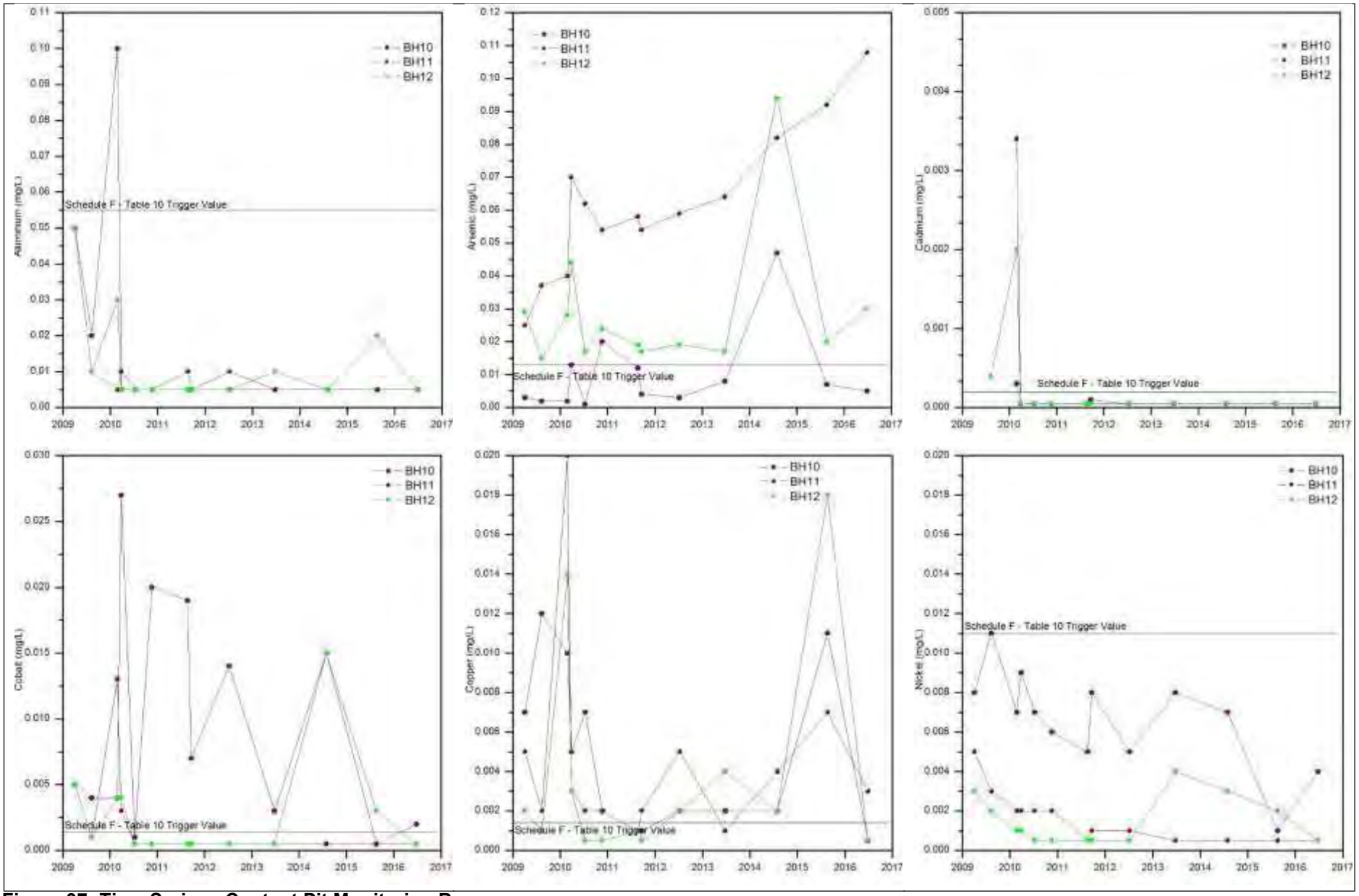


Figure 37: Time Series - Content Pit Monitoring Bores

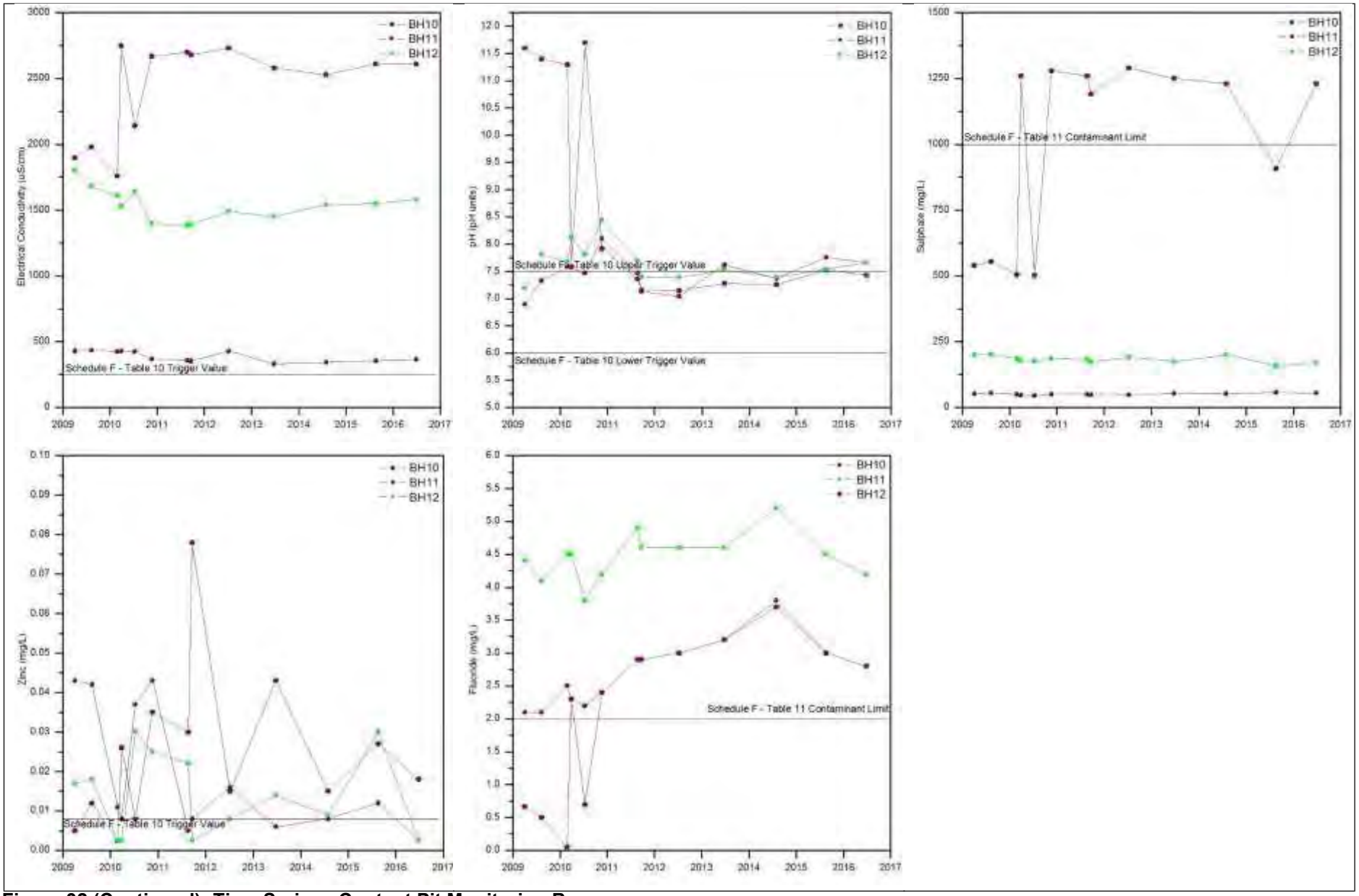


Figure 32 (Continued): Time Series - Content Pit Monitoring Bores

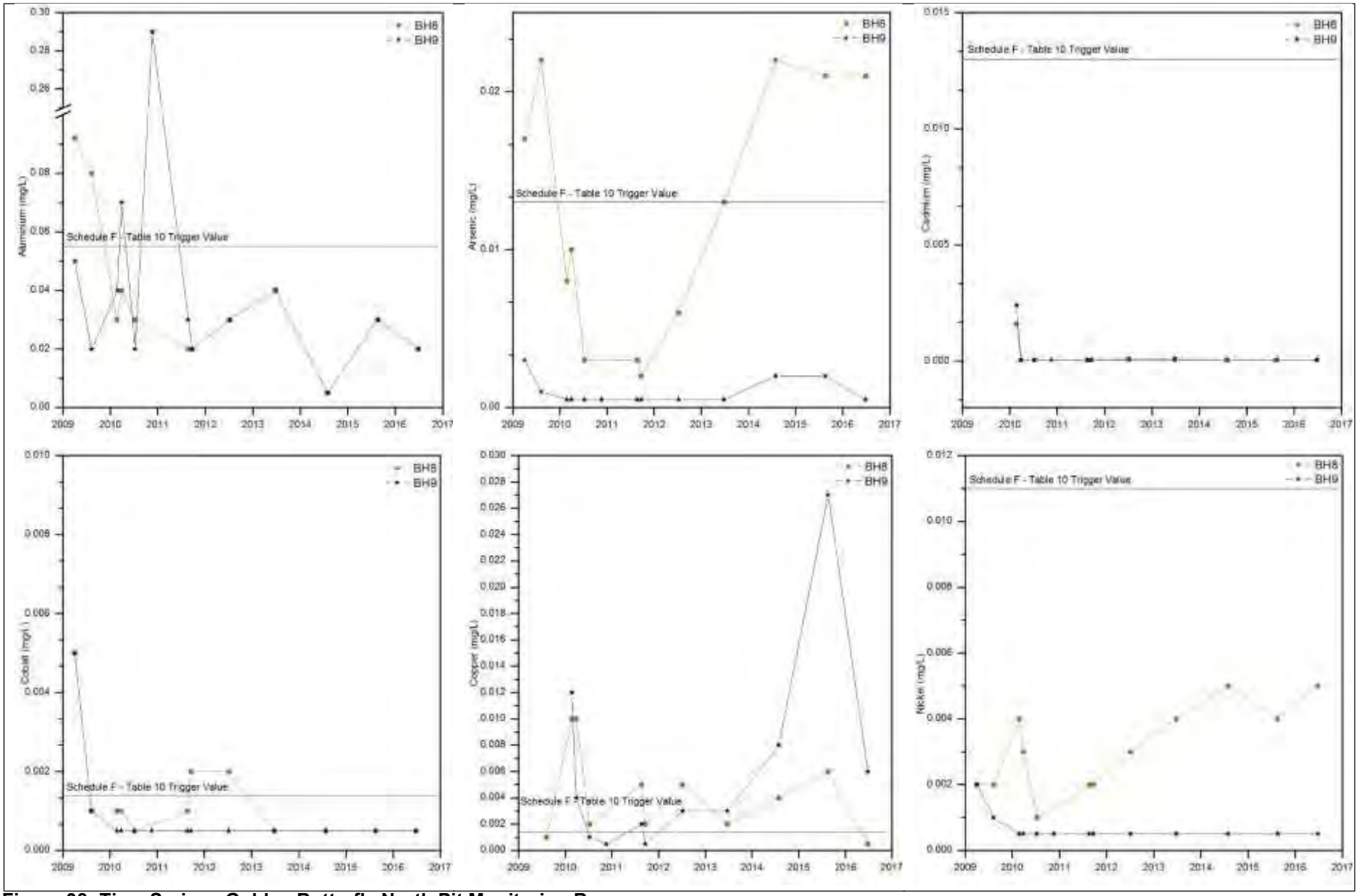


Figure 38: Time Series - Golden Butterfly North Pit Monitoring Bores

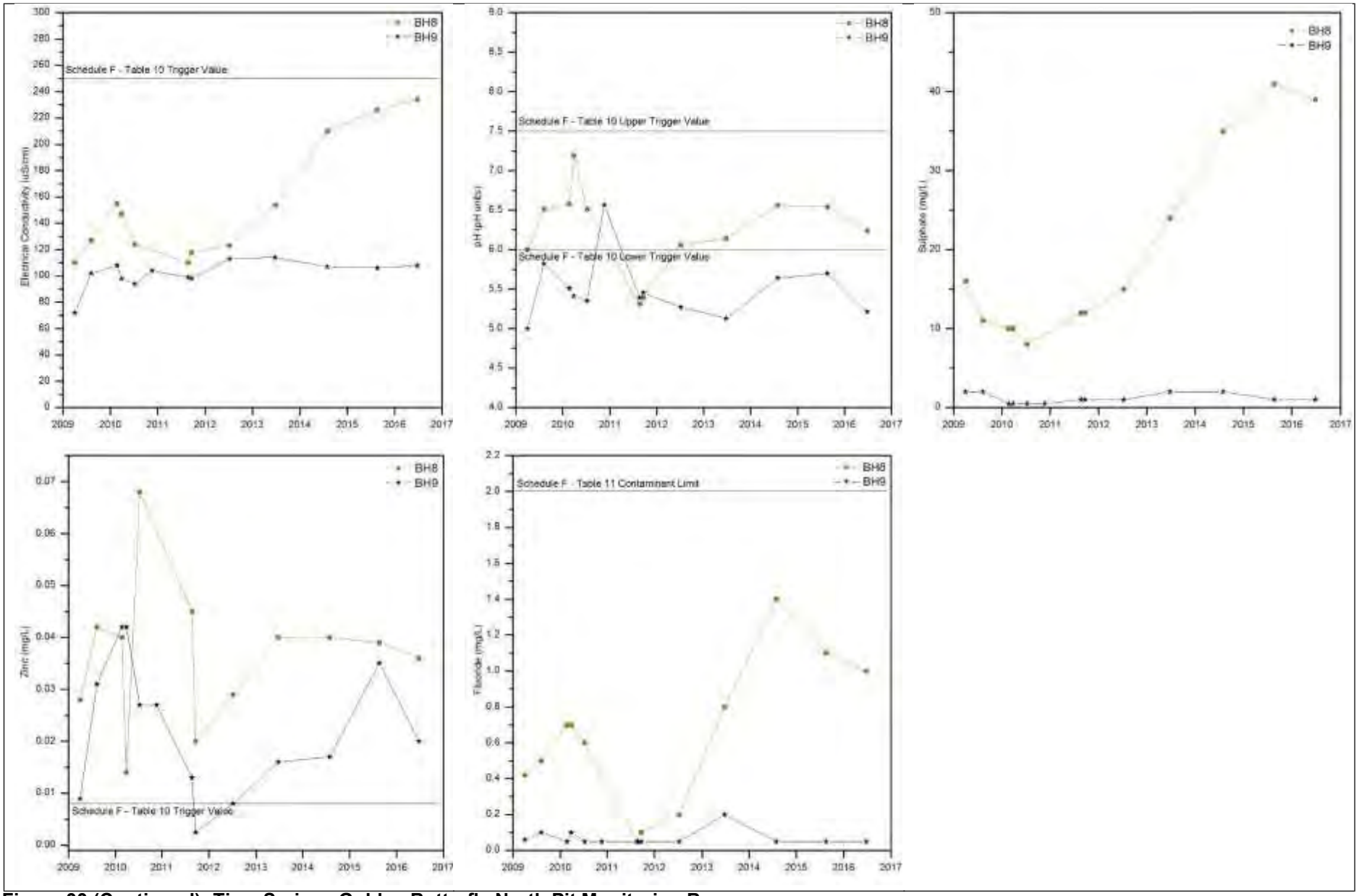


Figure 33 (Continued): Time Series - Golden Butterfly North Pit Monitoring Bores

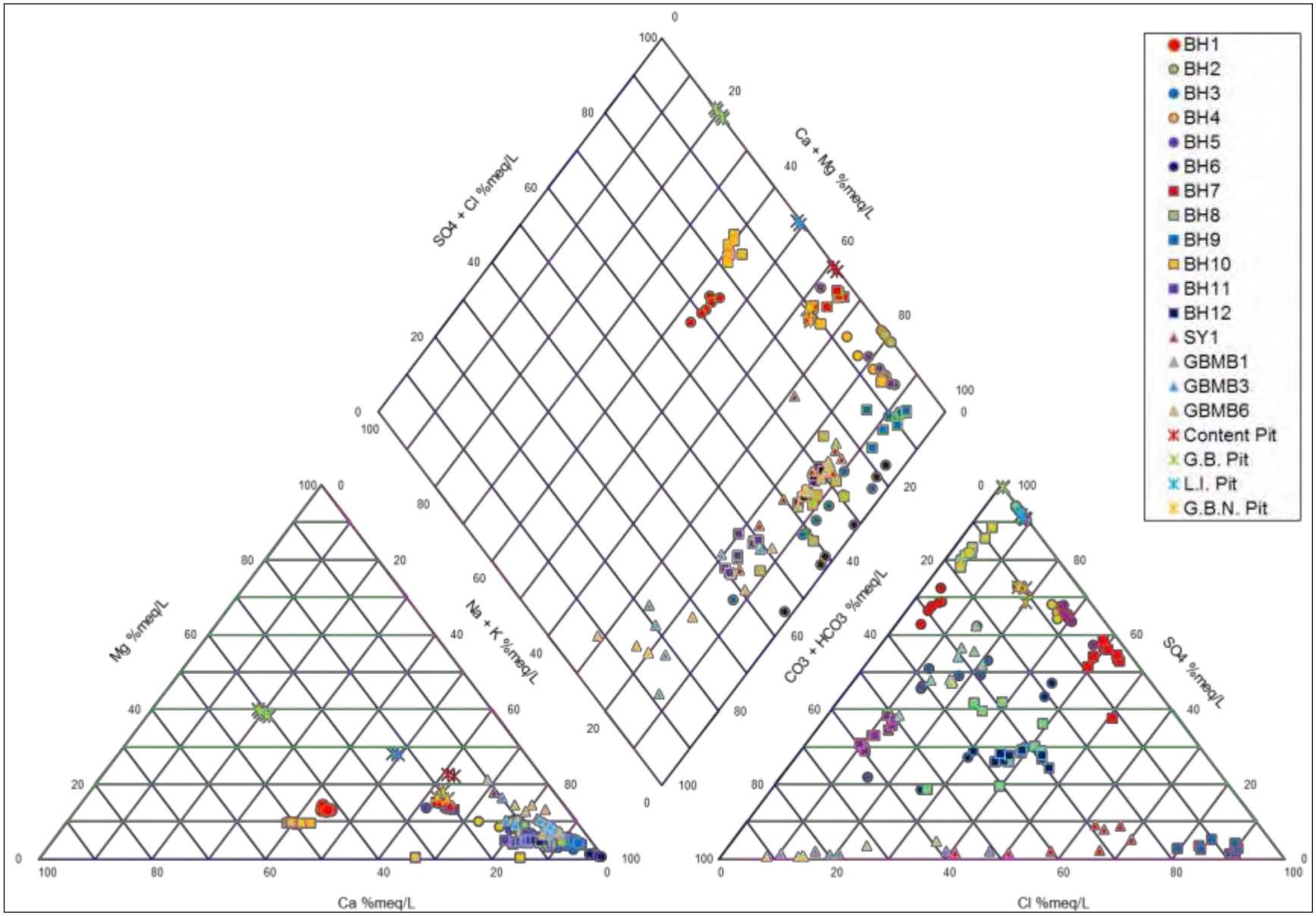
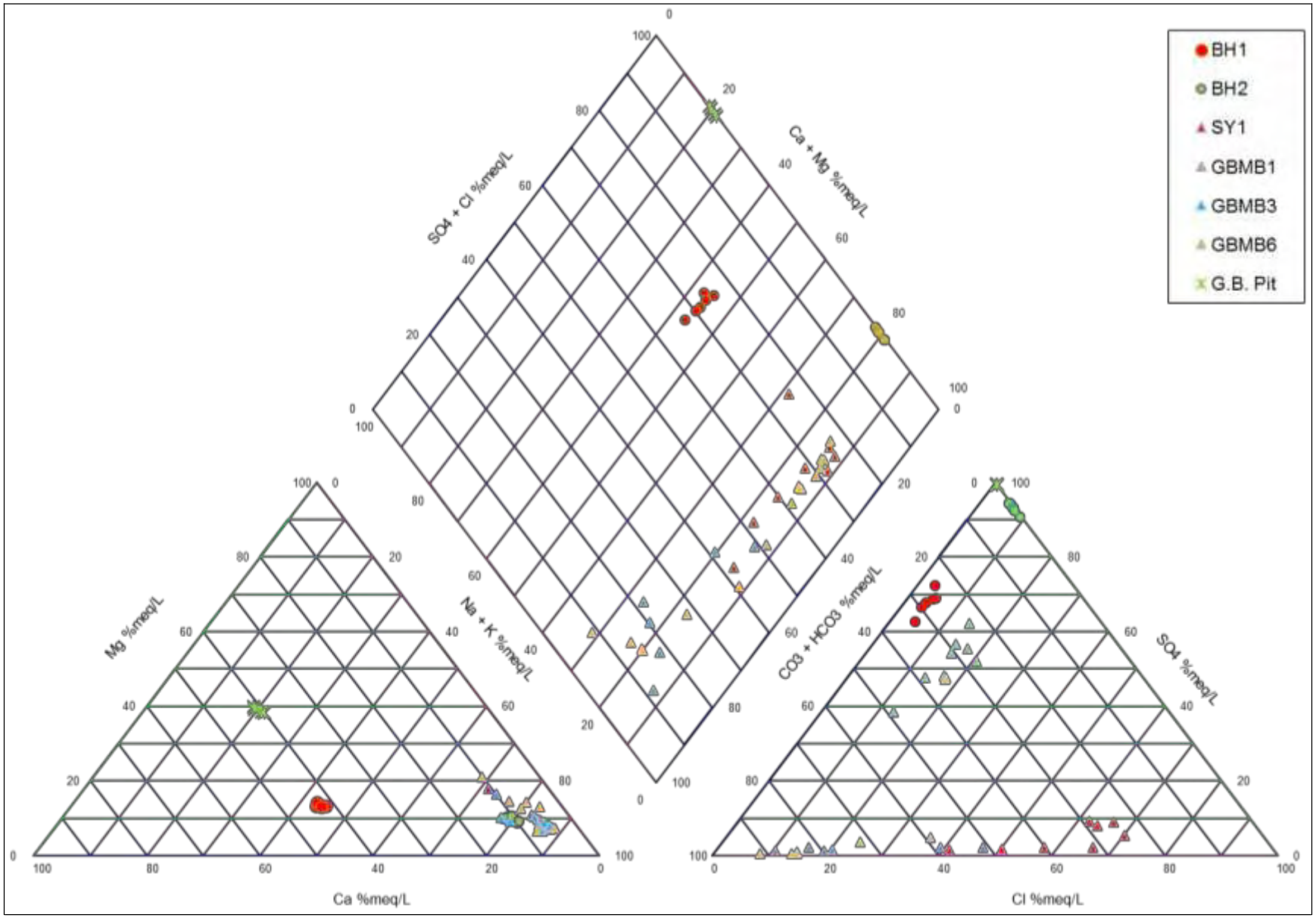


Figure 39: Piper Plot – All Bore Sites



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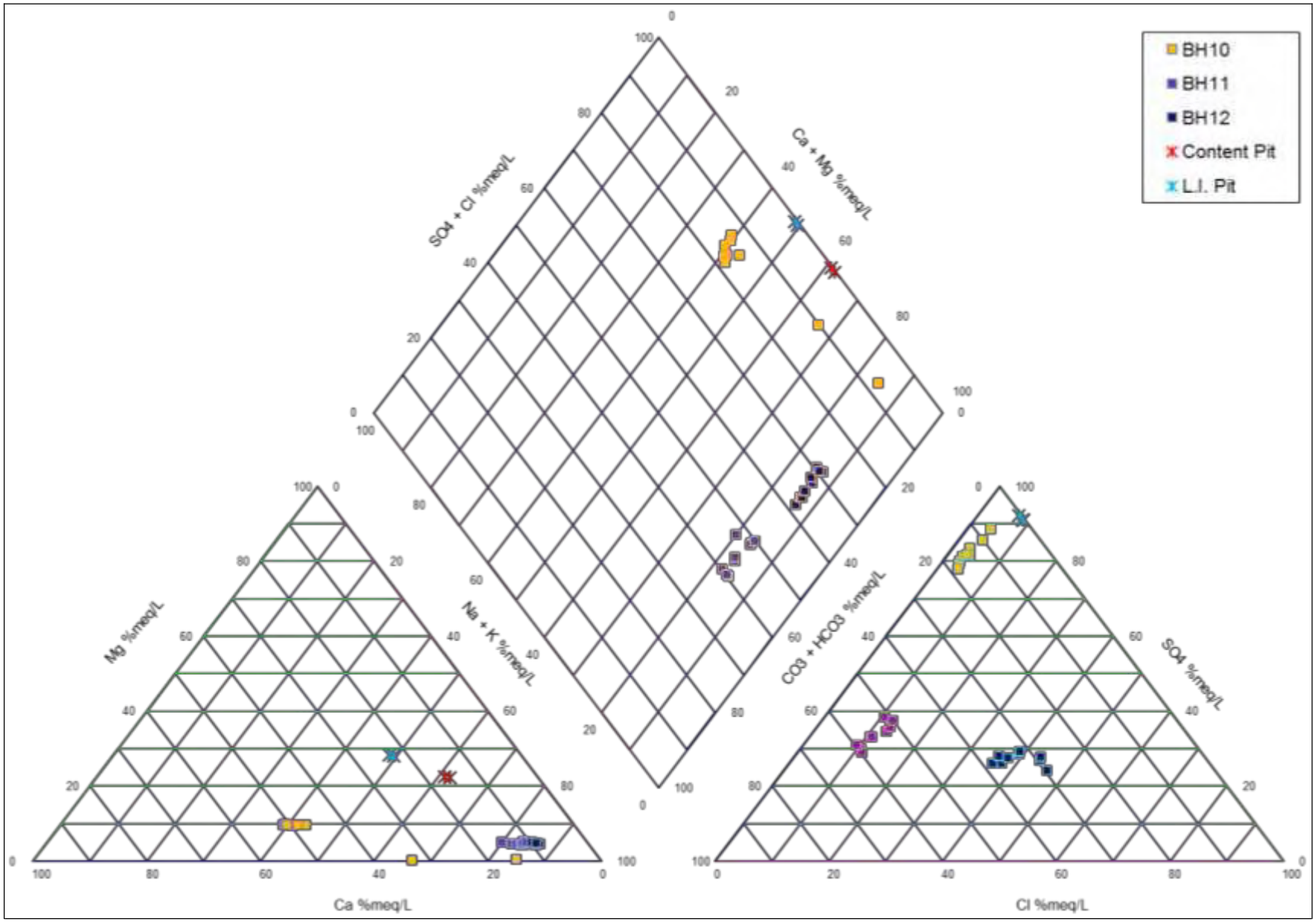

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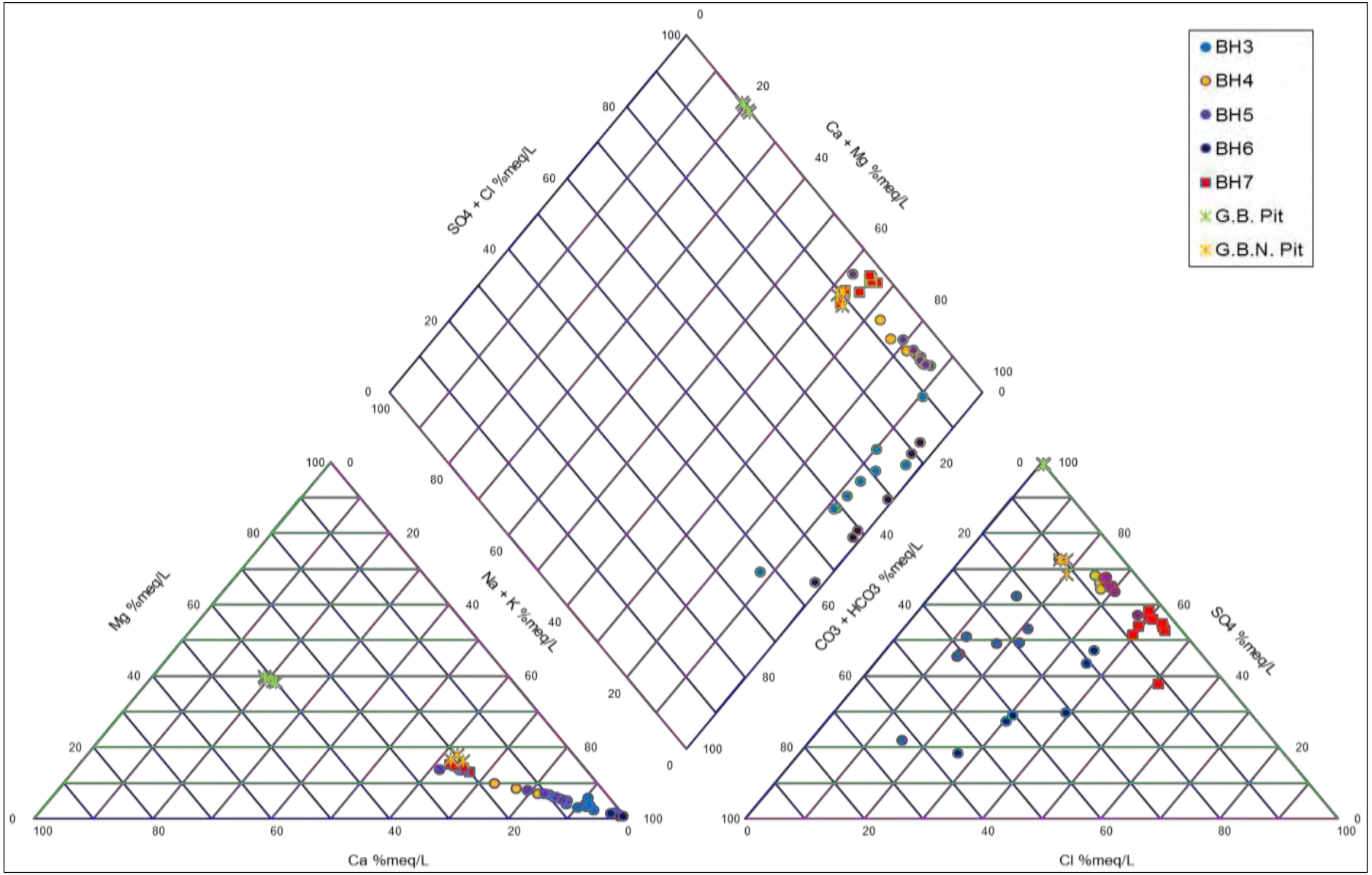
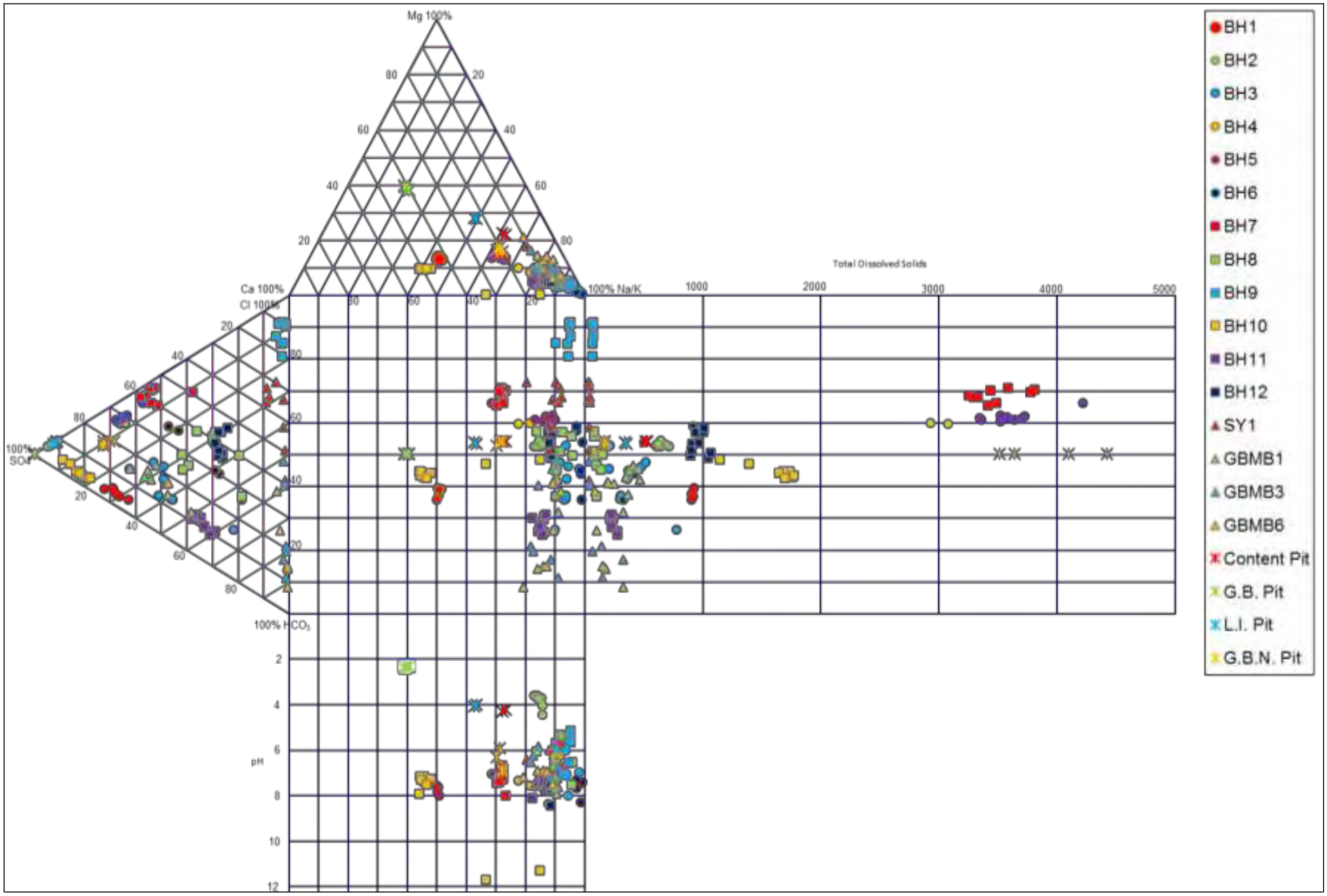


Figure 42: Piper Plot – Golden Butterfly Waste Rock Dump Bores



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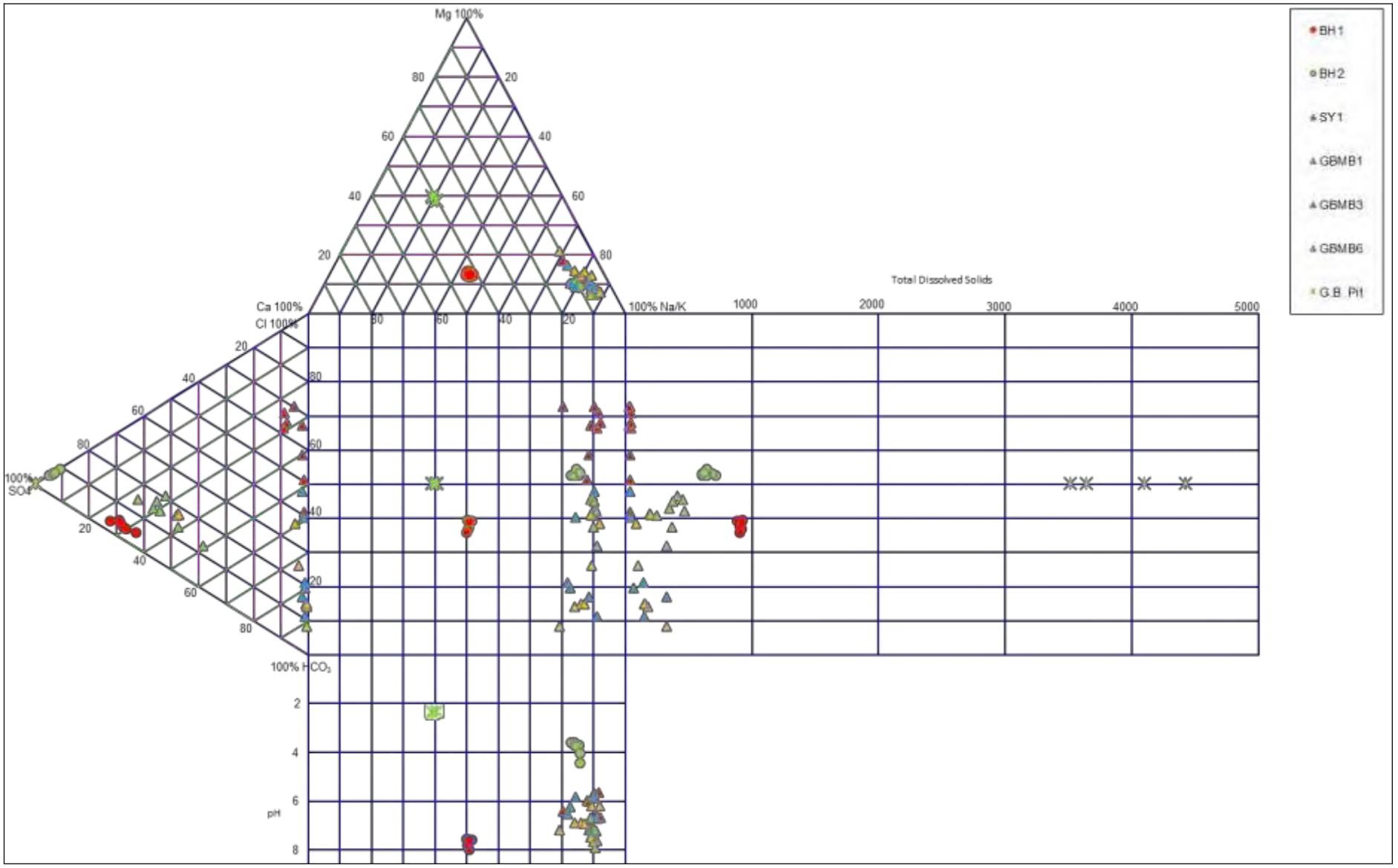

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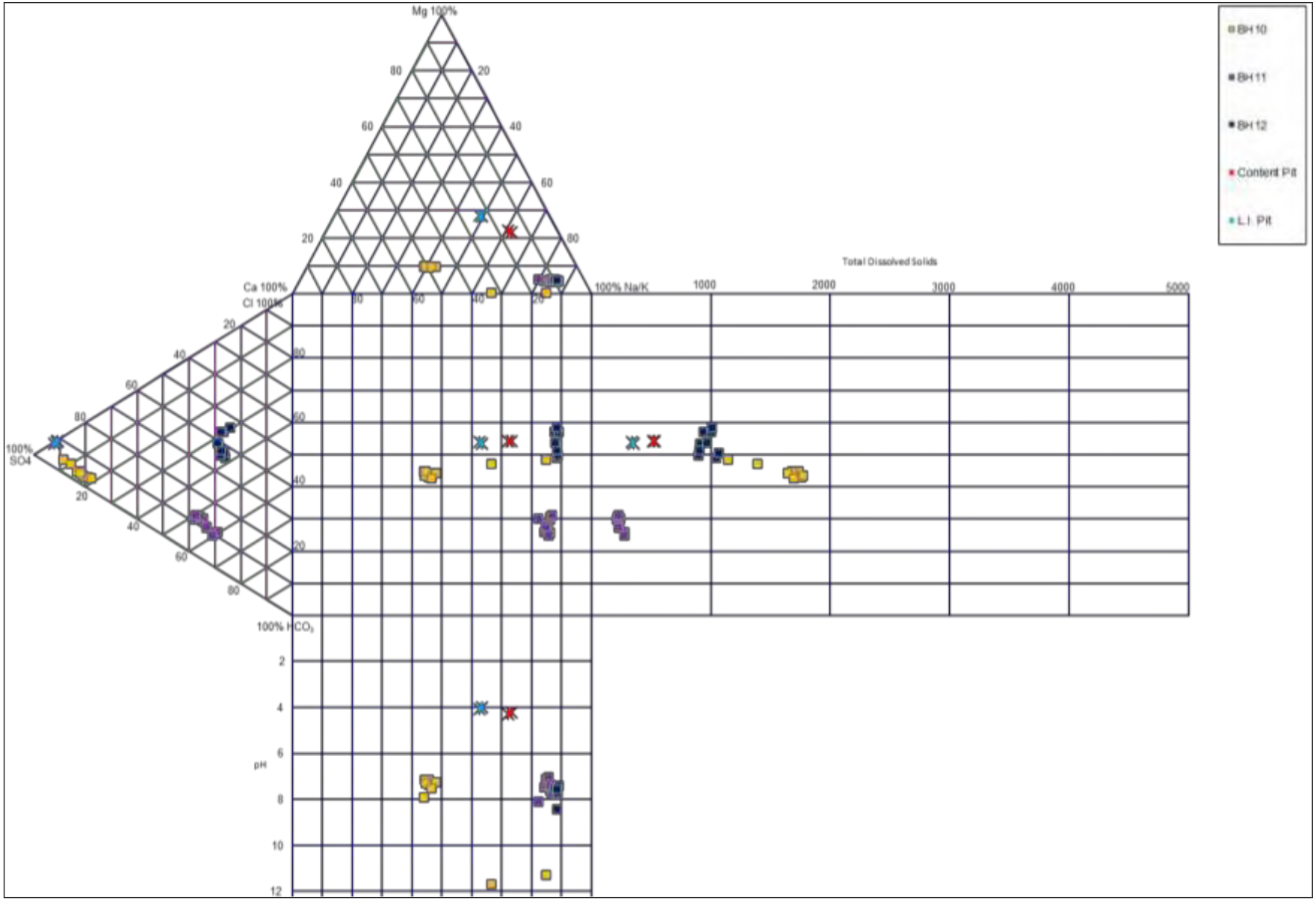

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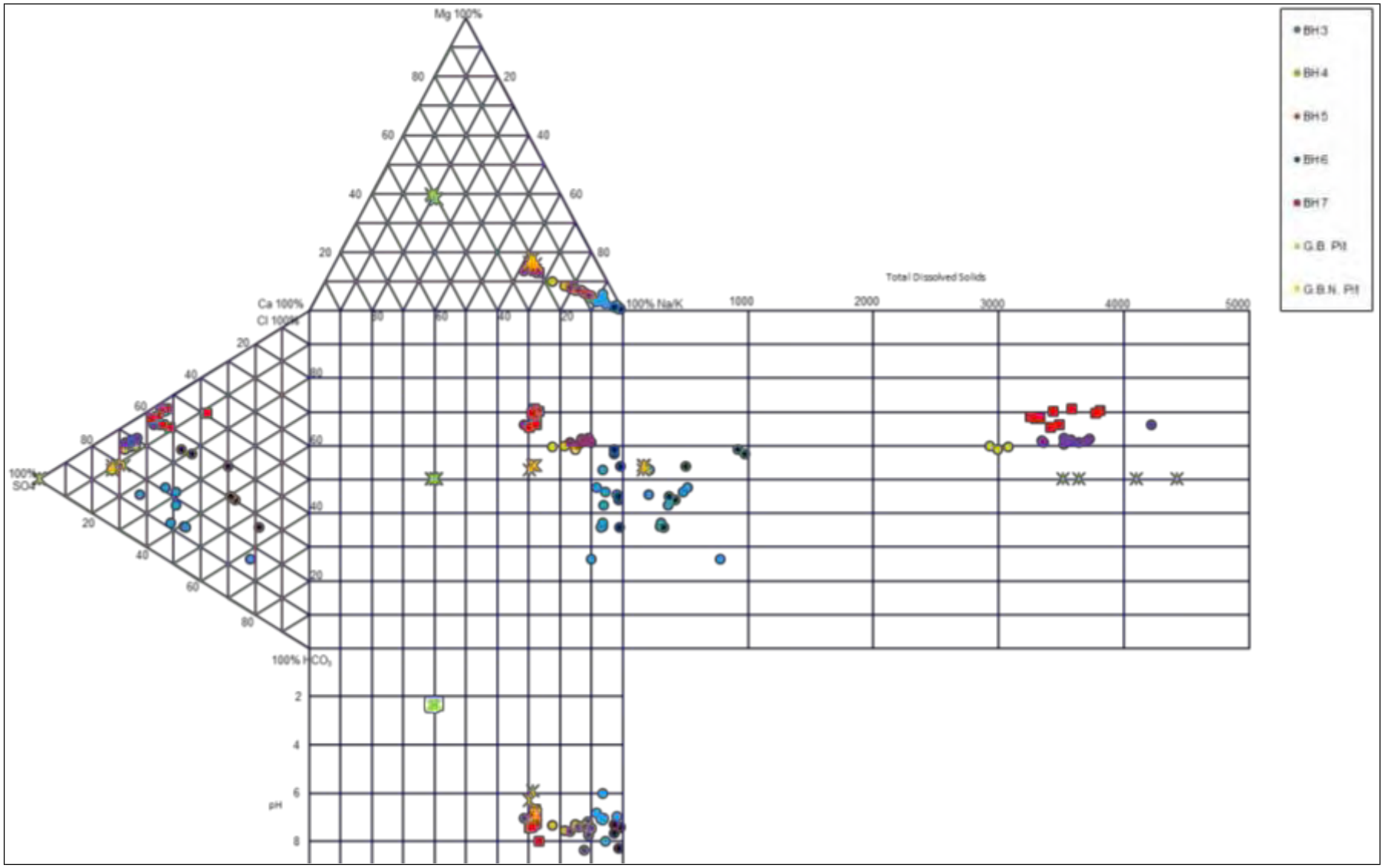

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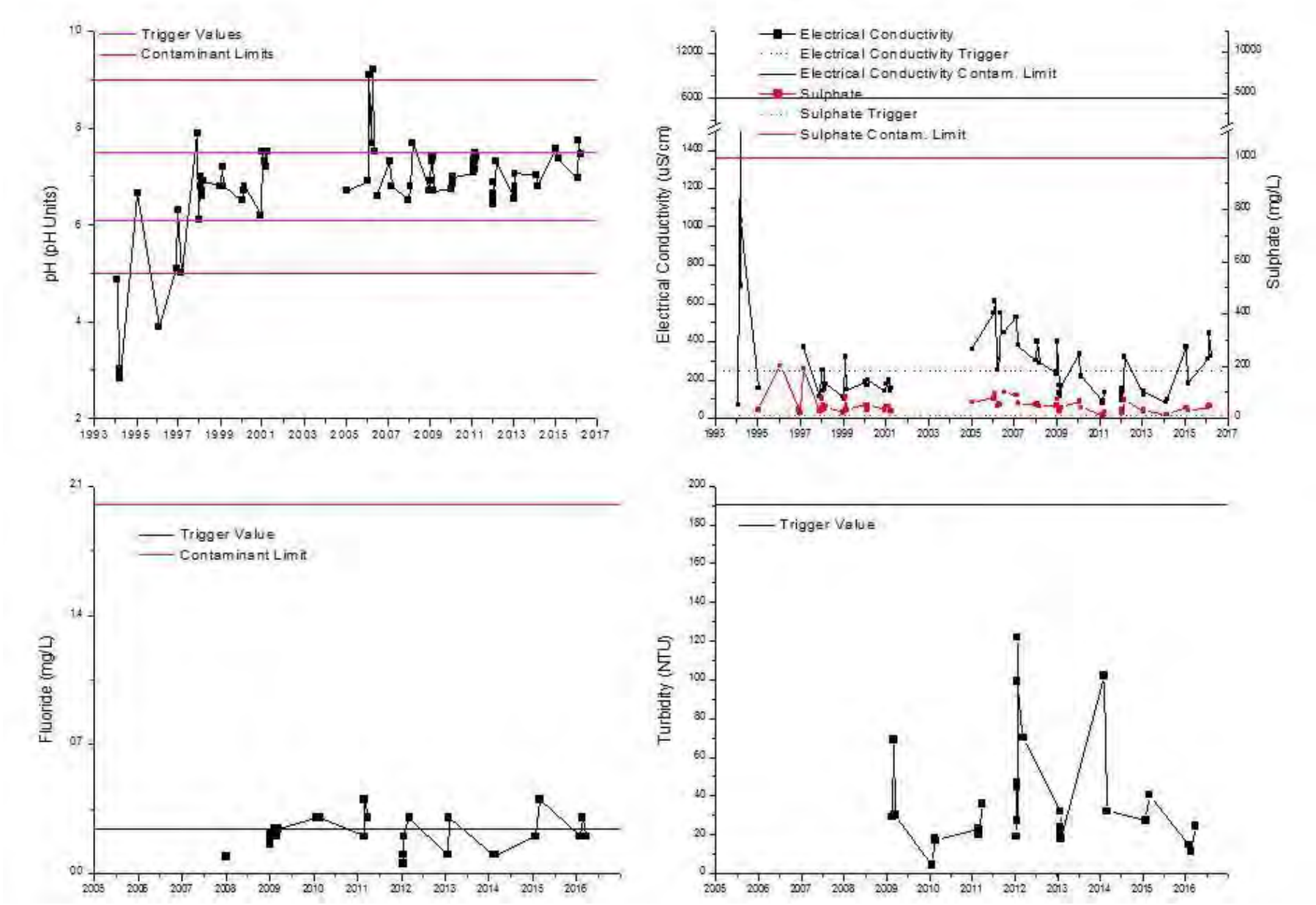


Figure 47: Sample Site SW1 – Physicochemical parameters versus time

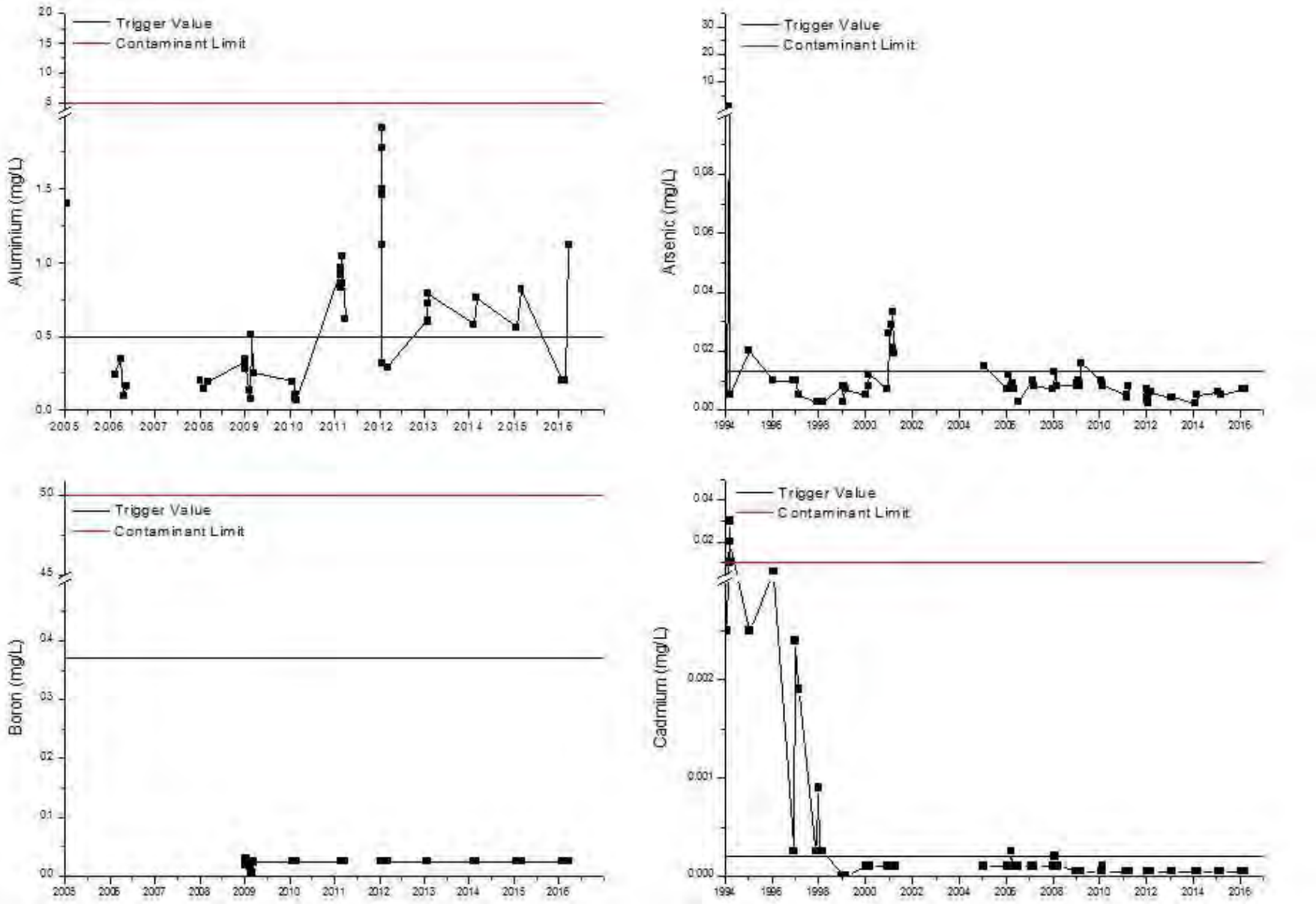
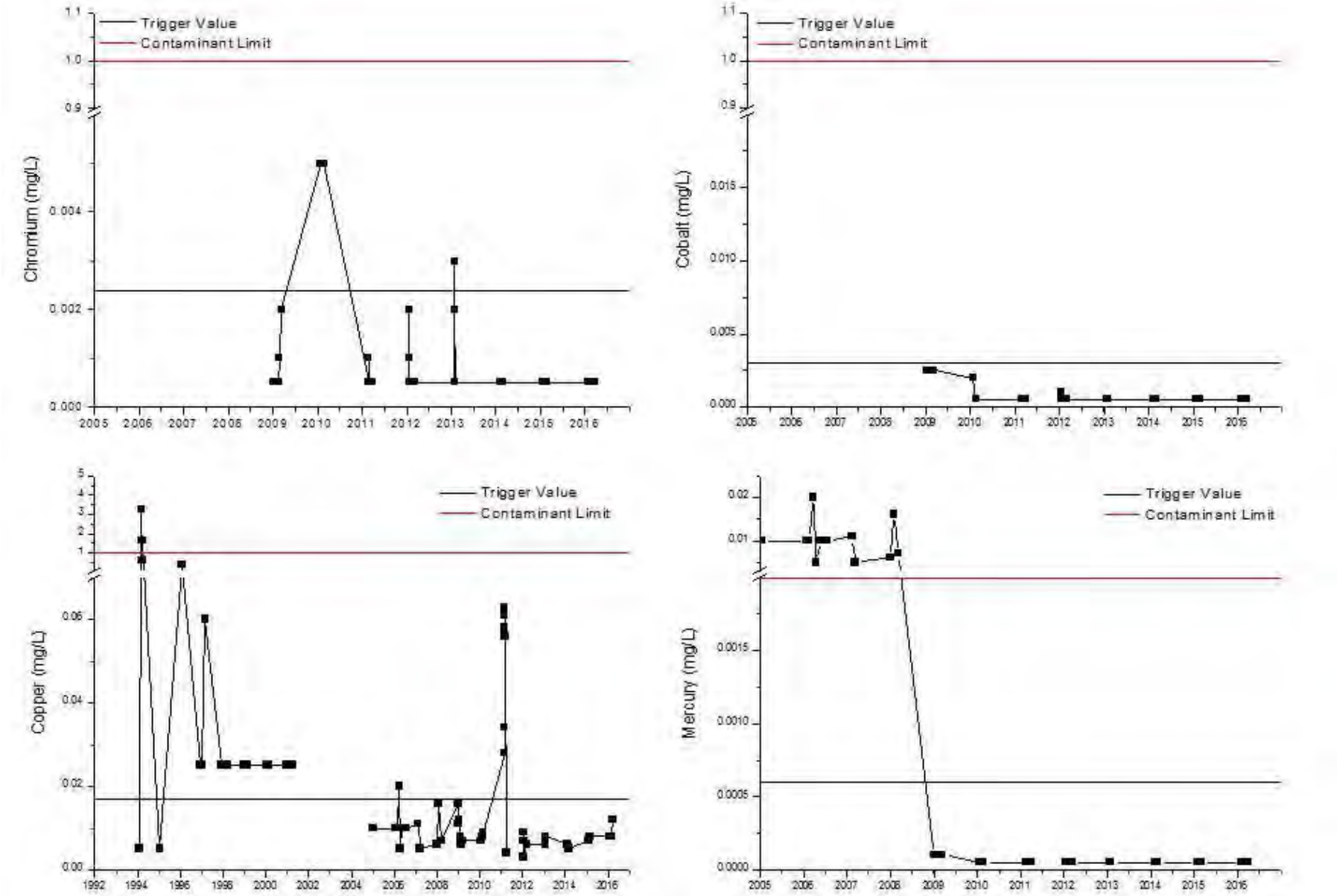


Figure 48: Sample Site SW1 – Filterable (<0.45µm) Al, As, B and Cd versus time



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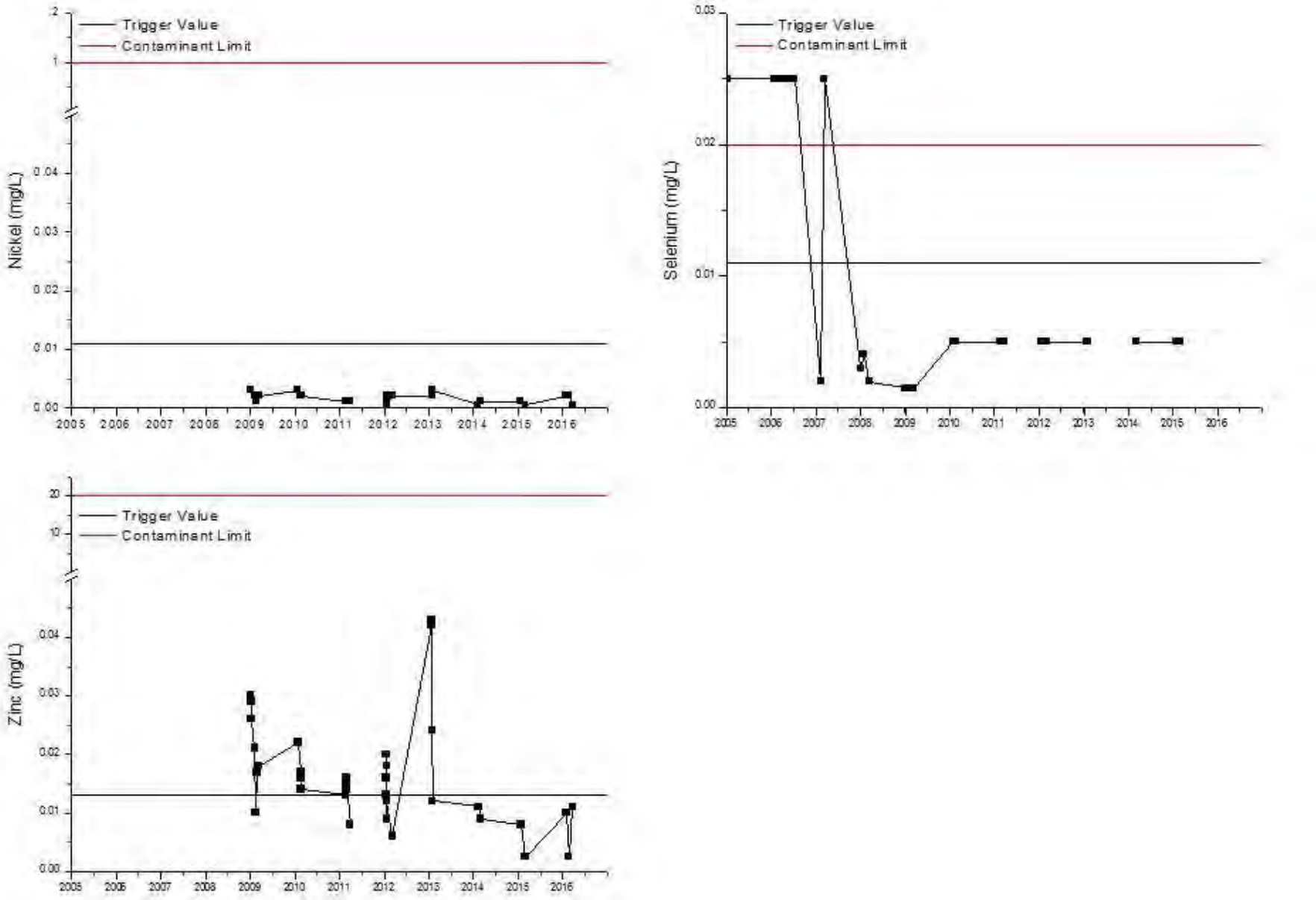


Figure 50: Sample Site SW1 – Filterable (<0.45µm) Ni, Se and Zn versus time

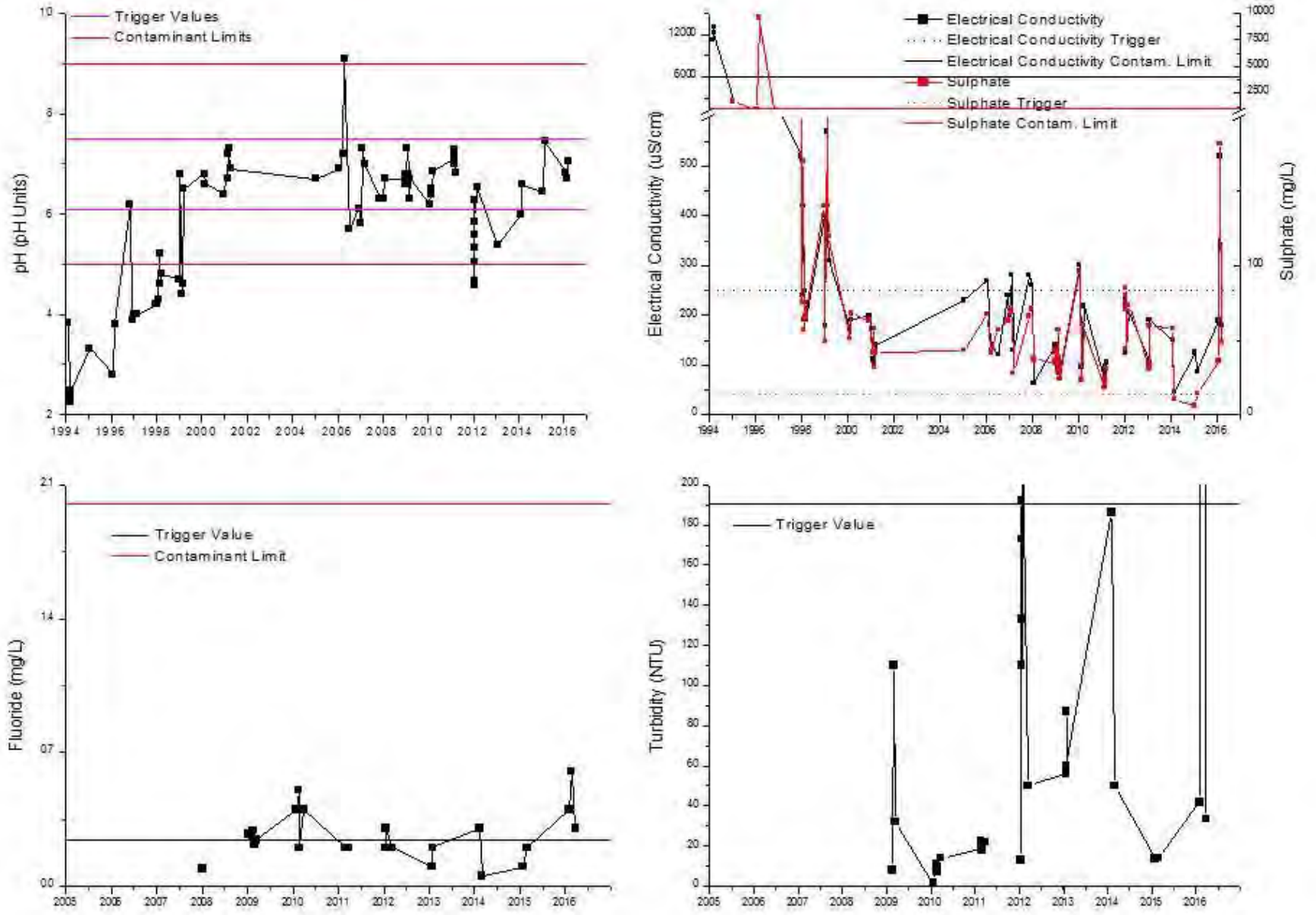
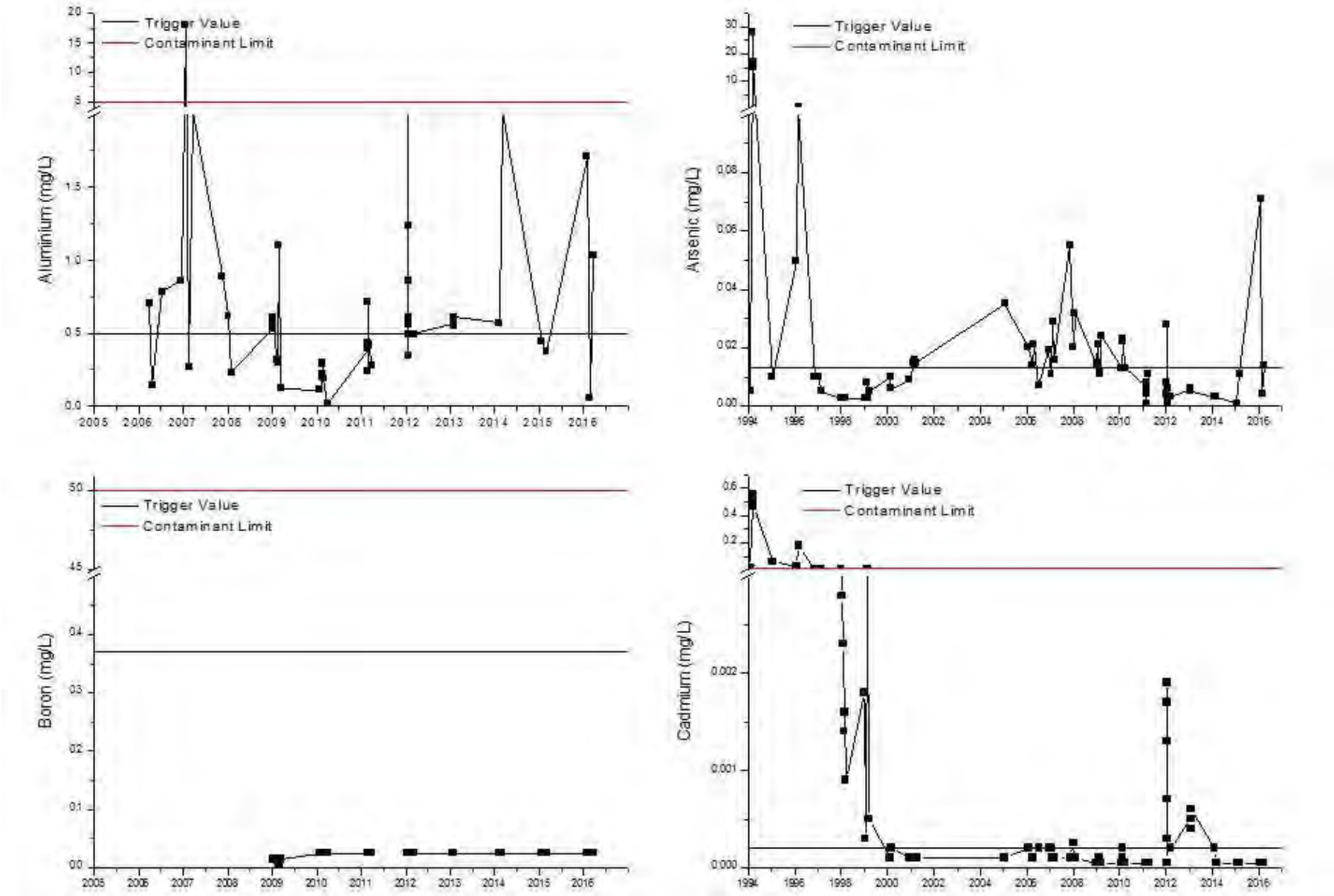


Figure 51: Sample Site SW2 – Physicochemical parameters versus time



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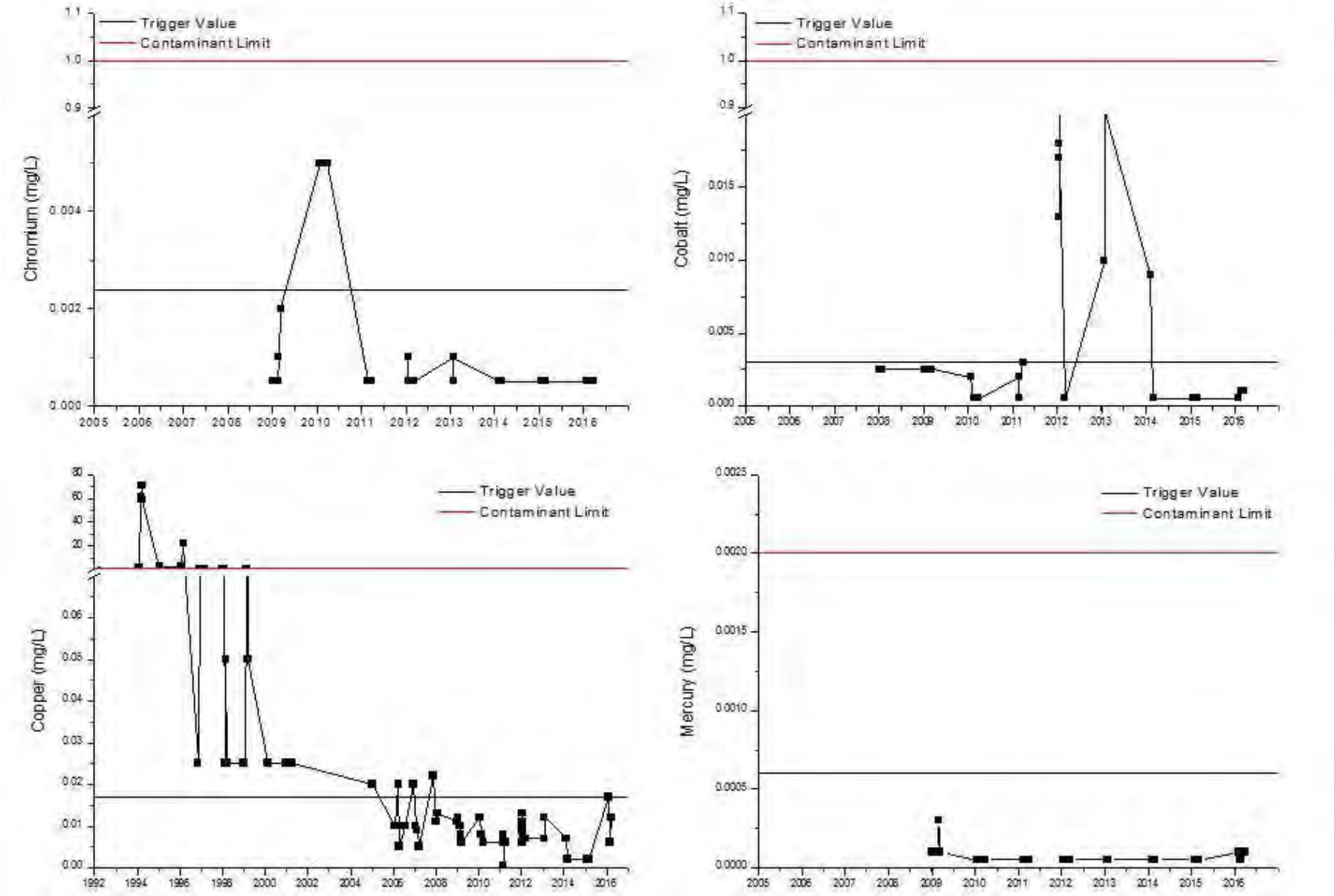

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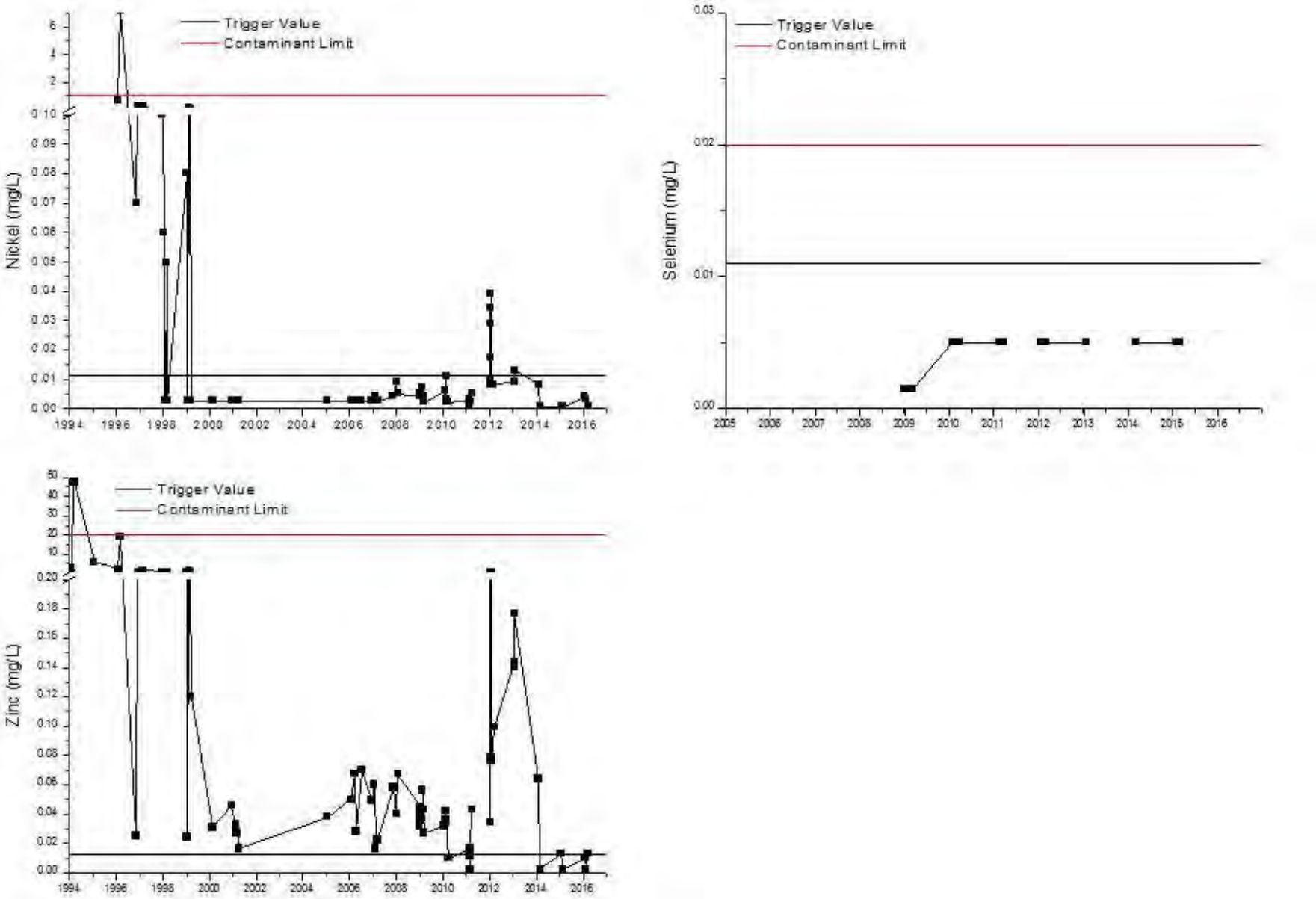
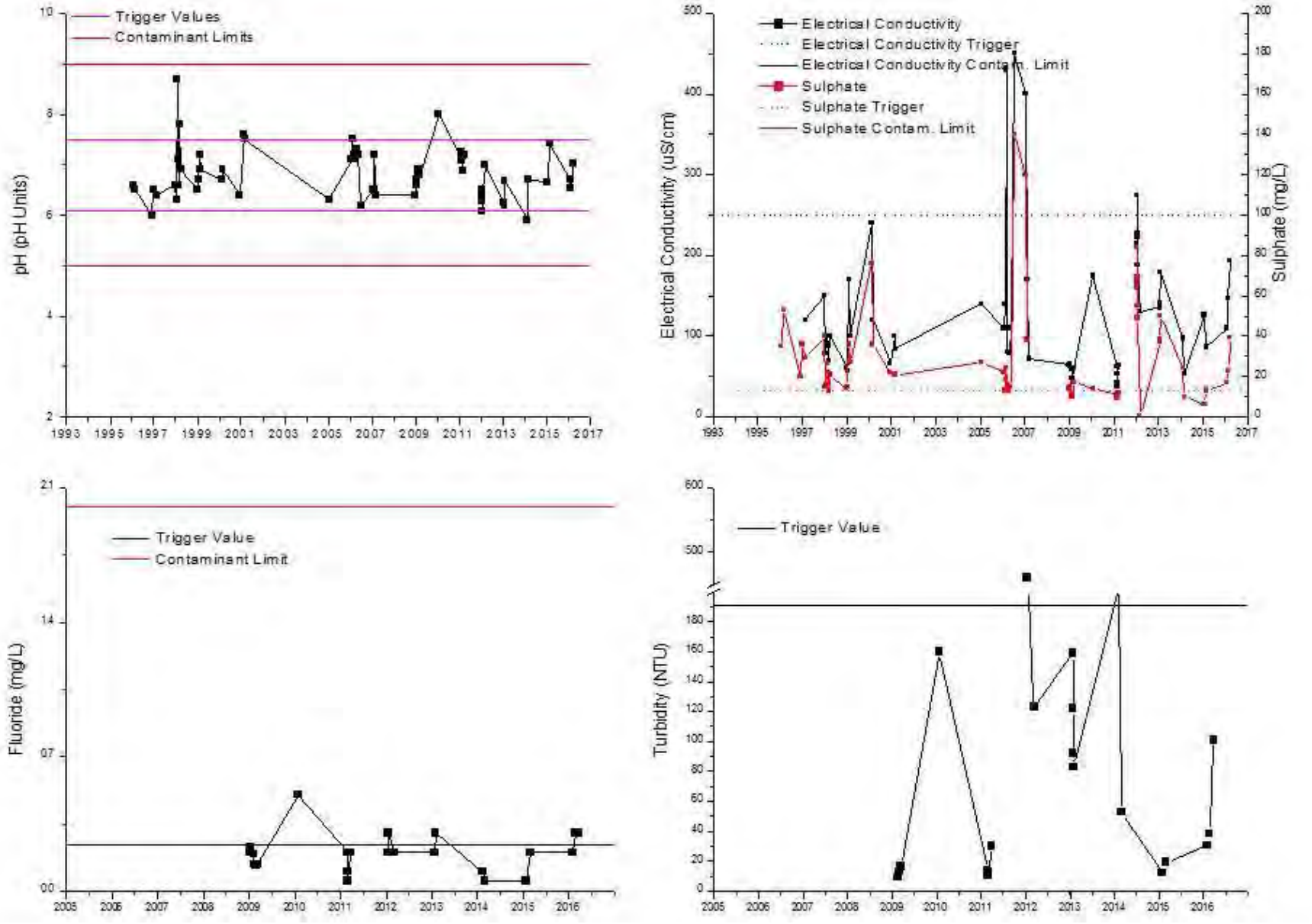


Figure 54: Sample Site SW2– Filterable (<0.45µm) Ni, Se and Zn versus time



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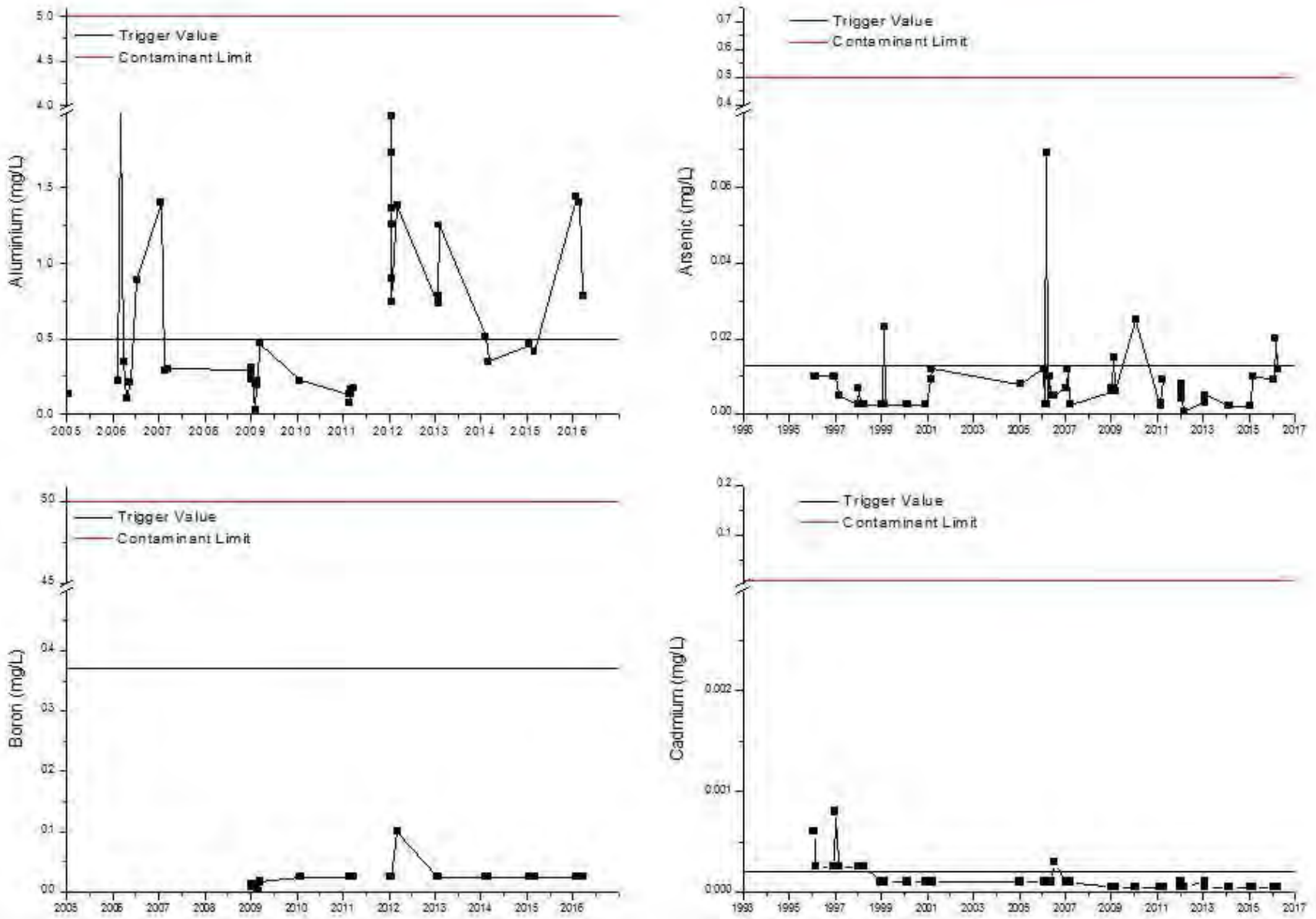


Figure 56: Sample Site SW3a– Filterable (<0.45µm) Al, As, B and Cd versus time

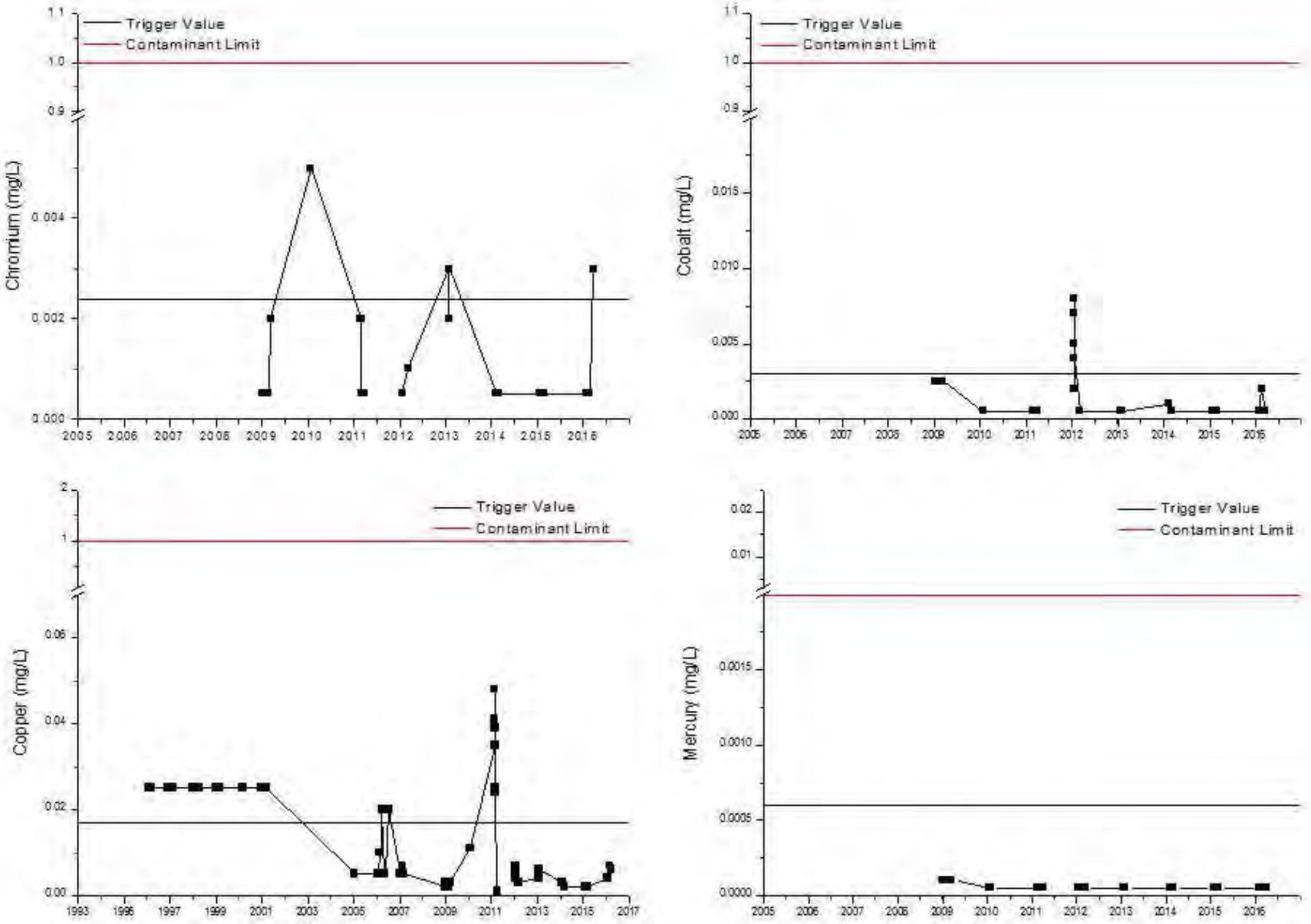


Figure 57: Sample Site SW3a– Filterable (<0.45µm) Cr, Co, Cu and Hg versus time

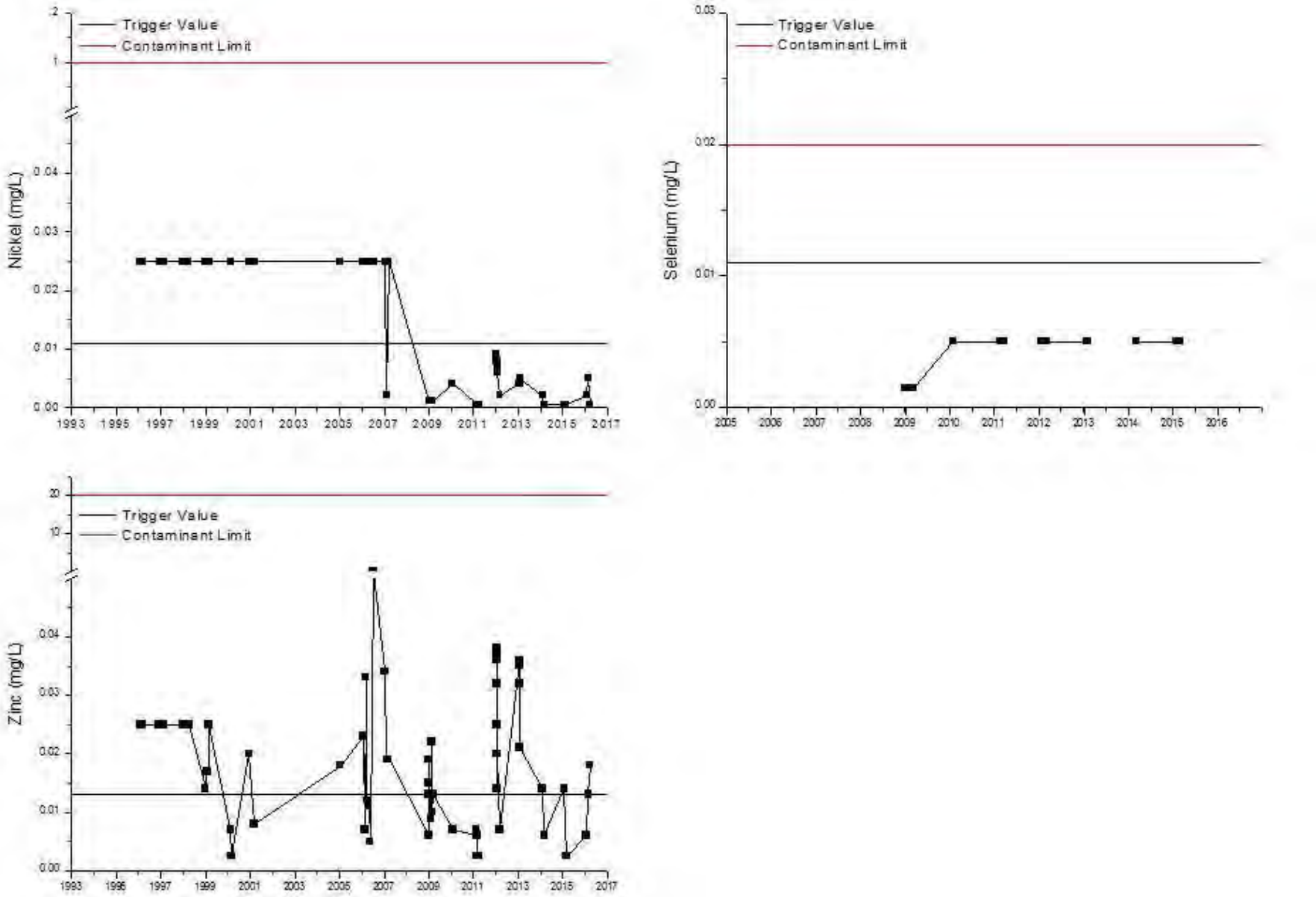


Figure 58: Sample Site SW3a– Filterable (<0.45µm) Ni, Se and Zn versus time

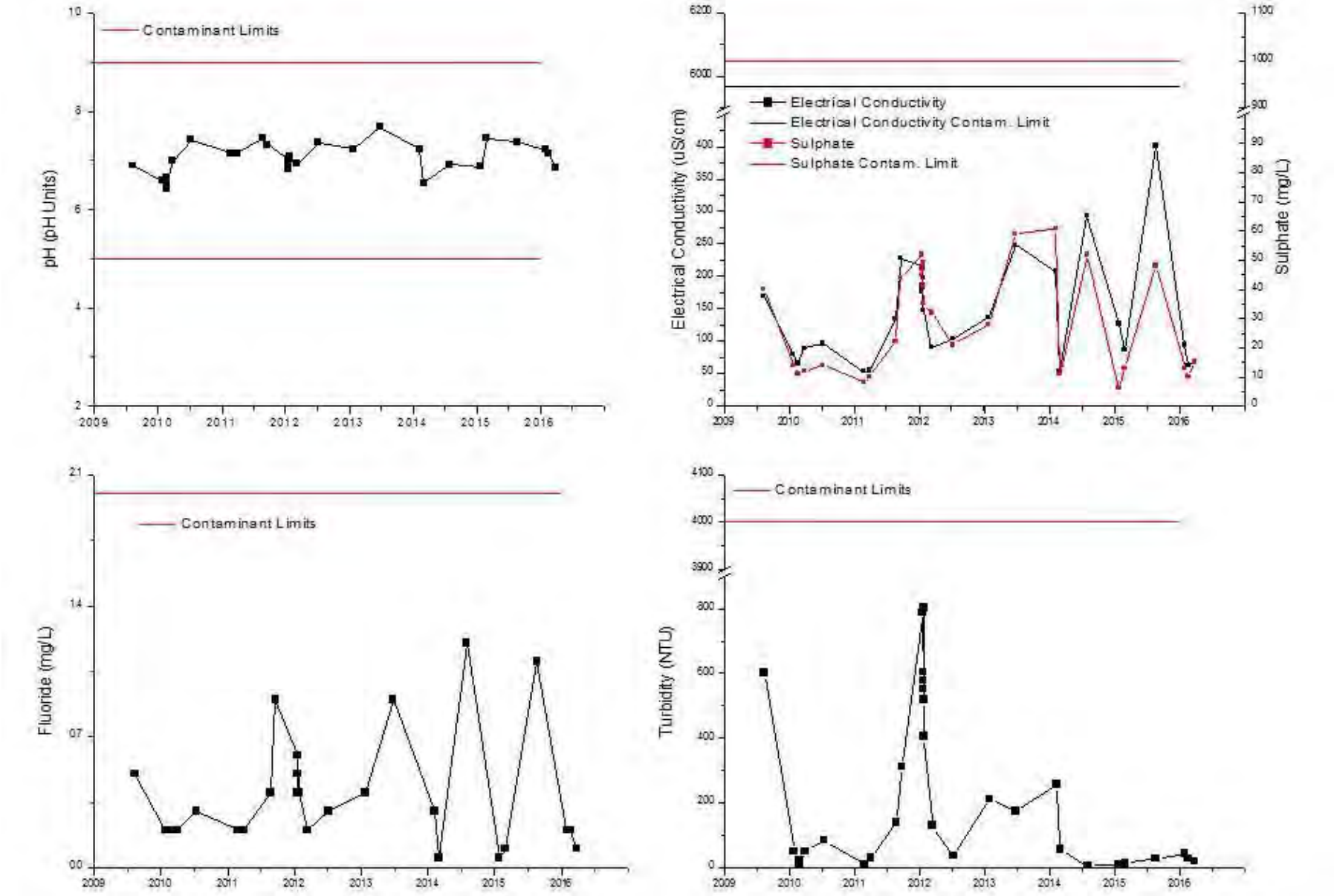


Figure 59: Sample Site SW4 – Physicochemical parameters versus time

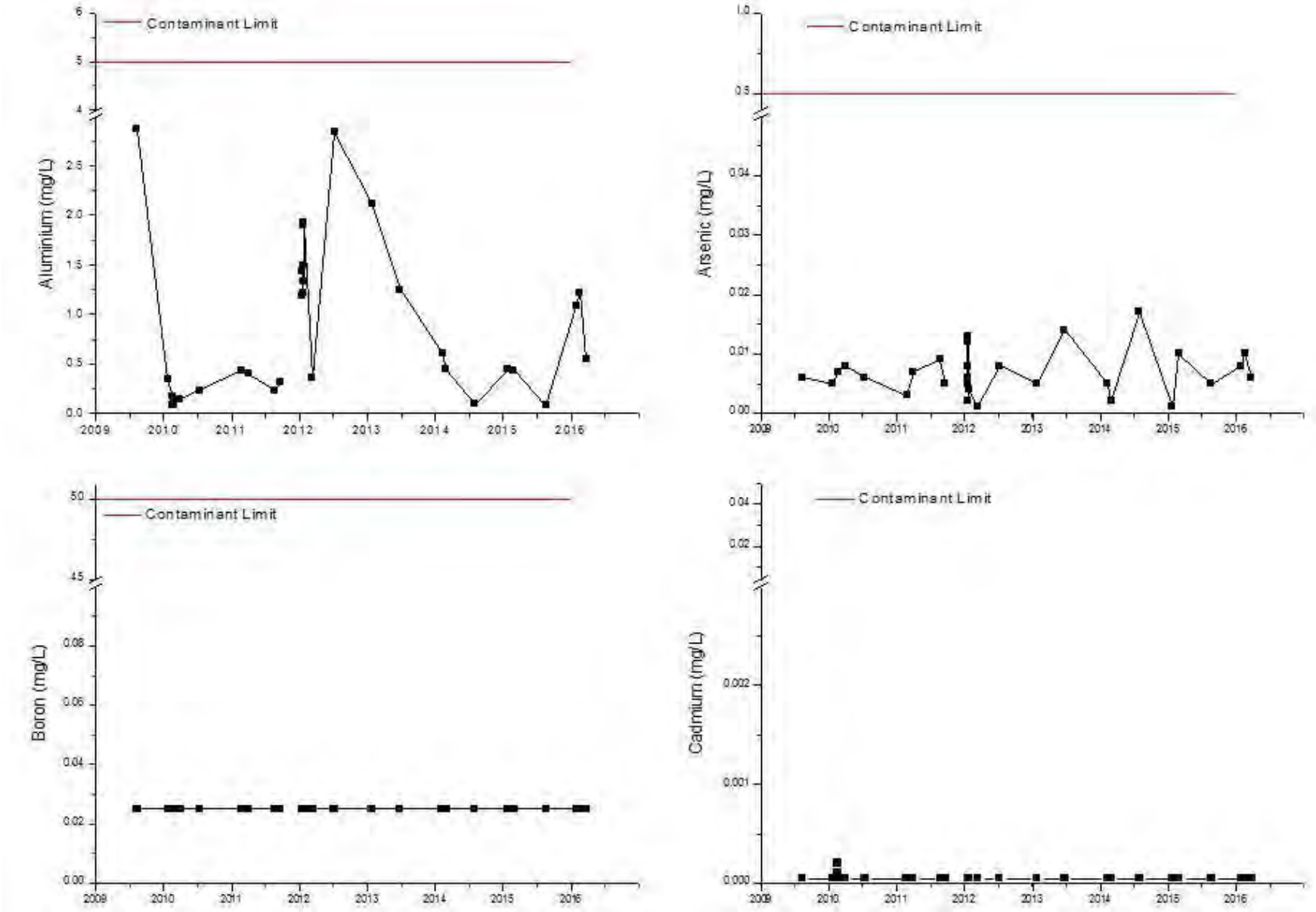
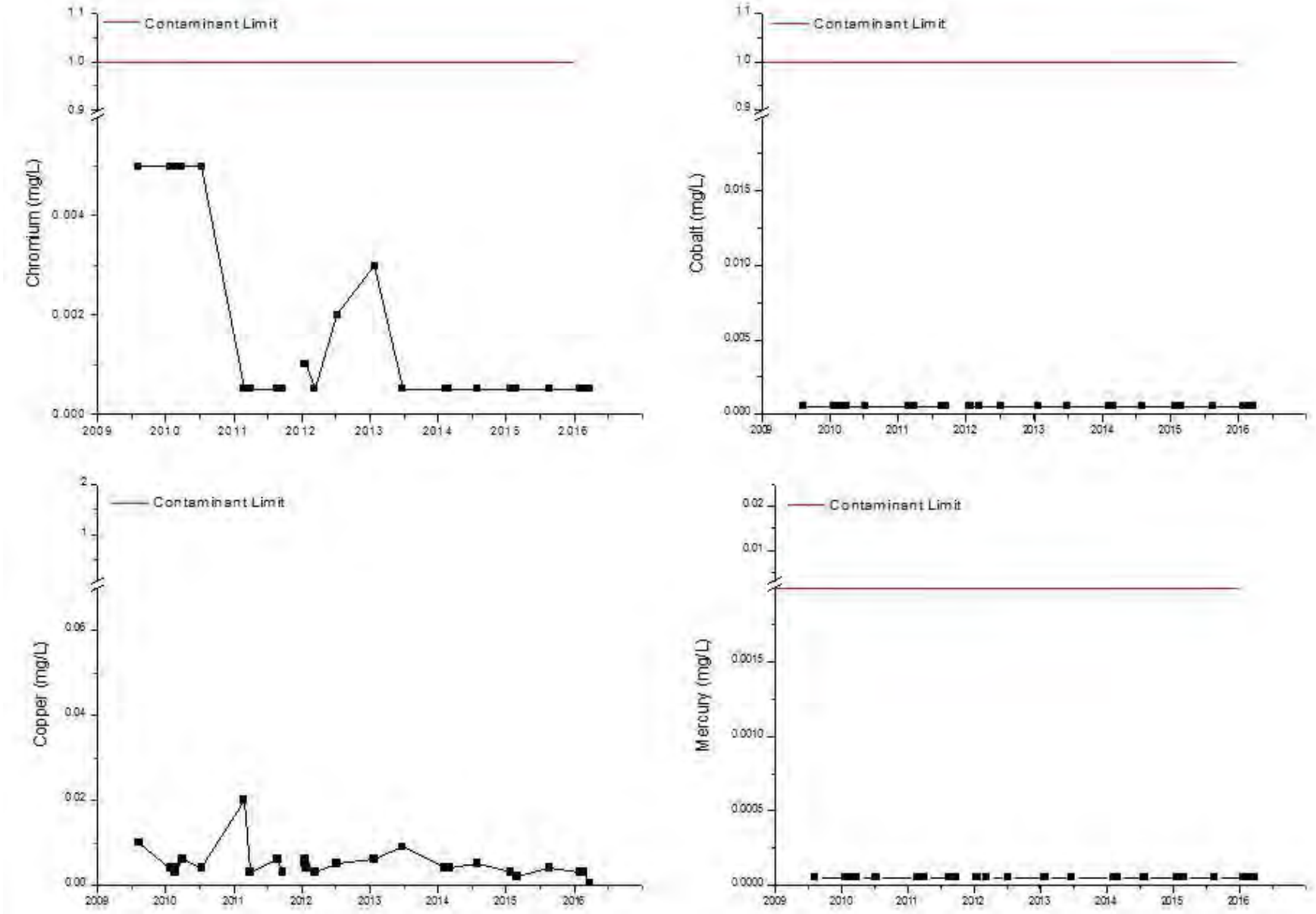


Figure 60: Sample Site SW4– Filterable (<0.45µm) Al, As, B and Cd versus time



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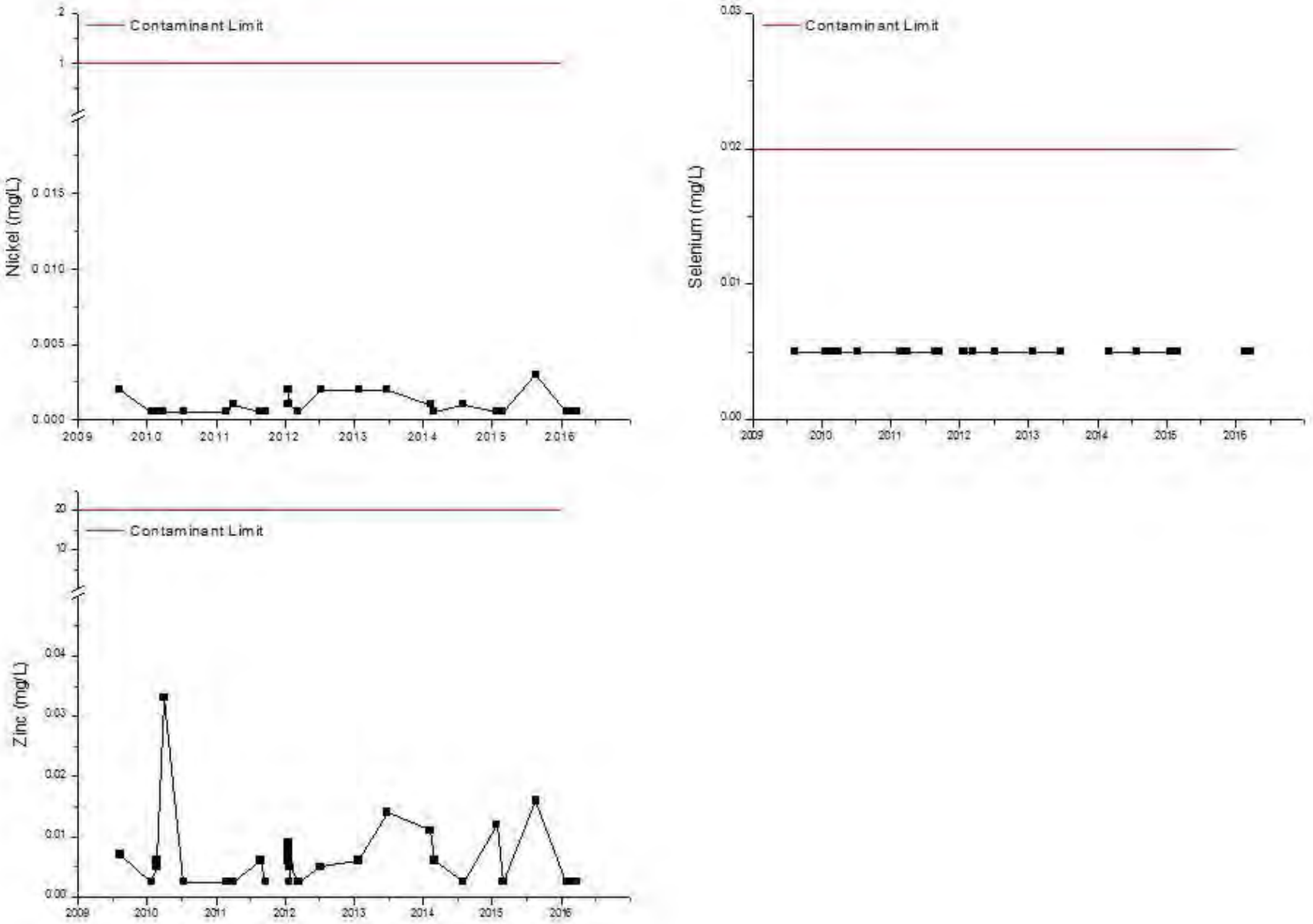

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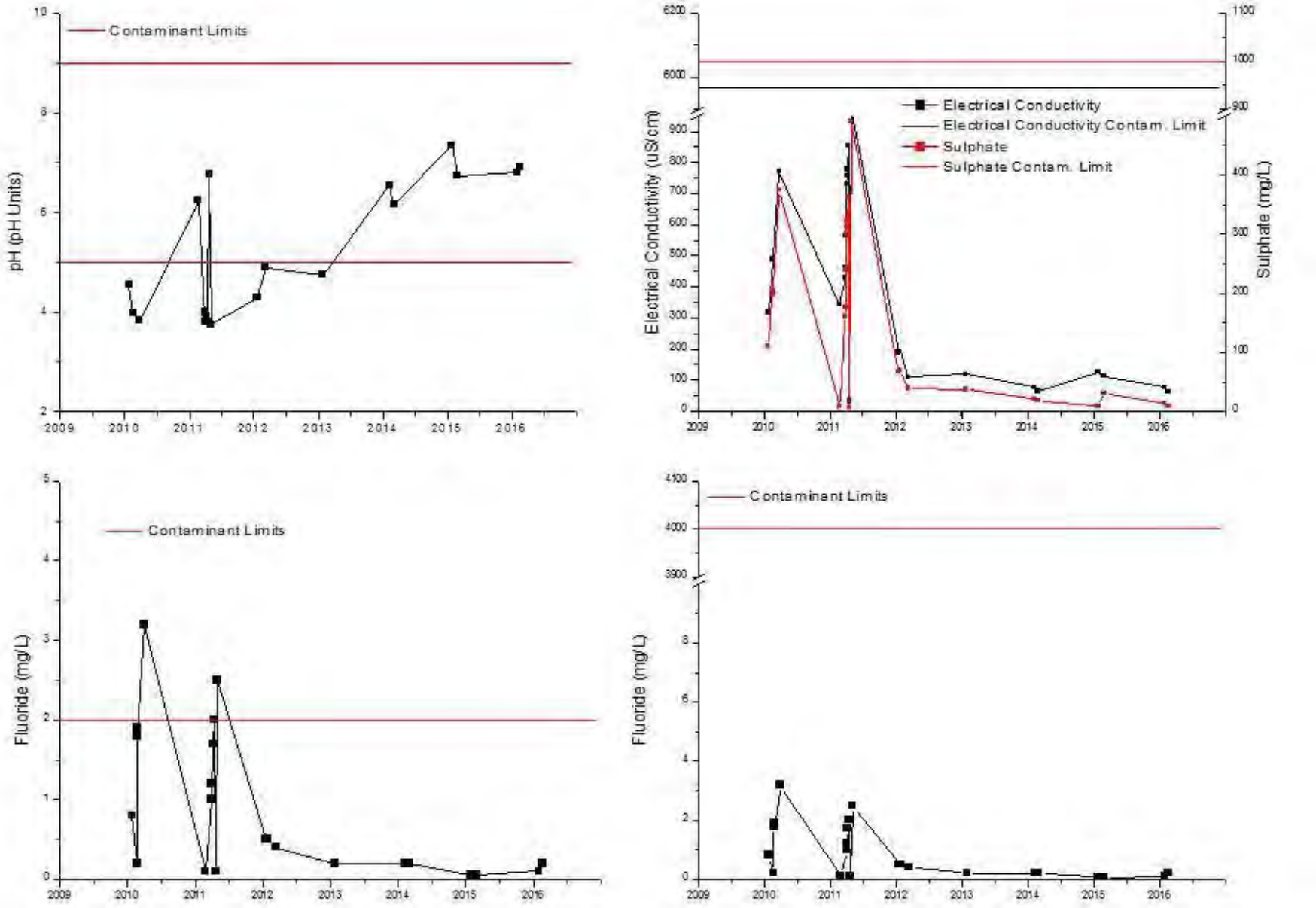


Figure 63: Sample Site SW5– Physicochemical parameters versus time

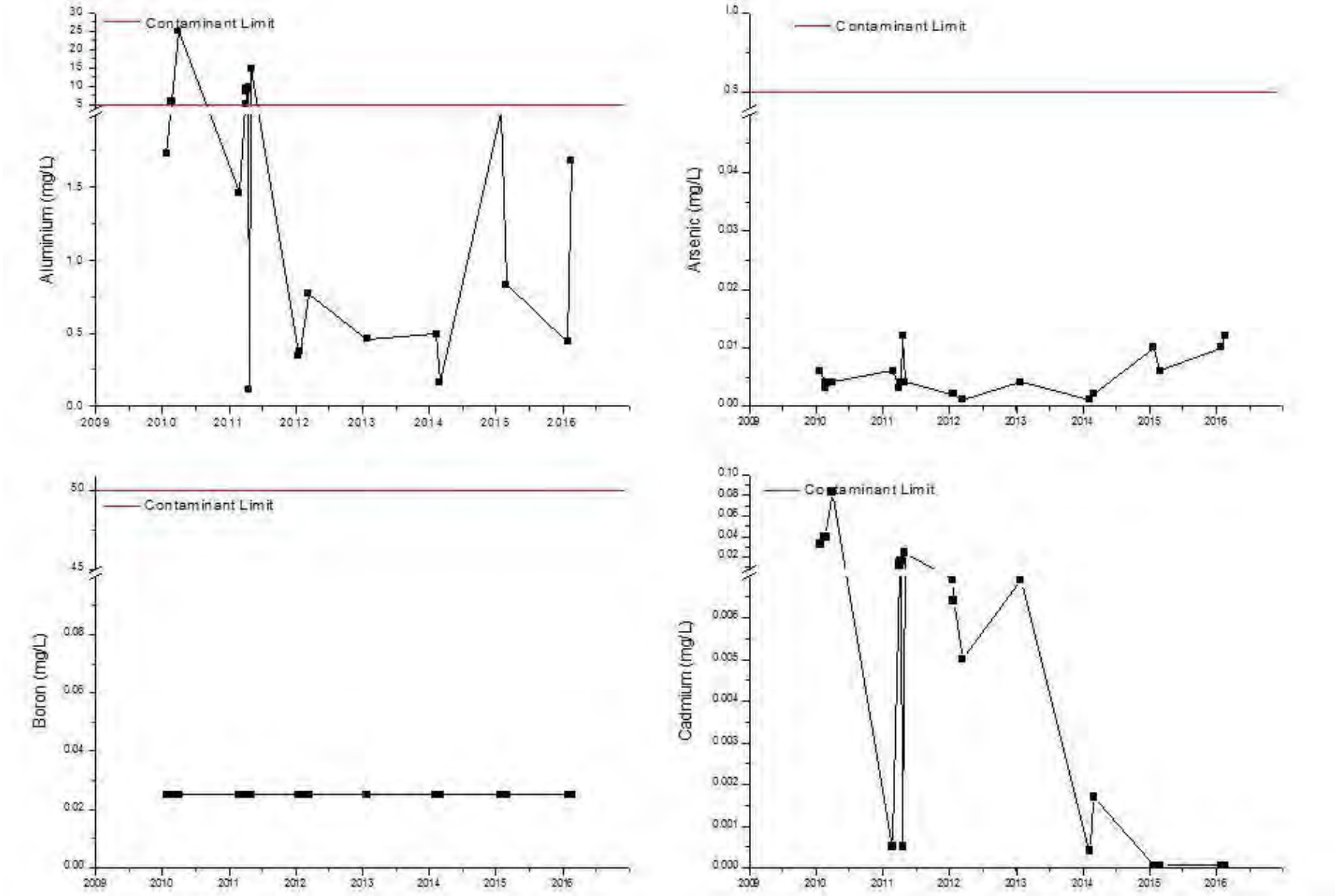


Figure 64: Sample Site SW5– Filterable (<0.45µm) Al, As, B and Cd versus time

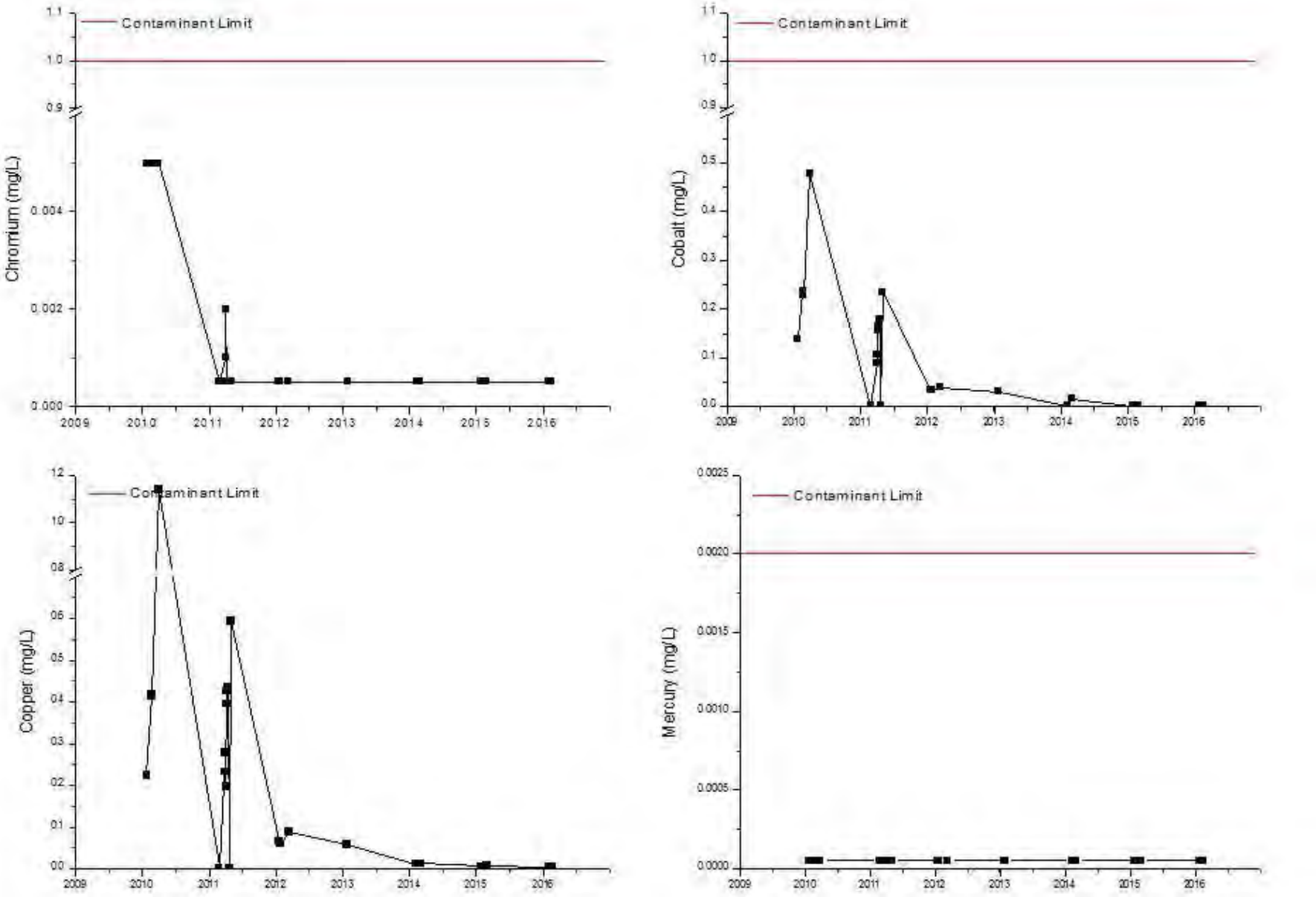


Figure 65: Sample Site SW5– Filterable (<0.45µm) Cr, Co, Cu and Hg versus time

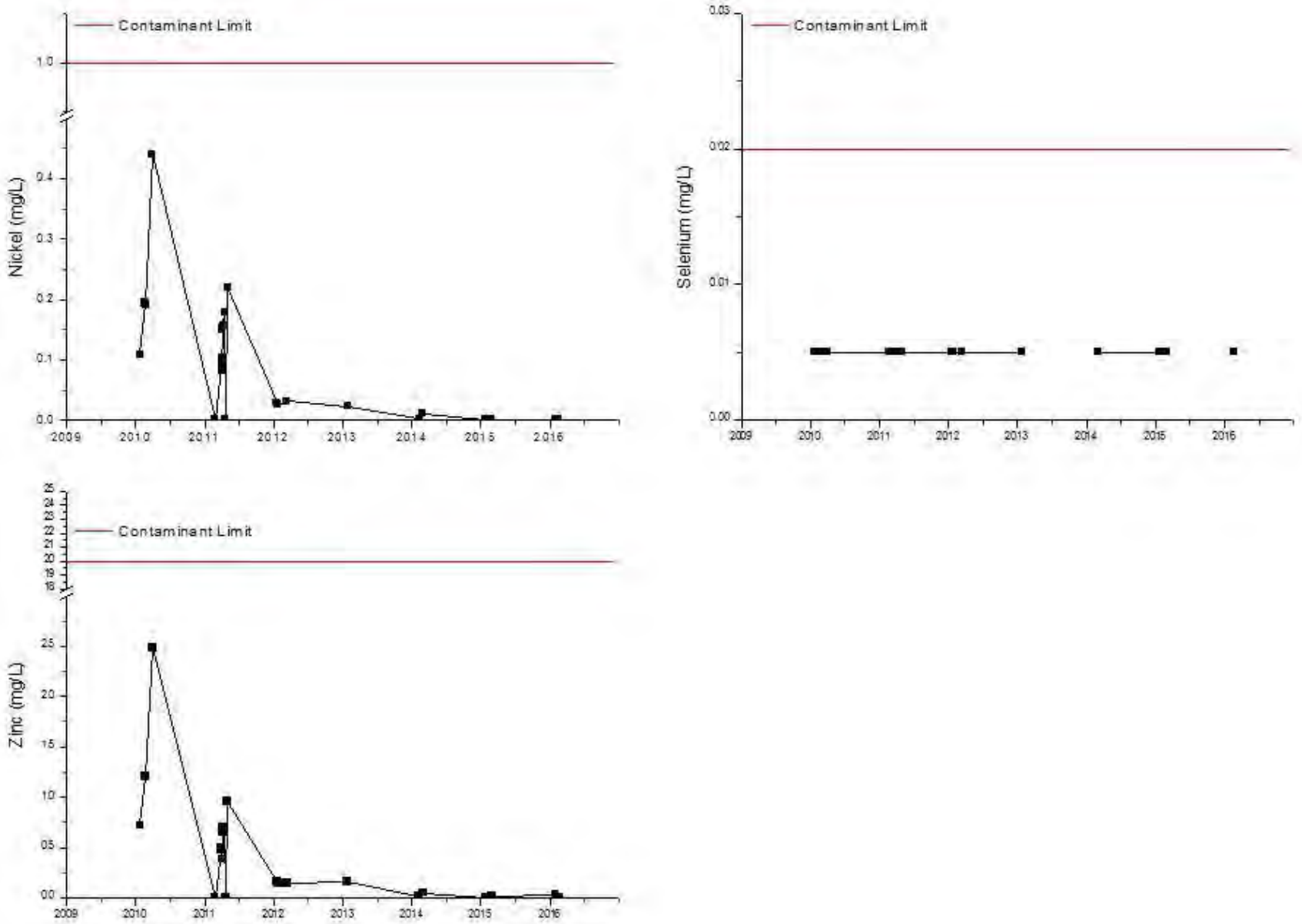


Figure 66: Sample Site SW5– Filterable (<0.45µm) Ni, Se and Zn versus time

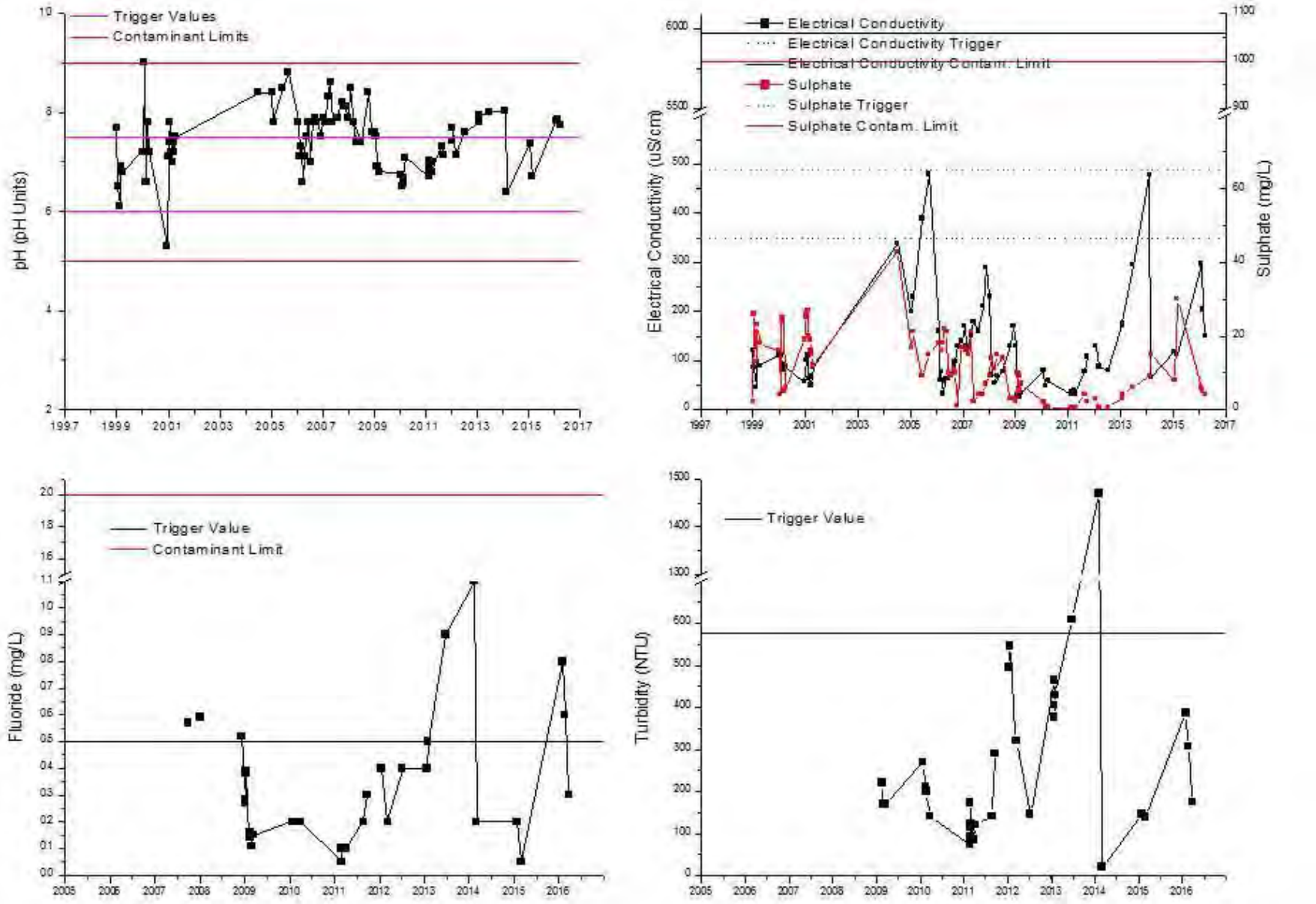


Figure 67: Sample Site SW6– Physicochemical parameters versus time

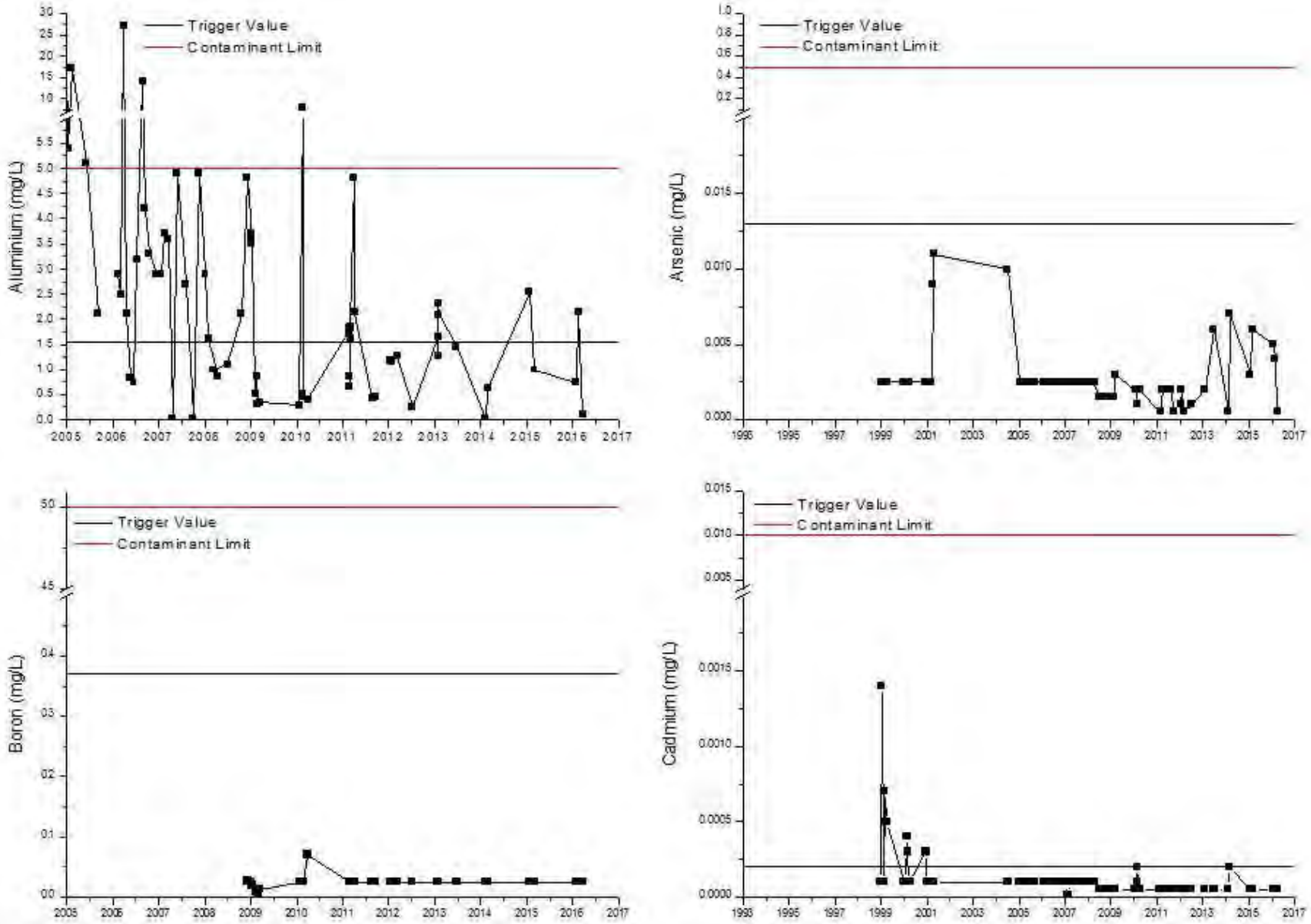


Figure 68: Sample Site SW6– Filterable (<0.45µm) Al, As, B and Cd versus time

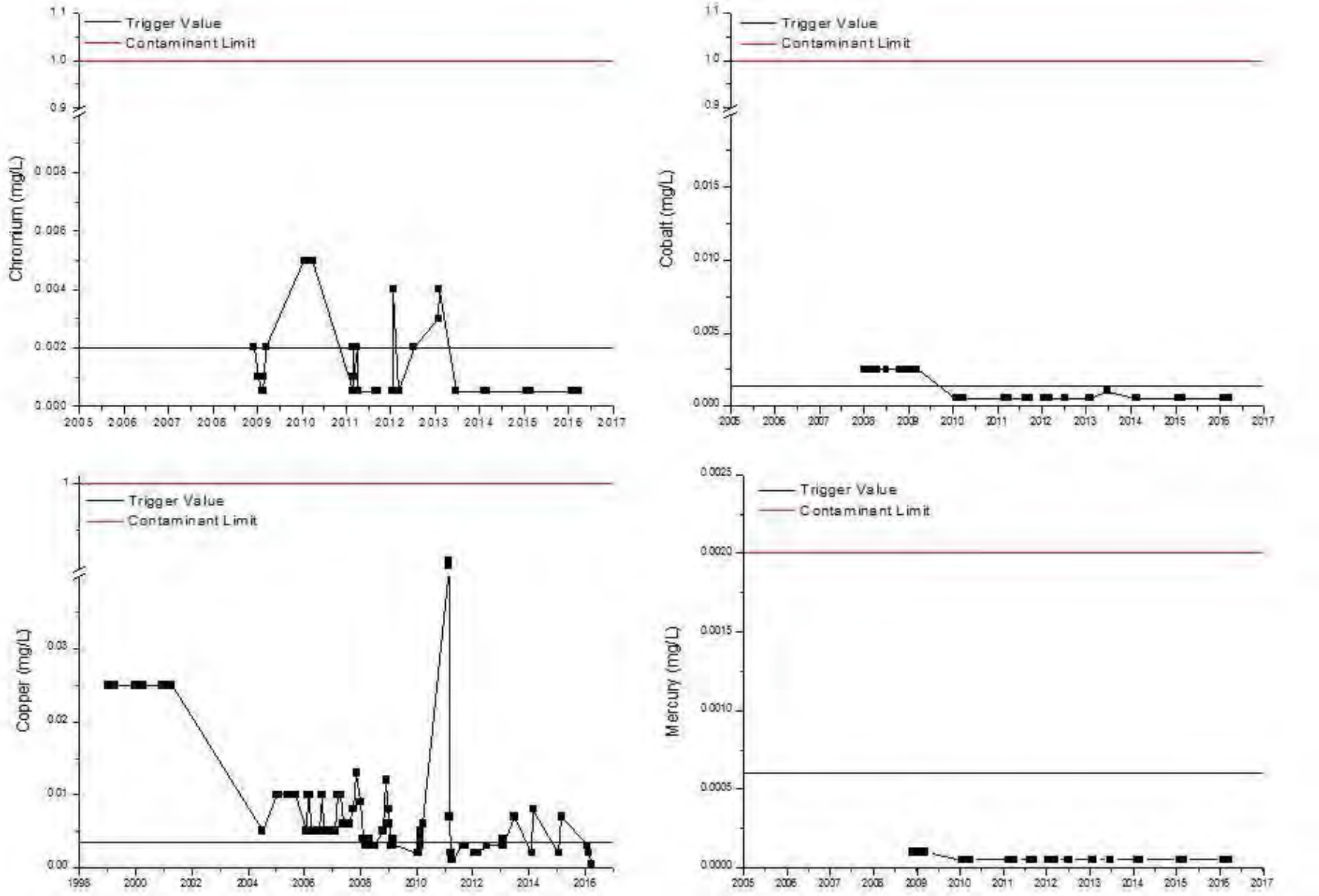
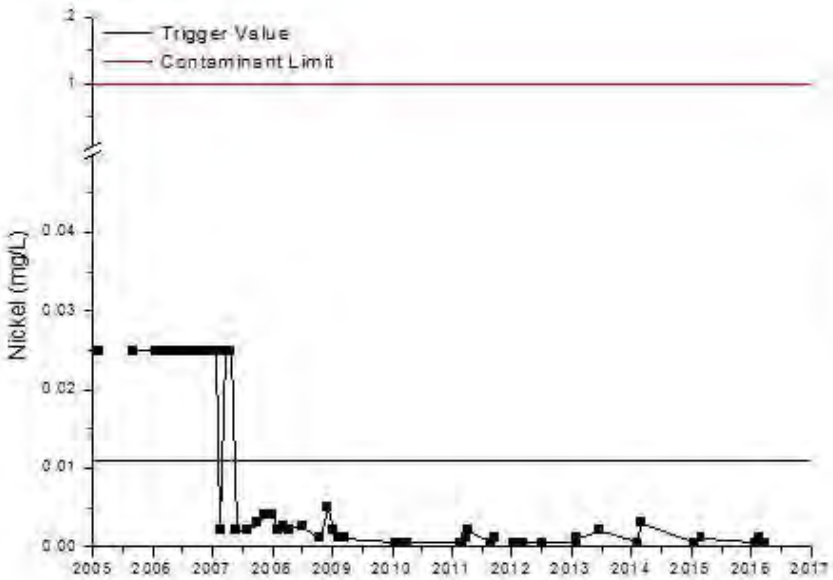
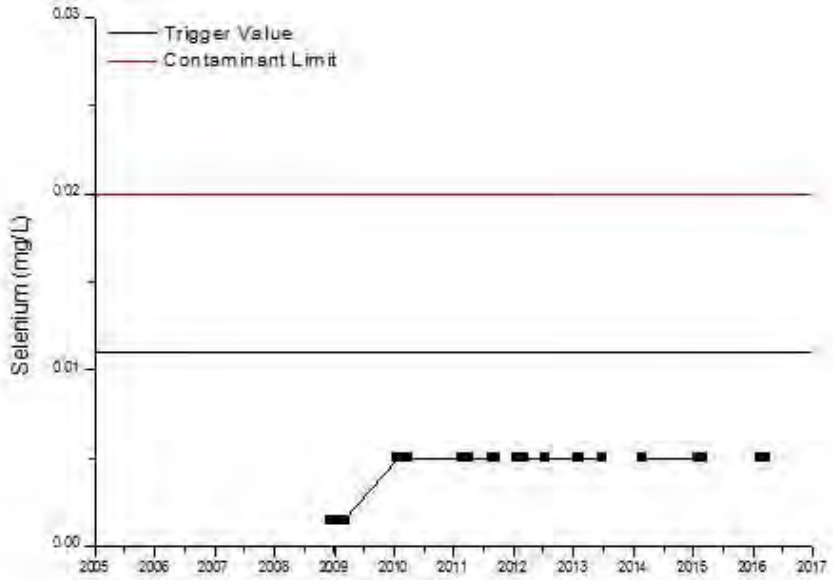
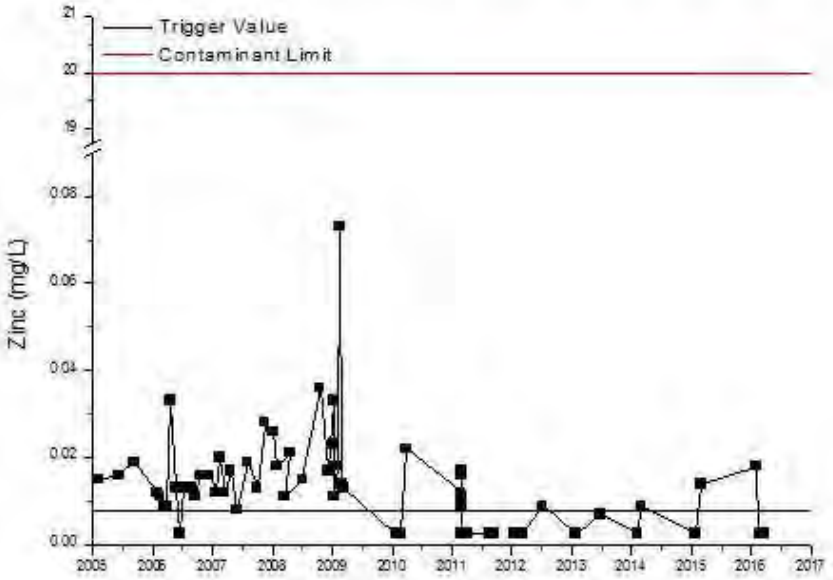


Figure 69: Sample Site SW6– Filterable (<0.45µm) Cr, Co, Cu and Hg versus time







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APPENDIX L ANNUAL GROUNDWATER MONITORING REPORT 2014

CROYDON GOLD MINE

ANNUAL GROUNDWATER MONITORING REPORT 2014

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1 EXECUTIVE SUMMARY

This Groundwater Monitoring Report has been prepared in accordance with EA Condition F7-4.

A conceptual hydrogeological model (Figure 16) was developed for the Project and surrounds during preparation of the Environmental Management Plan (EM Plan)[1]. The conceptual hydrogeological model was based on the hydrogeological study conducted by HLA-Envirosciences[2] and the then available groundwater quality information. The model indicates the pit voids act as groundwater sinks having limited capacity to influence groundwater quality much beyond the immediate footprint of the pits, with an overall long-term negative water balance never leading to pit overtopping.

The additional information now available proceeding the extraordinary succession of wet season rainfall totals from 2009 to 2011 followed by reversion to median conditions in 2012 has confirmed the conceptual model for the Golden Butterfly Pit and Golden Butterfly North Pit. The situation for the Content Pit and Lady Isabella Pit lakes differs in that if an unusual succession of high rainfall total wet seasons occurs pit overtopping could eventuate.

A proposal in 2012 to the DEHP to conduct limestone dosing treatment of the Content Pit and Lady Isabella Pit lakes to bring the contained water to within ANZECC (2000) stock water guidelines was accepted. After treatment was successfully completed in December 2012, the EA was amended by the DEHP to permit discharges from the Content Pit and Lady Isabella Pit in event of extreme rainfall.

Subsequently, the local pastoralist and Shire Council received approval to abstract water from the Content Pit and Lady Isabella Pit lakes for stock watering and road construction purposes respectively. This water abstraction from the Content Pit and Lady Isabella Pit lakes is expected to keep the pit lakes at low levels due to anthropogenic usage. Therefore, overtopping of the Content Pit and Lady Isabella Pit lakes is not expected to occur in the future. This is confirmed by current monitoring data.

In accordance with EA Condition F4-1 groundwater monitoring is conducted at the locations and frequencies defined in Schedule F - Table 9 of the EA for the parameters identified in Schedule F - Tables 10 and 11 of the EA. Trigger values were calculated as per the instructions in the footnotes to Schedule F – Table 10 of the EA for groundwater monitoring locations specified in Schedule F Table 9 of the EA. Table 4 provides a summary of trigger value and contaminant limit exceedences for groundwater monitoring locations during the reporting period which are discussed in terms of the potential for environmental harm in Section 5.1.

The major difficulty in assessing the relevance of the observed trigger value exceedences is that no reference sites have been stipulated against which to judge the results. The default of using the ANZECC(2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems does not appear appropriate considering that groundwater is being assessed, not surface water, and further, the bores are located within a metalliferous area that has hosted mining for over one hundred years.

Notwithstanding these difficulties, time series graphs and hydrochemical pattern diagrams such as Piper-Hill Plots and Durov Diagrams in conjunction with information about lithology, rock structural features, groundwater levels and climate factors such as rainfall enable interpretation of the groundwater analysis data in terms of potential environmental impact from mining associated landforms.

In all cases, it is demonstrated that groundwater quality is not significantly influenced by landforms associated with the mining lease, with the immediate localised geology being indicated as the significant factor influencing observed groundwater quality at these locations. This is further supported by reference to the hydraulic gradient in the vicinity of the Golden Butterfly Pit and Golden Butterfly North Pit being towards the pit voids and levels of potential contaminants (e.g., fluoride) being lower in the pit lakes than that observed in relevant groundwater bores.

Since the various bores appear to be within locations having different hydrochemical facies, it would appear that a number of sets of "reference values" based upon the existing data from the relevant group of bores, each applicable to a particular hydrogeological regime would be necessary. However, an alternative proposition is to assess the available hydrological, geochemical, geological and climatological data holistically to determine the likelihood and or extent of possible impact of landforms associated with the mining lease on off-site groundwater quality.

This is in contrast to the existing restricted approach, which due to the absence of appropriate baseline data, is focussed solely on the attainment of necessarily arbitrary water quality criteria (which may or may not be appropriate to the situation at hand).

The assessment of the groundwater quality data concluded that the various trigger level and contaminant limit exceedences are most readily explained as related to features associated with the immediate localised geology, as opposed to indicating adverse input from mining related landforms such as the pit void lakes and waste rock dumps. Nevertheless, EA clause F7-2 requires an investigation in accordance with ANZECC (2000) methodology if groundwaters at the bores identified in EA Schedule F Table 9 exceed any of the trigger levels stated in EA Schedule F Table 10.

The investigation in accordance with ANZECC (2000) methodology is reported in Section 6 and concludes:

> "it can be readily seen that the existing trigger levels based upon ANZECC(2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems, are not likely relevant to providing the appropriate level of protection for the identified environmental risk and beneficial use.
>
> Trigger levels for the protection of irrigation and stock drinking water environmental values are reasonably assumed to be significantly higher than the necessarily low concentrations for potential toxicants and stressors in order to protect water suitable for sustaining slightly disturbed tropical Australian upland river ecosystems. Therefore, the observed concentrations of the various chemical constituents that create trigger level exceedence in groundwater using the current definition in the EA do not indicate an environmental risk to the assumed relevant environmental values of irrigation and stock drinking water."

2 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low-grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring, investigations and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Barrick holds Environmental Authority (EA) No. EPML00950913 for the Project.

This Groundwater Monitoring Report has been prepared in accordance with EA Condition F7-4:

> *F4-4 Annual groundwater monitoring reports analysing groundwater chemistry and hydrogeological status of all groundwater bores and groundwater conditions are to be prepared by November each year as an element of the water management strategy review.*

The remainder of this Groundwater Monitoring Report is structured as follows:

Section 2: Provides a description of the hydrogeological status of the Project.

Section 3: Outlines the groundwater monitoring program for the Project.

Section 4: Analyses the groundwater monitoring results for the Project.

Section 5: Provides tabulated monitoring results and various time series graphs.

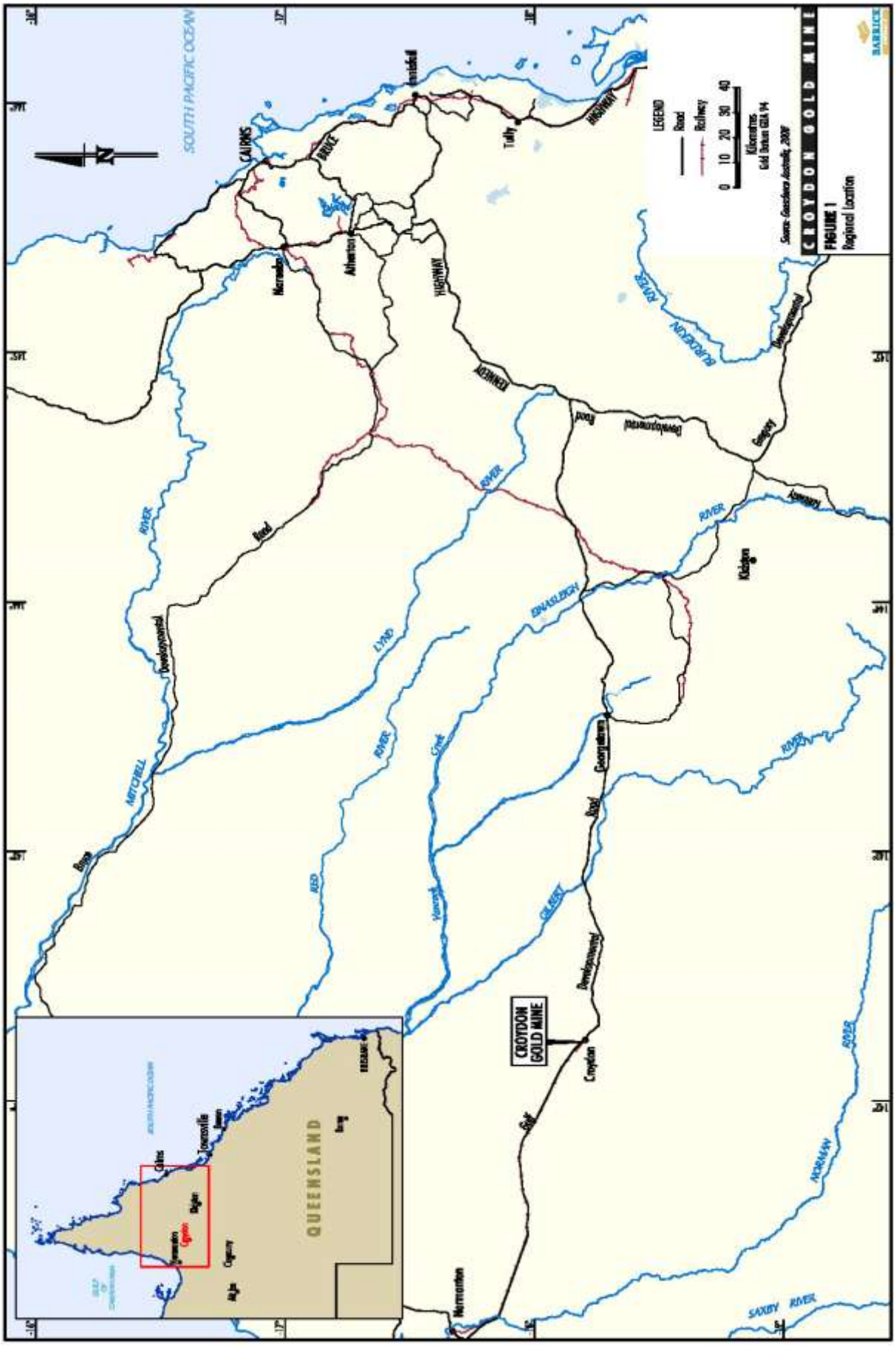


Figure 1: Croydon project site location

3 HYDROGEOLOGICAL STATUS

3.1 RAINFALL

Daily rainfall records are available from the Queensland Bureau of Meteorology (BoM) Croydon Township Weather Station (station number 29012) since 1889 with various statistics summarised in Table 1 and Figure 2 to Figure 9. The rainfall statistics show that the 2013/2014 wet season was a "median" event following a previous low rainfall wet season which in turn broke the previous three successive years of extraordinarily high rainfall wet season periods. To date the 2014 calendar year rainfall indicates the potential drought conditions persisting.

Table 1: Croydon Township Weather Station Rainfall Data

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	
Mean rainfall (mm)	222.1	180.1	116.9	25.1	7.8	8.4	3.9	2.7	5.5	13.9	44.6	115.3	747.8	1889 - 2012
Highest rainfall (mm)	860.5	601.4	591.4	279.8	129.3	139.2	83.4	44.2	92.7	145	384.7	312	1565.8	
Date	1974	1964	1936	2010	1920	1990	2006	1924	1943	1975	1973	1942	2010	
Lowest rainfall (mm)	49.4	5.3	0	0	0	0	0	0	0	0	0	0.5	225.4	
Date	2003	1926	1988	2012	2011	2013	2011	2012	2011	2008	2003	1934	1952	
Decile 1 rainfall (mm)	73.8	45.9	17	0	0	0	0	0	0	0	5.9	36.6	440.1	
Decile 5 (median) rainfall (mm)	196	166.6	93.7	9.2	0.4	0.4	0	0	0	4.6	27.8	102.4	720.2	
Decile 9 rainfall (mm)	395.4	303.3	242	63.6	22.8	20.6	11.1	8.9	19.7	37	95.4	230.7	1038.6	
Highest daily rainfall (mm)	381	367.8	245.9	155.2	63.5	91	35	39.6	77.5	63.5	151.1	153	381	
Date	29 Jan 1908	05 Feb 1964	12 Mar 1936	06 Apr 2010	07 May 1956	05 Jun 1990	15 Jul 2006	29 Aug 1924	04 Sep 1943	15 Oct 1964	27 Nov 1973	20 Dec 1976	29 Jan 1908	
Mean number of days of rain	12.8	12.3	8.4	2.1	1.1	1	0.6	0.4	0.6	1.8	4.5	8.3	53.9	
Mean number of days of rain ≥ 1 mm	11.9	11.3	7.3	1.8	0.8	0.8	0.5	0.3	0.5	1.4	3.8	7.5	47.9	
Mean number of days of rain ≥ 10 mm	6	5.5	3.3	0.6	0.2	0.2	0.1	0.1	0.2	0.5	1.3	3.3	21.3	
Mean number of days of rain ≥ 25 mm	2.8	2.2	1.4	0.3	0.1	0.1	0	0	0.1	0.1	0.5	1.4	9	
Monthly rainfall (mm)	100.6	220	28.9	12.4	1.2	6.2	0	0.8	0	0	51.8	-	-	2014
Highest daily rainfall (mm)	30.8	37	19.8	6	1.2	2.6	0	0.8	0	0	32.4	-	-	
Number of days of rain	8	19	5	3	1	5	0	1	0	0	4	-	-	
Number of days of rain ≥ 1 mm	7	19	4	3	1	3	0	0	0	0	4	-	-	
Number of days of rain ≥ 10 mm	4	7	1	0	0	0	0	0	0	0	1	-	-	
Number of days of rain ≥ 25 mm	1	3	0	0	0	0	0	0	0	0	1	-	-	

Note: Data sourced from www.bom.gov.au (Croydon Station No 29012) for period 1st Jan 2014 to 23rd Mar 2014 and 1st Nov 2014 to 30th Nov 2014. Additional data from the Barrick rain gauge at the Content Pit site.

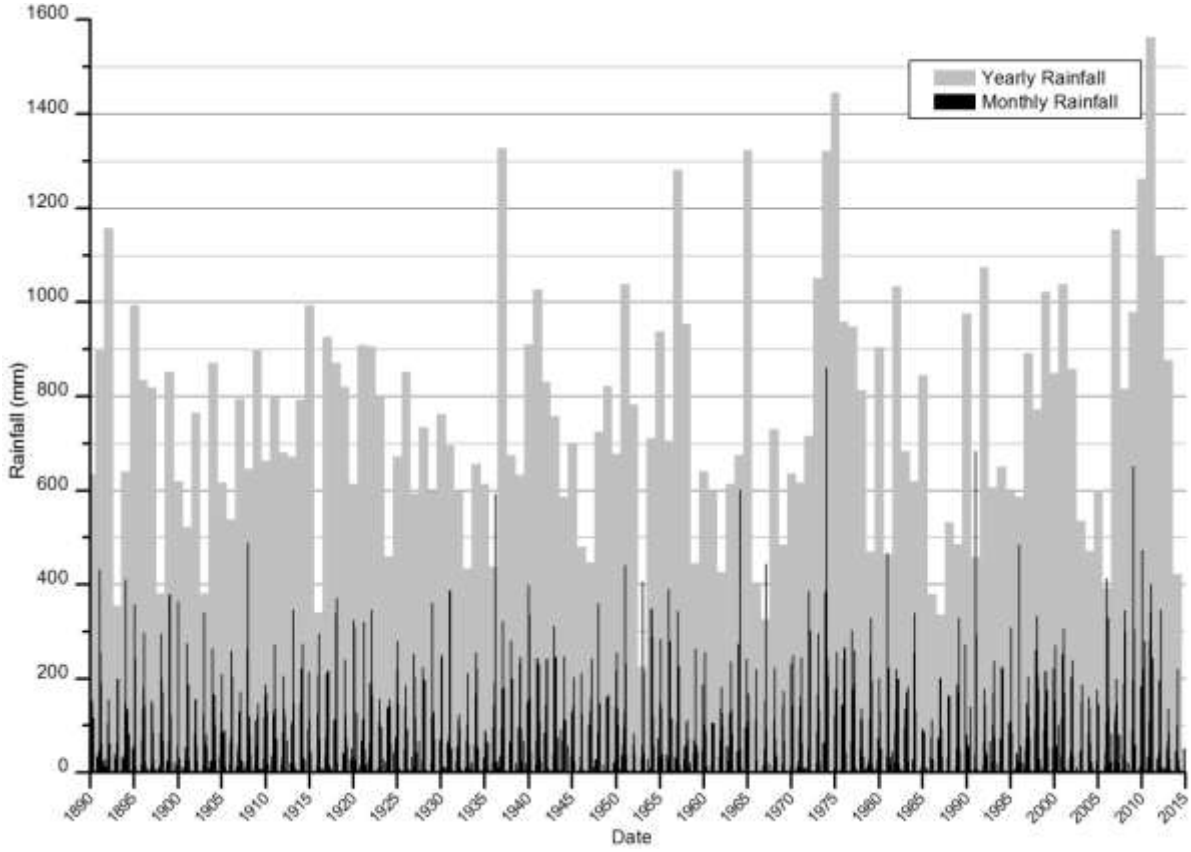


Figure 2: Yearly rainfall totals from Croydon Weather Station, 1889 to 2014

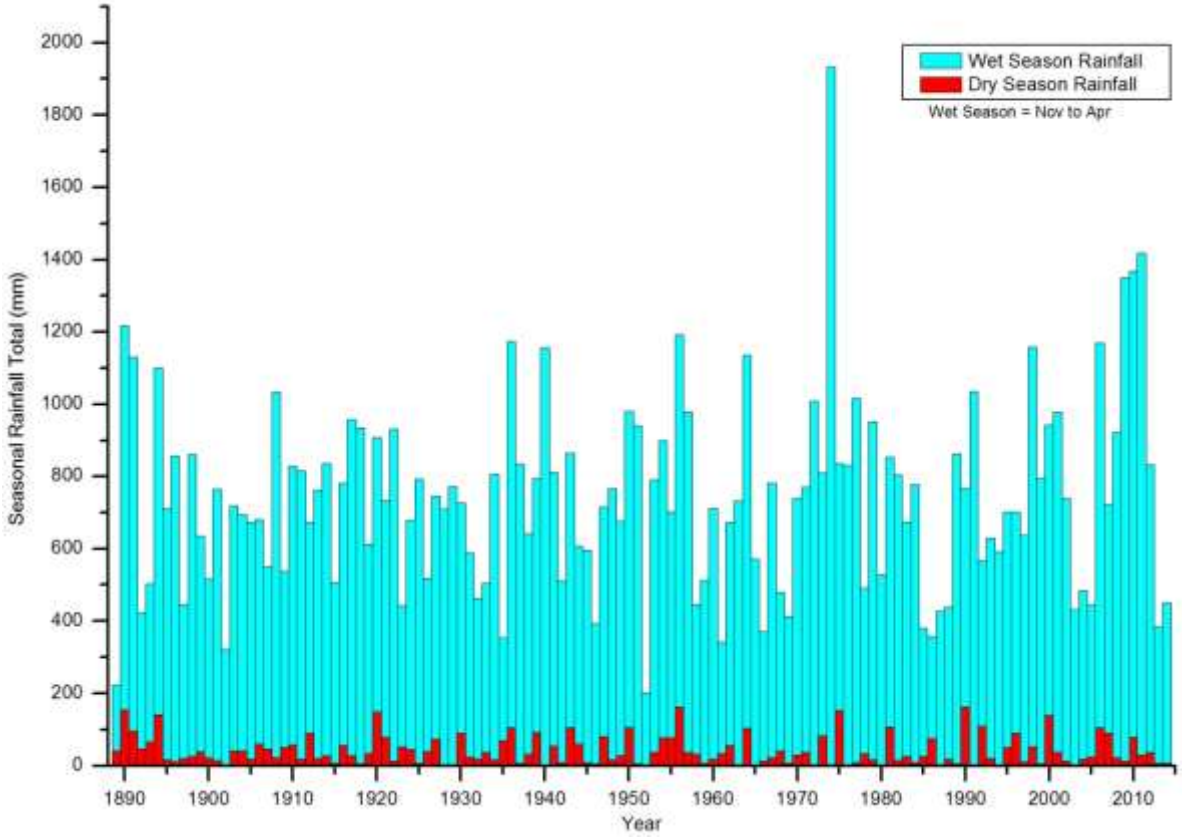


Figure 3: Wet and dry season rainfall totals from Croydon Weather Station, 1889 to 2014

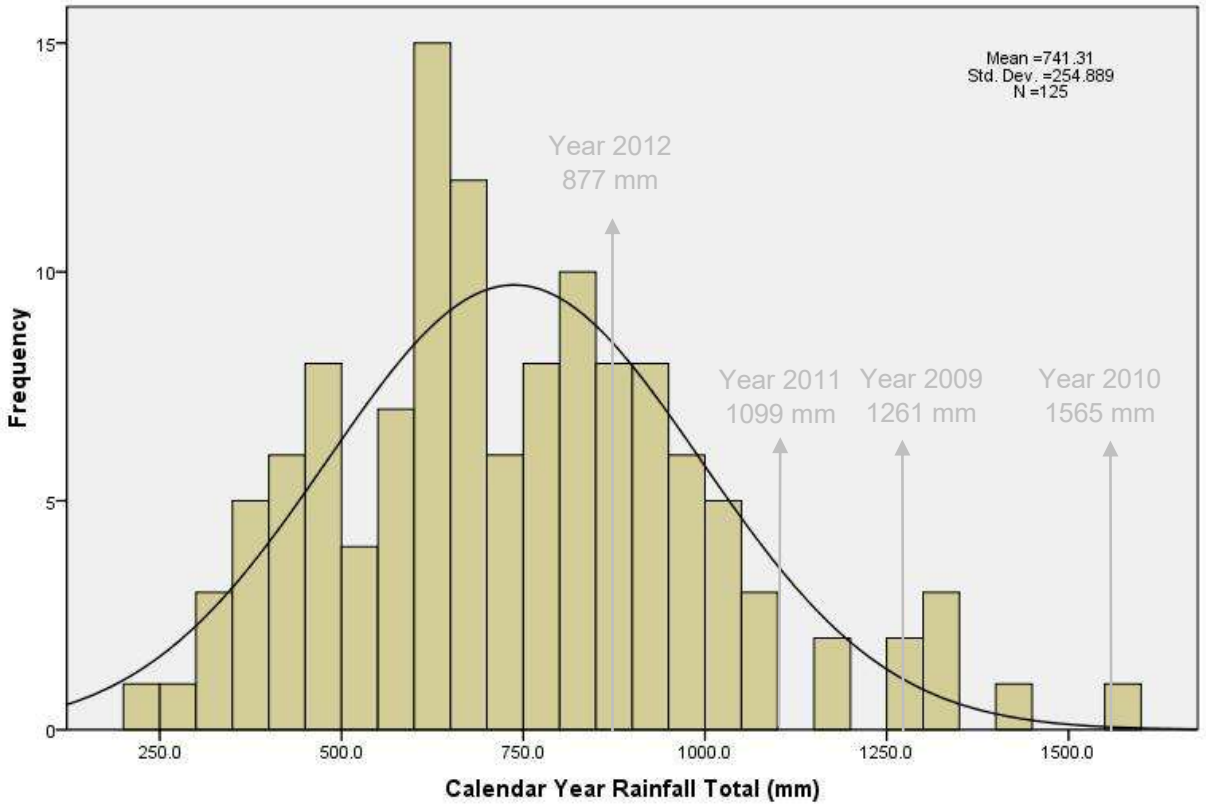


Figure 4: Frequency histogram of calendar year rainfall totals for Croydon

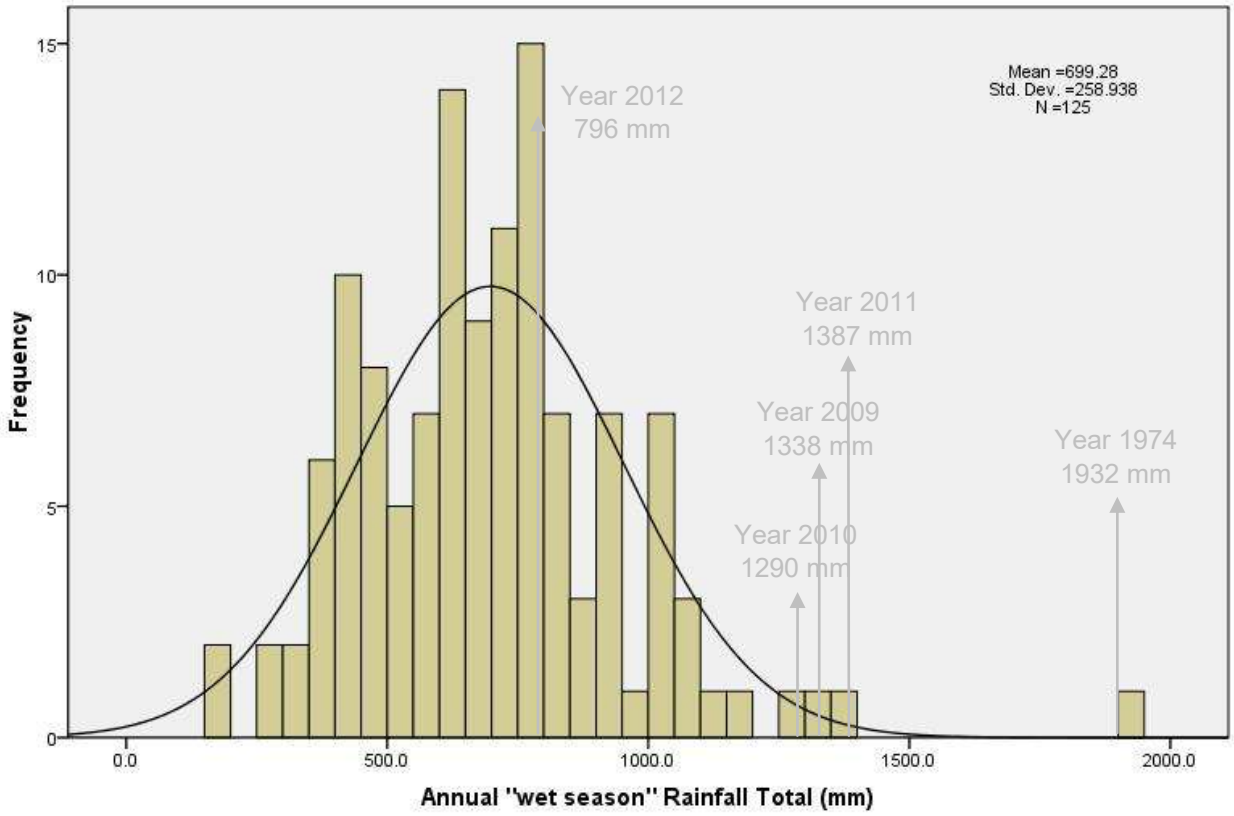


Figure 5: Frequency histogram of annual "wet season" rainfall totals for Croydon

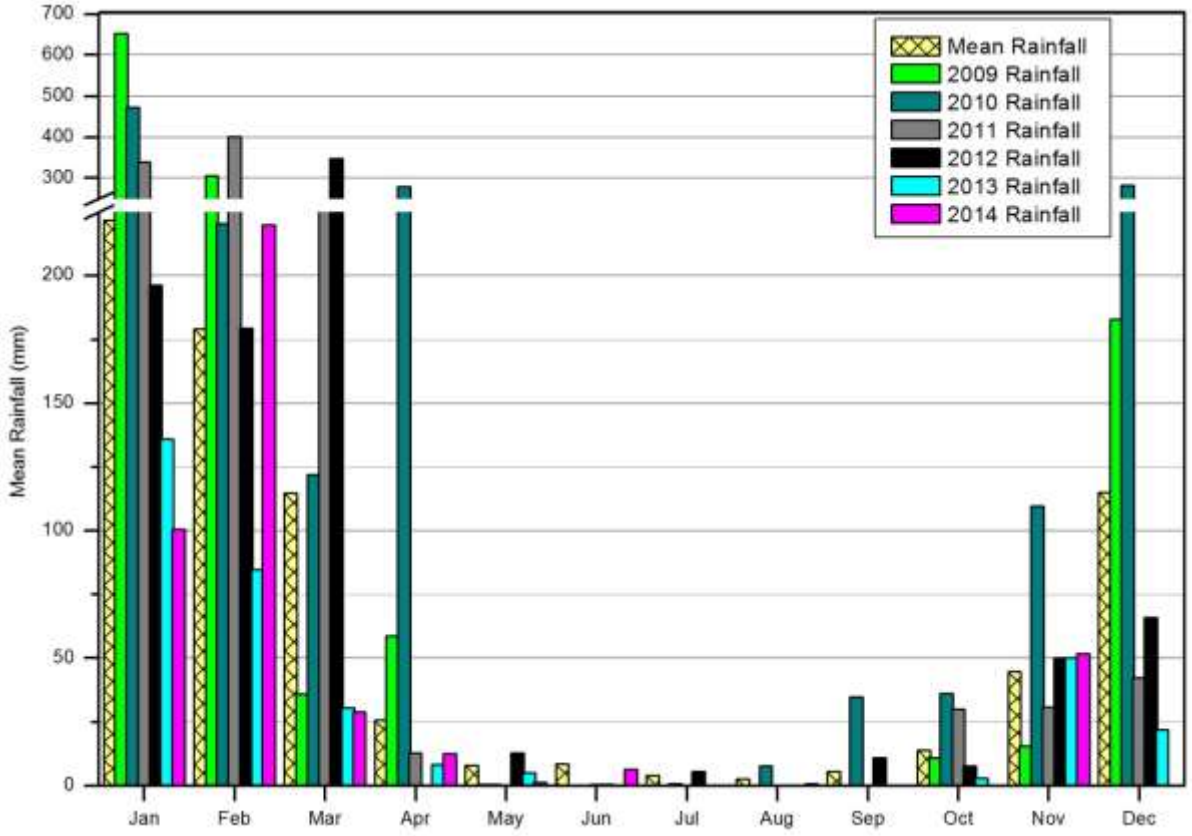


Figure 6: Mean 2014 monthly rainfall totals for Croydon

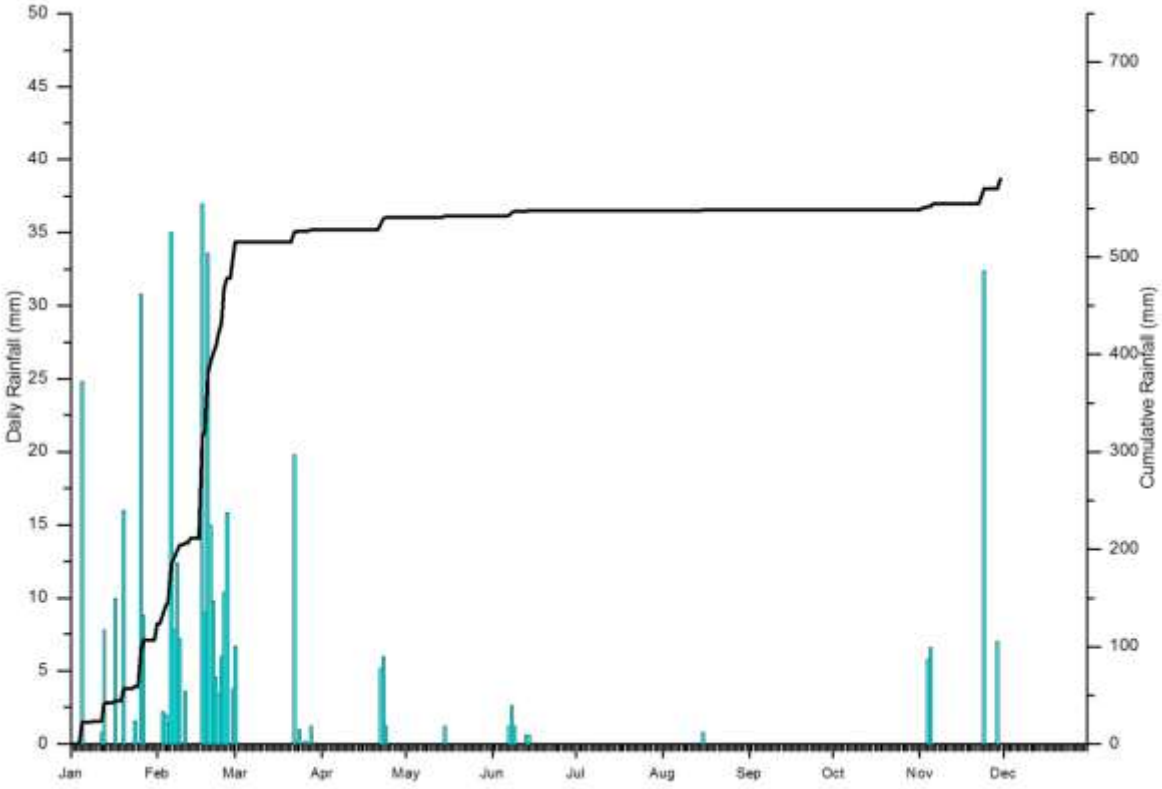


Figure 7: Daily and cumulative 2014 rainfall for Croydon

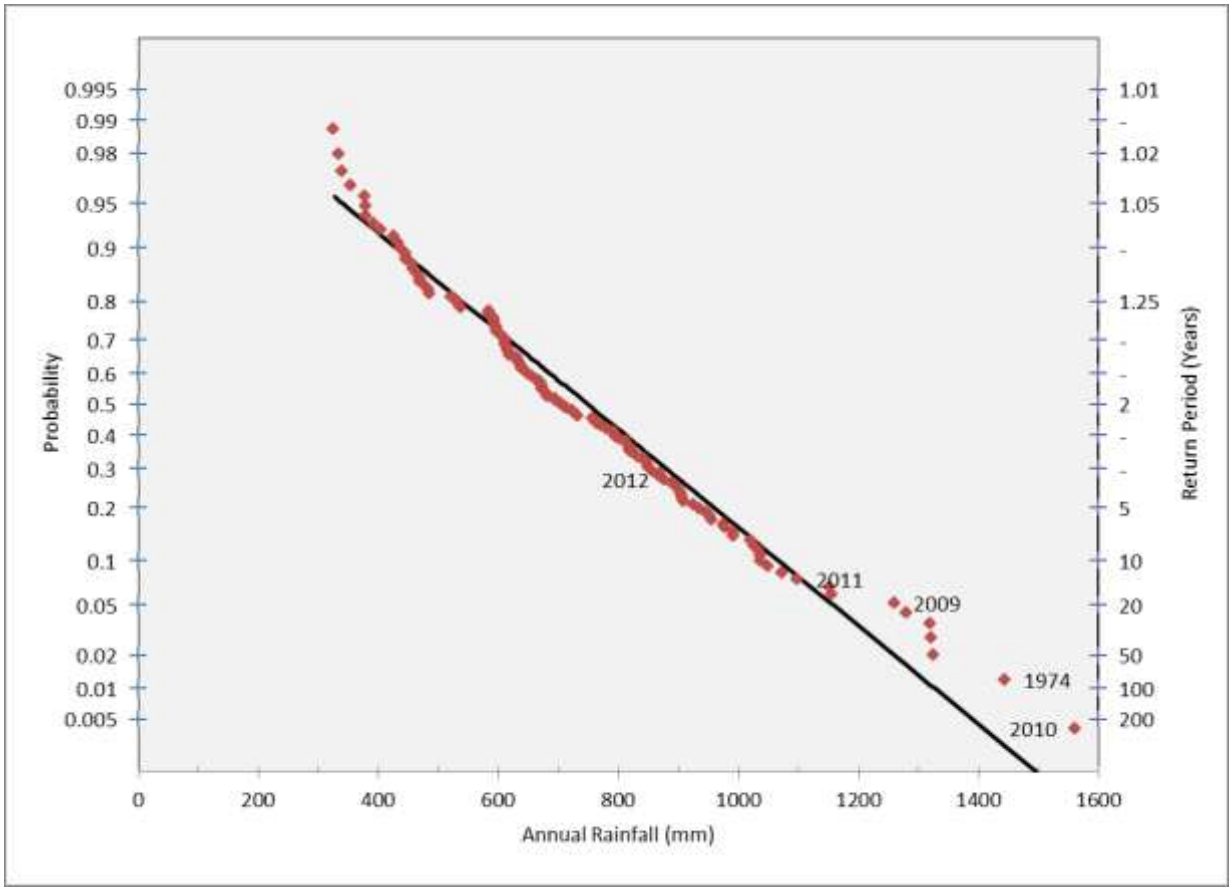


Figure 8: Croydon Calendar Year Annual Rainfall Normal Probability Plot

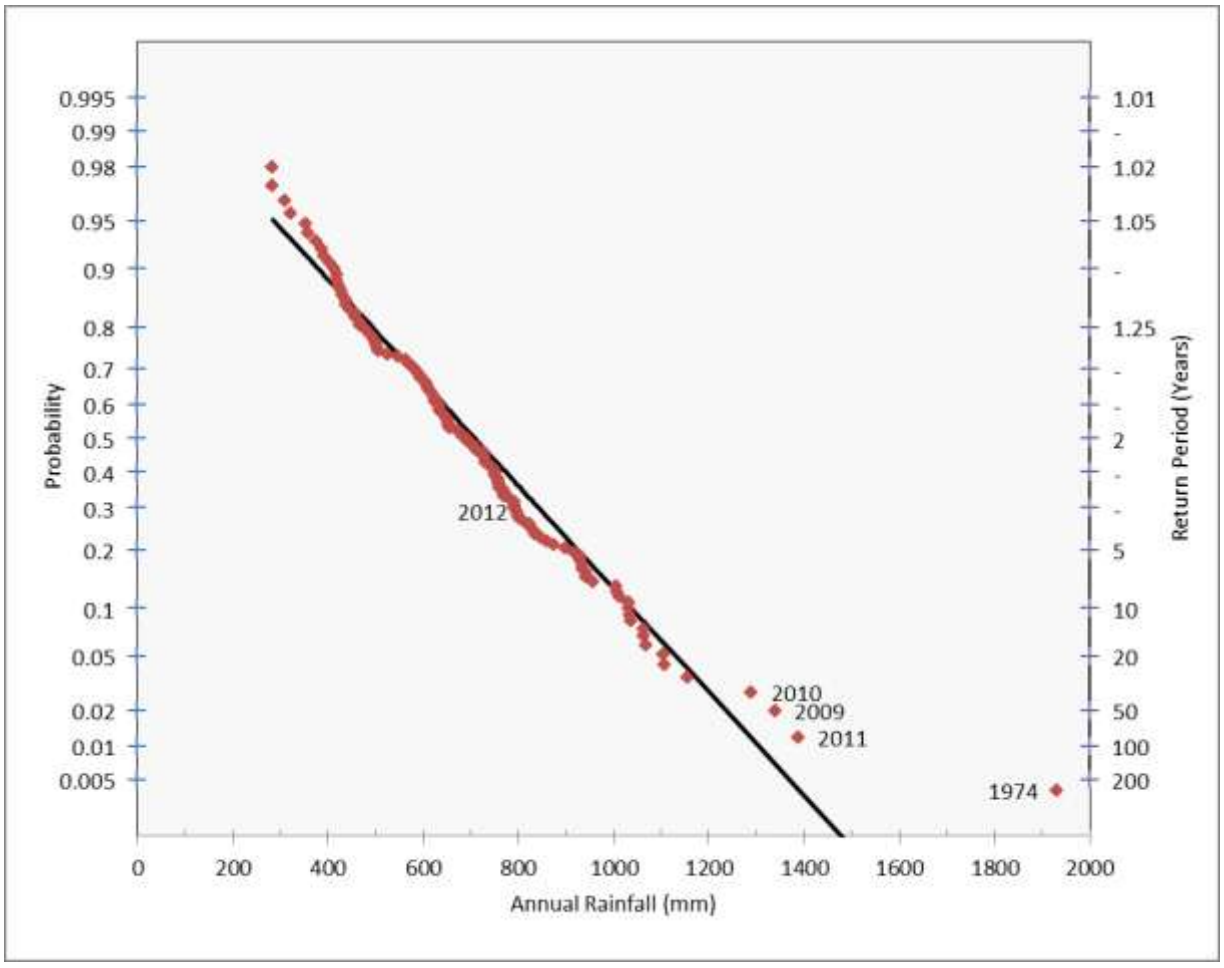


Figure 9: Croydon "water year" annual rainfall normal probability plot

3.2 CONCEPTUAL HYDROGEOLOGICAL MODEL

A conceptual hydrogeological model (Figure 16) was developed for the Project and surrounds during preparation of the Environmental Management Plan (EM Plan)[3]. The conceptual hydrogeological model was based on the hydrogeological study conducted by HLA-Envirosciences[4] and available groundwater quality information.

The hydrogeological study indicates that the pit lakes are expected to act as groundwater sinks and have limited capacity to influence groundwater quality much beyond the immediate footprint of the pits. In addition, the hydrogeological study showed that historic rainfall and evaporation data indicate a relatively large deficit (due to short wet season and high evaporation during most of the year) and that even in the wettest years there is no risk of the pit lakes overtopping[5]. Despite these conclusions from the conceptual hydrogeological model the unprecedented rainfall totals experienced since 2008/2009 (see Section 3.1) raised concerns about the model's robustness.

The 2008/2009 and 2009/2010 wet seasons resulted in extraordinary rainfall totals (see Figure 2). In recognition of the possibility of a discharge from the Content Pit, Barrick had undertaken short-term remediation works involving the transfer from water from the Content Pit to the Golden Butterfly Pit to minimise the risk of the Content Pit overtopping during the 2010/2011 wet season. The water level of the Content Pit was decreased by approximately four (4) meters during November and December 2010 (with a subsequent increase of one (1) meter in the Golden Butterfly Pit). Nevertheless, on the 29th March 2011 the Content Pit began discharging water which continued until the 13th April 2011 when no flow was observed to be entering receiving streams. This event obviously shows that the conceptual hydrogeological model in terms of the Content Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation.

In order to provide additional information to assist in modifying the conceptual hydrological model, a series of water level monitoring stations were installed in each of the pit lakes at Croydon (see Figure 10) in January 2012. Each of these stations is fitted with a pressure sensor transducer connected to a data logger with solar powered battery supply. Additionally, in the event of a further discharge from the Content Pit, a measuring flume has been installed in the v-drain which will direct any outflow from the Content Pit.

The additional information now available proceeding the extraordinary succession of wet season rainfall totals from 2009 to 2011 followed by reversion to median conditions in 2012 allow the conceptual model to be refined as follows.

The pit lake water levels in the Golden Butterfly Pit and Golden Butterfly North Pit were observed to increase over the period since closure in 1995 but maintain significant freeboard capacity up to 2009. After which occurred a period of three successive record wet season rainfall totals from 2009 to 2011. However, this still resulted in freeboard capacity within the Golden Butterfly Pit and Golden Butterfly North Pit lakes remaining greater than approximately nine meters. The subsequent return to median rainfall conditions during 2012 has resulted in a decrease in pit lake levels of approximately 2m. Therefore, the conceptual hydrological model for the Golden Butterfly Pit and Golden Butterfly North Pit lakes acting as groundwater sinks having limited capacity to influence groundwater quality much beyond the immediate footprint of the pits, with an overall long-term negative water balance never leading to pit overtopping is supported by the collected field data.

The situation for the Content Pit and Lady Isabella Pit lakes however differs in response to the potential situation of successive high rainfall total wet seasons. The approximately fifteen year period prior to 2009 resulted in the Content Pit and Lady Isabella Pit lakes fluctuating in response to climatic and hydrological factors but maintaining freeboard capacity and not overtopping. However, the three successive record wet season rainfall totals from 2009 to 2011 demonstrated that the Content Pit and potentially the Lady Isabella Pit can overtop. The subsequent return to median rainfall conditions during 2012 show that these pit lakes again show a negative water balance with reducing pit lake levels.

During December 2012 limestone dosing of both the Content Pit and Lady Isabella Pit lakes was performed to raise the pH to approximately neutral conditions. This enabled the Content Pit lake water to meet all stock watering guidelines and similarly for Lady Isabella Pit, with the exception of fluoride. Subsequently the local pastoralist and Shire Council received approval to abstract water from the Content Pit and Lady Isabella Pit lakes for stock watering and road construction purposes respectively. This water abstraction from the Content Pit and Lady Isabella Pit lakes is expected to keep the pit lakes at low levels due to anthropogenic usage. Therefore, overtopping of the Content Pit and Lady Isabella Pit lakes is not expected to occur in the future.

Table 2: Croydon Pit Lake Levels prior to automatic logging stations

	Content Pit[f]		Golden Butterfly Pit[f]		Lady Isabella Pit[f]		Golden Butterfly North Pit[f]	
	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate	Water Level (m)	Freeboard to Gate
10th July 2010	102.53	1.54	102.07	12.57	106.93	3.13	112.01	9.71
13th Aug 2010	102.35	1.36	102.0	12.5	106.75	2.95	111.8	9.5
27th Aug 2010	102.30	1.40	101.97	12.47	na	na	na	na
18th Oct 2010	102.10	1.60	na	na	106.53	3.17	111.44	9.86
19th Nov 2010	101.98	1.72	101.86	12.64	106.37	3.33	111.27	10.03
7th Dec 2010	98.98	4.72	103.36	11.14	106.48	3.23	na	na
29th Dec 2010	99.305	4.395	103.56	10.94	na	na	na	na
23rd Feb 2011	103.7	0	na	na	109.7	0.0	na	na
23rd Aug 2011	103.24	0.47	106.31[a]	8.19	108.26[a]	1.44	113.31	9.40
20th Oct 2011	102.89	0.81	104.91[a]	9.59	107.90[a] 108.13[b]	1.57	112.64	10.07
6th Dec 2011	102.65[d]	1.05	104.75[d]	9.75	107.96[c] 107.82[d]	1.74	na	na
22nd Dec 2011	102.57[d]	1.13	104.74	9.76	107.76[d]	1.94	113.78[d]	8.92

a. Using Dumpy Level
b. Compared to last gauge board reading (8th Dec 2010)
c. Using gauge board reading
d. Using survey equipment
e. Reference RL's: Content Pit 103.7m; Golden Butterfly Pit 114.5m; Lady Isabella Pit 109.7m; Golden Butterfly North Pit 122.7m
f. After Dec 2011 water levels were automatically monitored using pressure sensors

Lady Isabella Pit

Golden Butterfly North Pit

Golden Butterfly Pit

Content Pit

Figure 10: Croydon Pit Lake water level monitoring stations

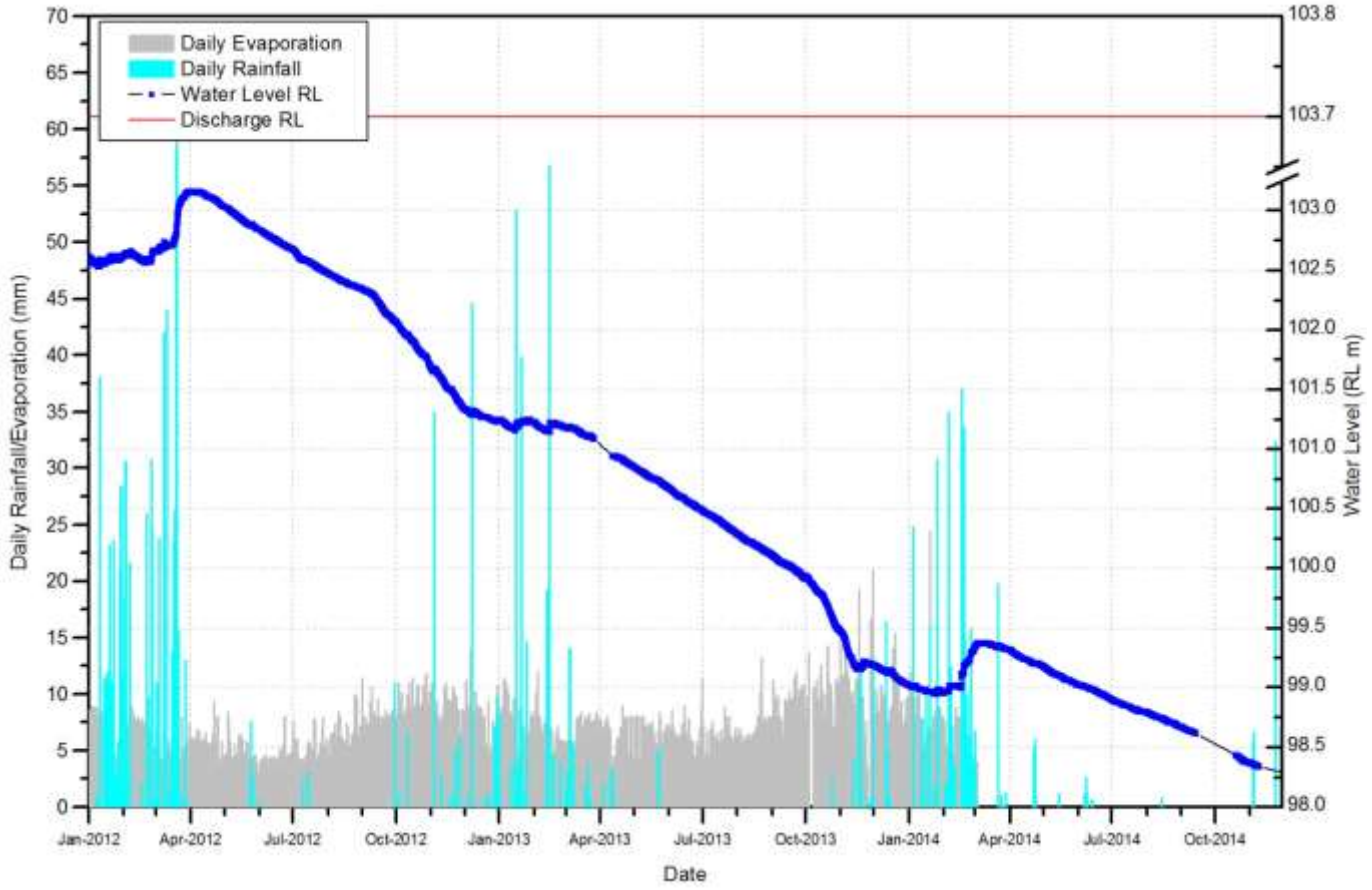


Figure 11: Pit Lake Water Level - Content Pit

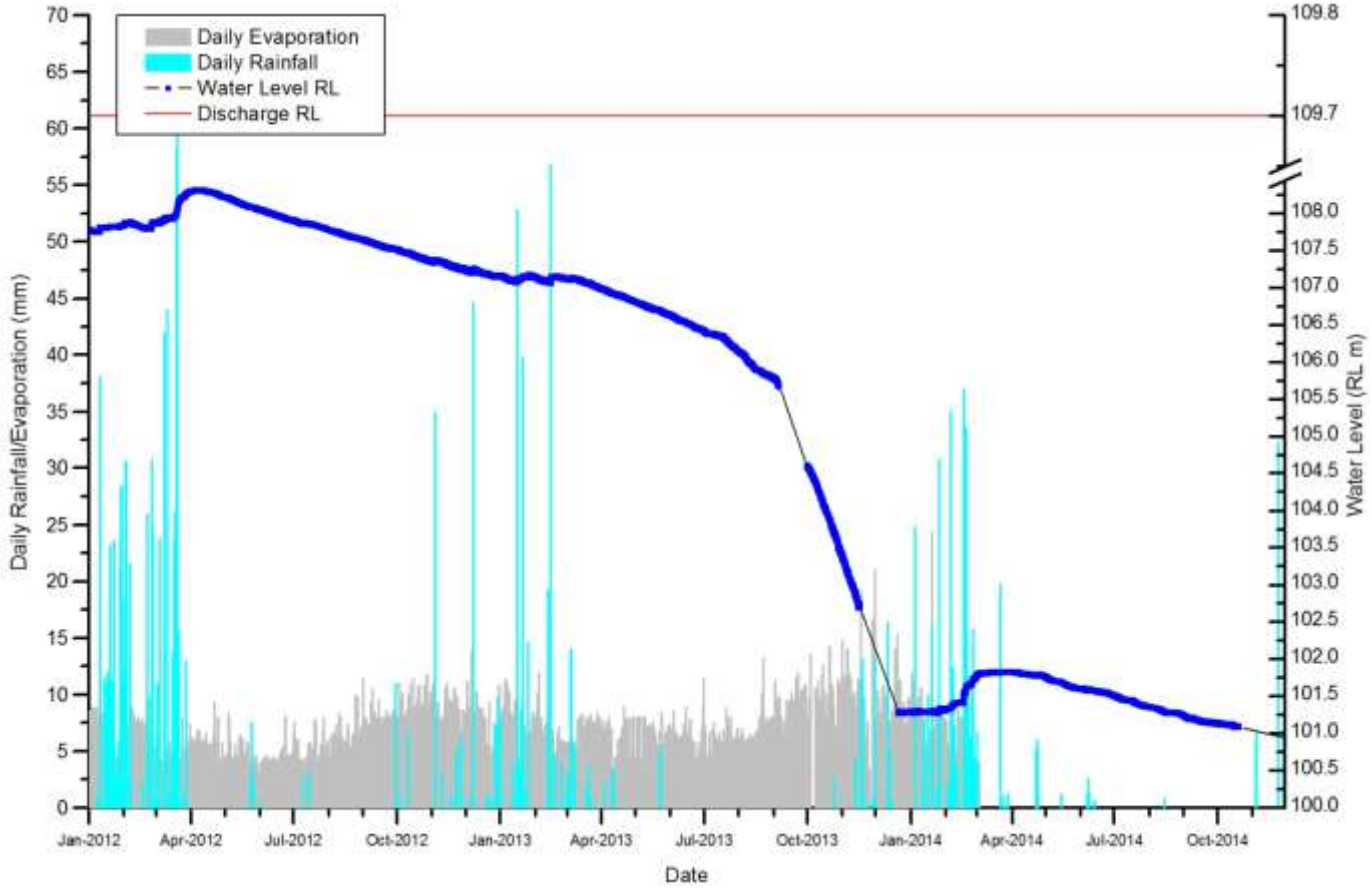


Figure 12: Pit Lake Water Level - Lady Isabella Pit

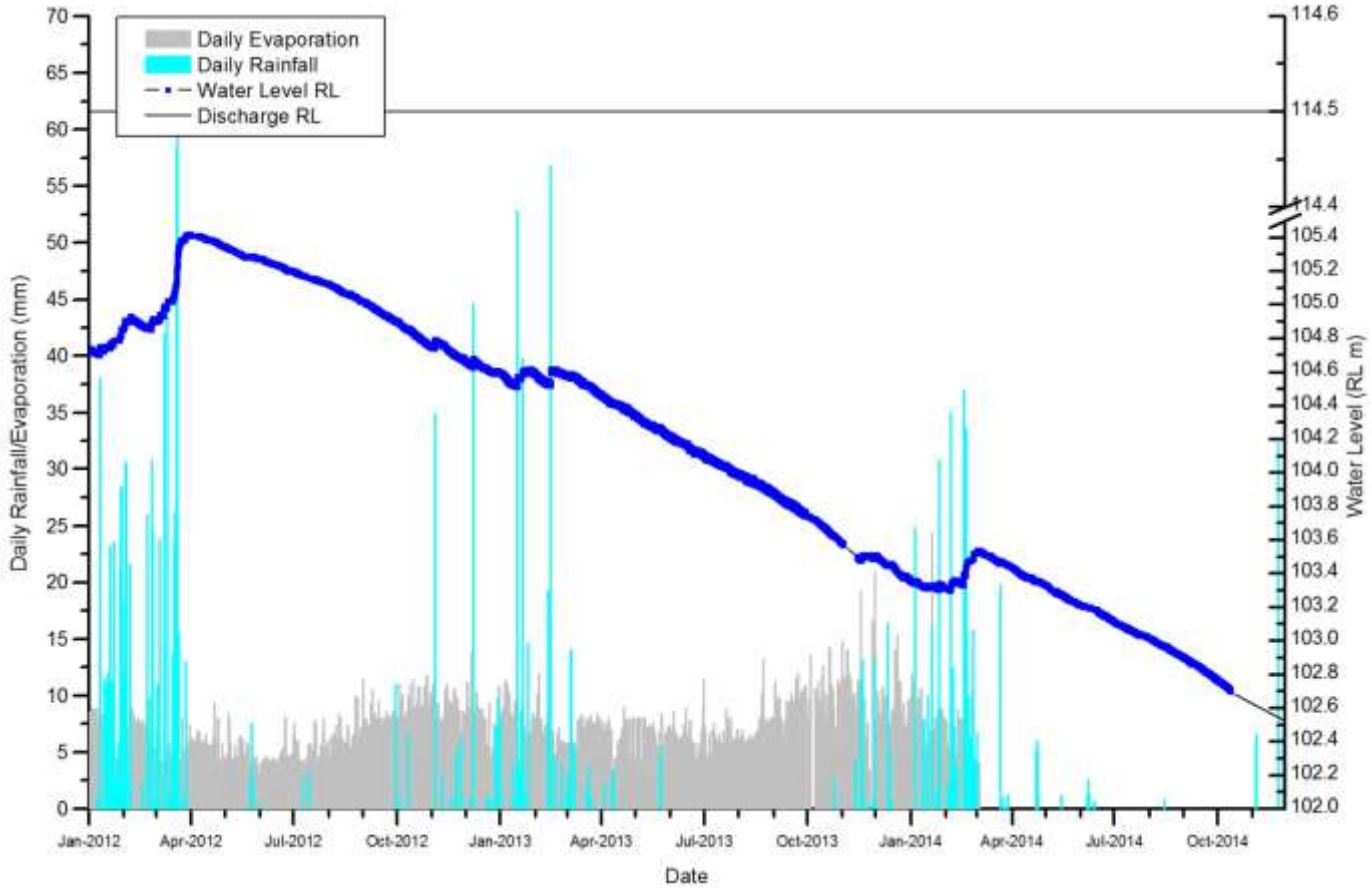


Figure 13: Pit Lake Water Level - Golden Butterfly Pit

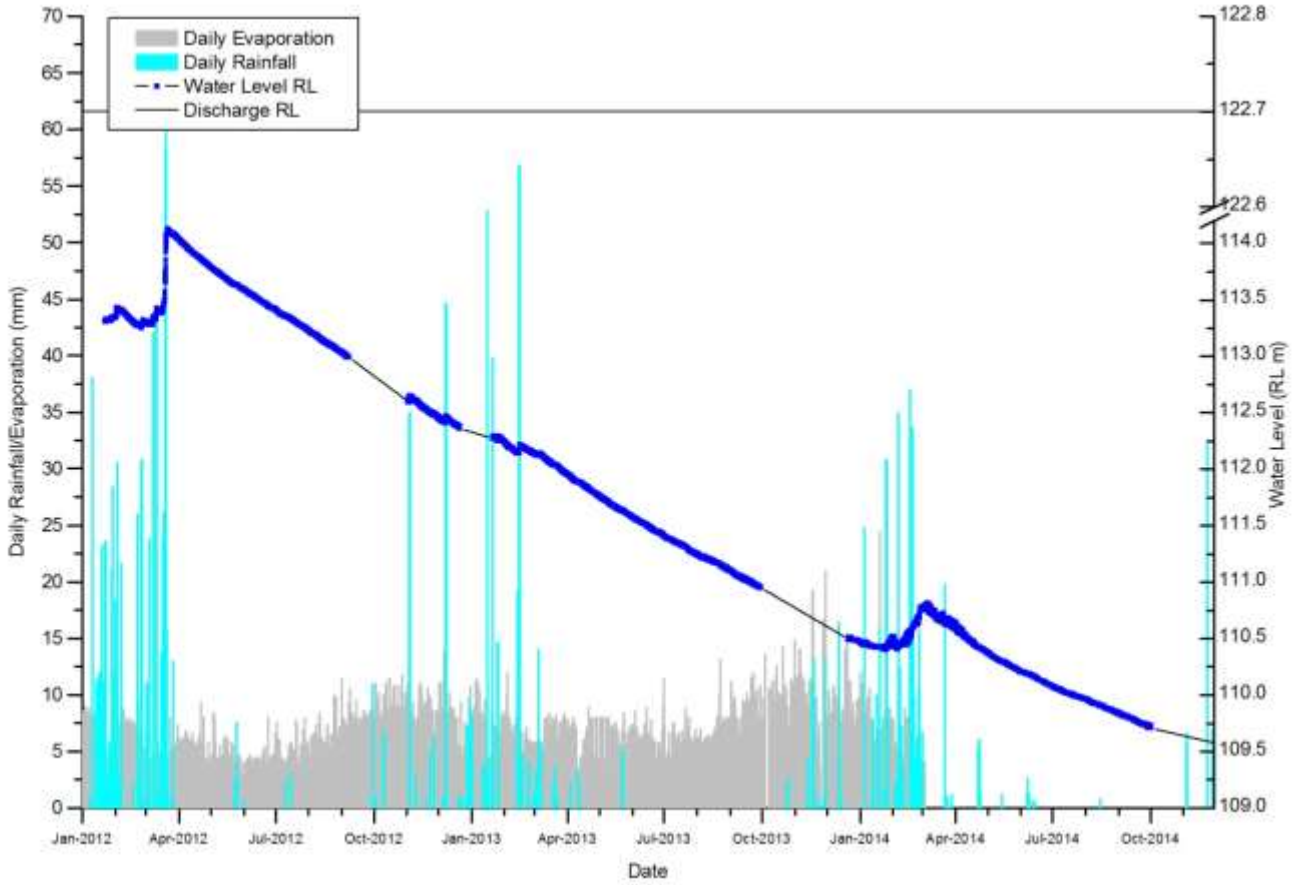


Figure 14: Pit Lake Water Level - Golden Butterfly North Pit

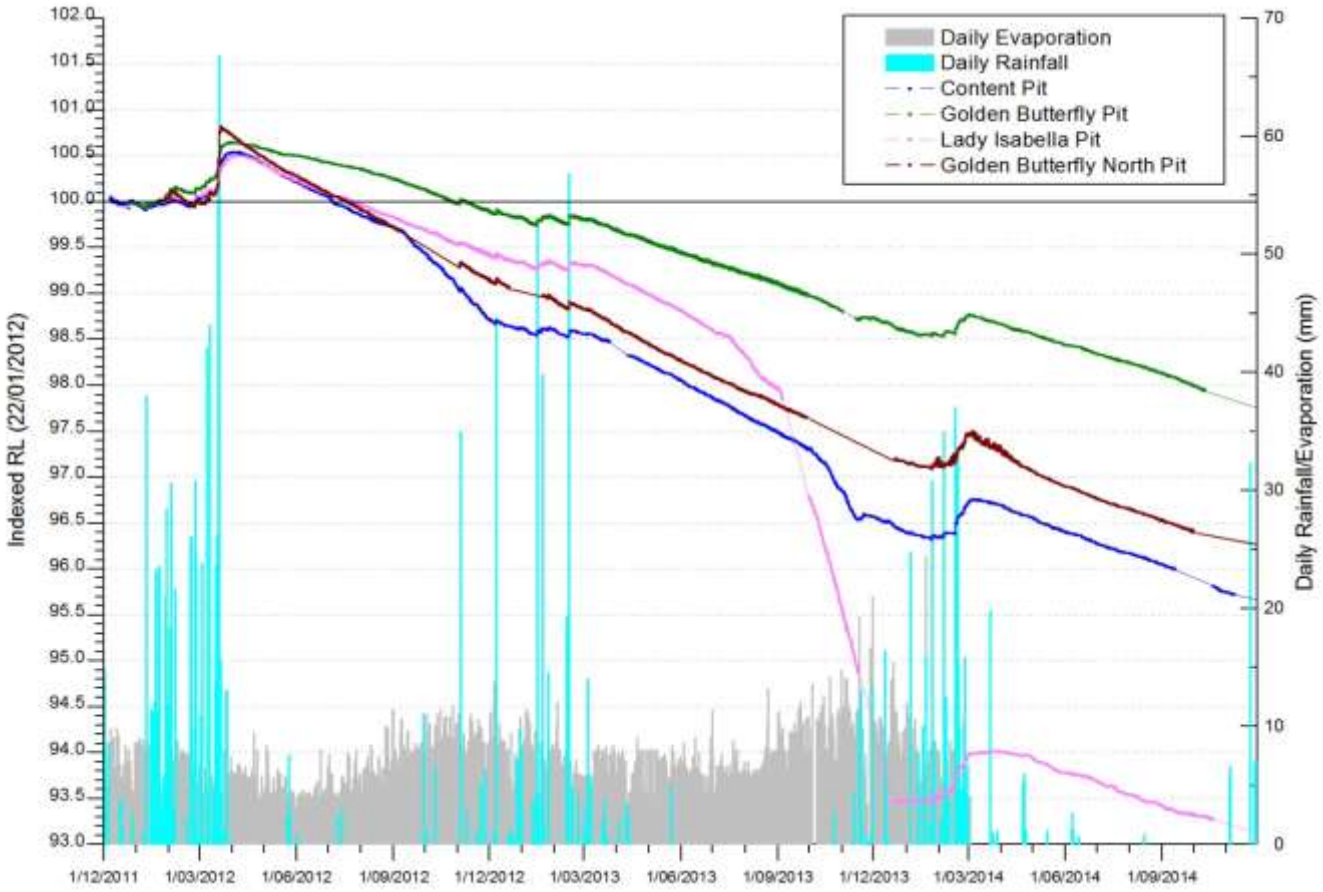


Figure 15: Pit Lake Water Level Comparison – Indexed to 100 (22nd Jan 2012)

3.3 EXISTING GROUNDWATER ENVIRONMENT

ML 5248 contains no springs or groundwater supported surface drainage features. Groundwater occurs in deep fractured rock aquifers, but is not utilised as a water resource on or adjacent to ML 5248. Any aquifers linked to the main mineralised zones might be expected to have raised levels of metals and sulphate. This assumption is supported by water quality analysis from the monitoring bores located in this area. It is likely that water quality will vary significantly between individual fractured rock aquifers, with limited hydrogeological linkage between aquifers. These aquifers would therefore not be considered potential potable water supplies, irrespective of potential yields.

The original Croydon town borefield, decommissioned more than 15 years ago, is located within Slaughteryard Creek approximately 1 km south-west of Golden Butterfly Pit (see Figure 20). It is considered that the borefield exploits both an unconfined alluvial aquifer and deeper fractured rock aquifers in the underlying sandstone units. A series of monitoring bores (i.e. GBMB series Figure 21) located between the old town borefield and ML 5248 have been monitored for more than 15 years and continue to show no influence (i.e. hydrogeological linkage) between Golden Butterfly Pit and the borefield.

In accordance with EA Condition F4-5 additional monitoring bores BH8, BH9, BH10, BH11, BH12 and SY1 were constructed in late October 2008 (Figure 3) and continue to be monitored. A detailed analysis of the groundwater monitoring bore results is provided in Section 5.

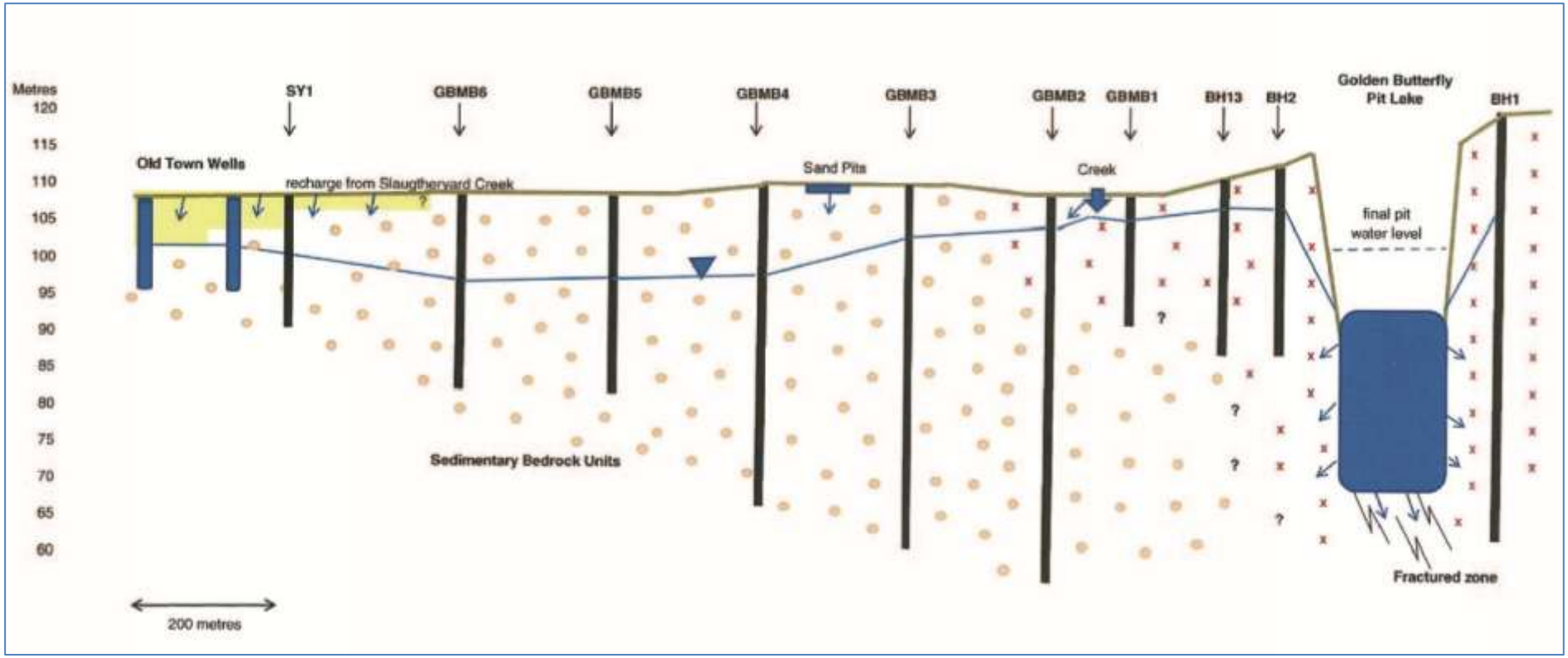


Figure 16: Croydon conceptual hydrological model

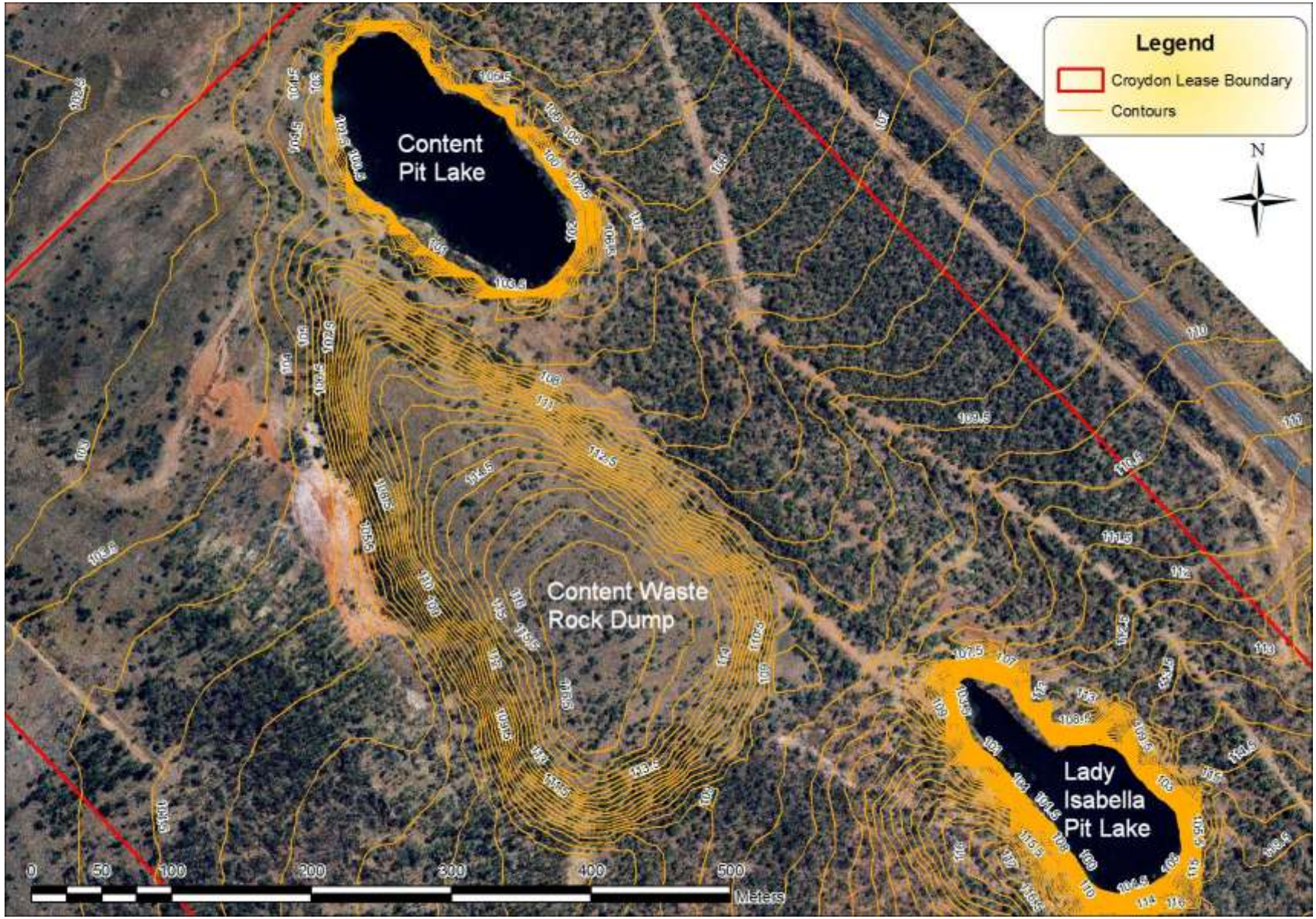


Figure 17: Content Pit contour map

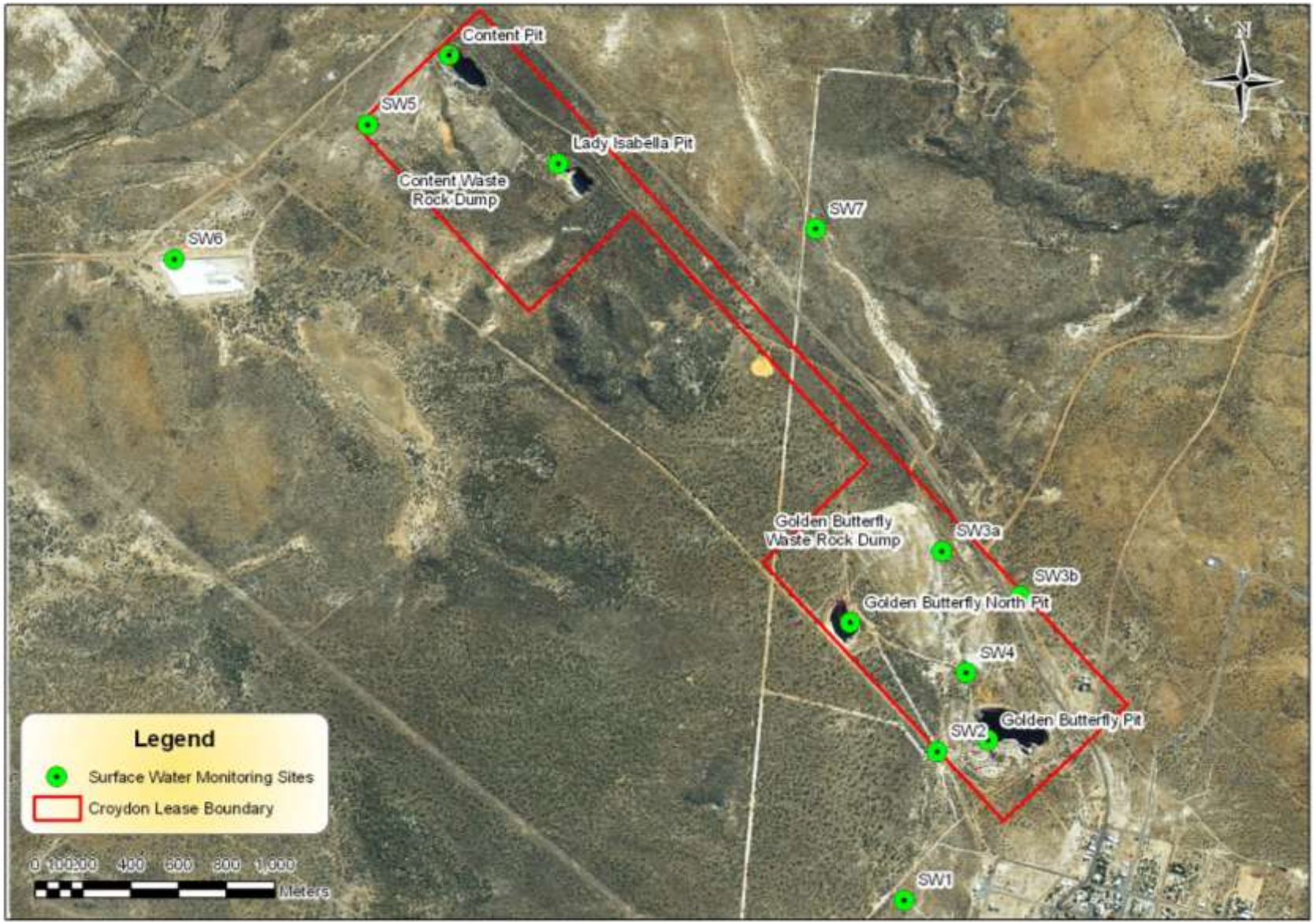


Figure 18: Croydon Surface Water Monitoring Sites

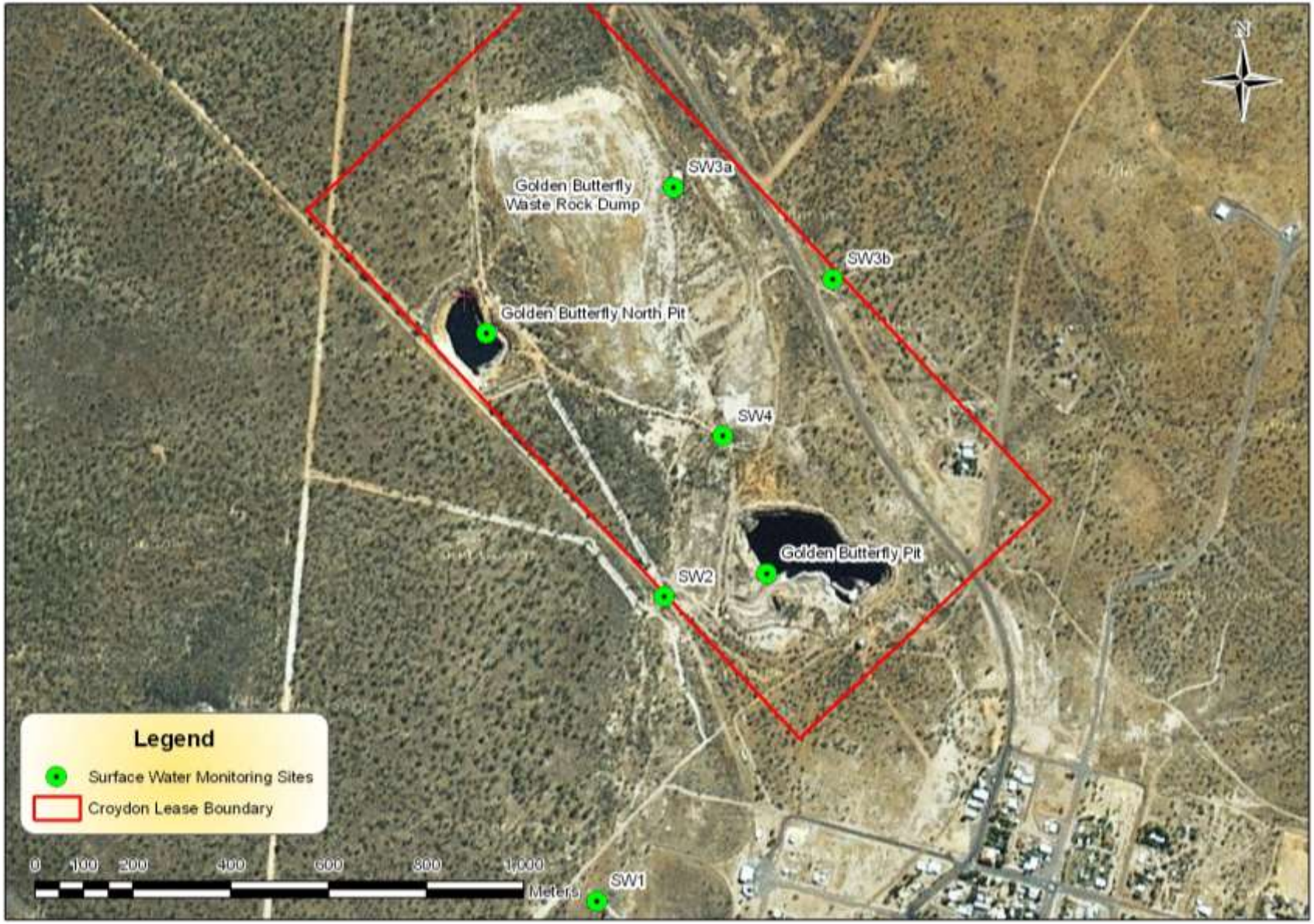


Figure 19: Croydon Surface Monitoring Sites – South-Eastern Close-up

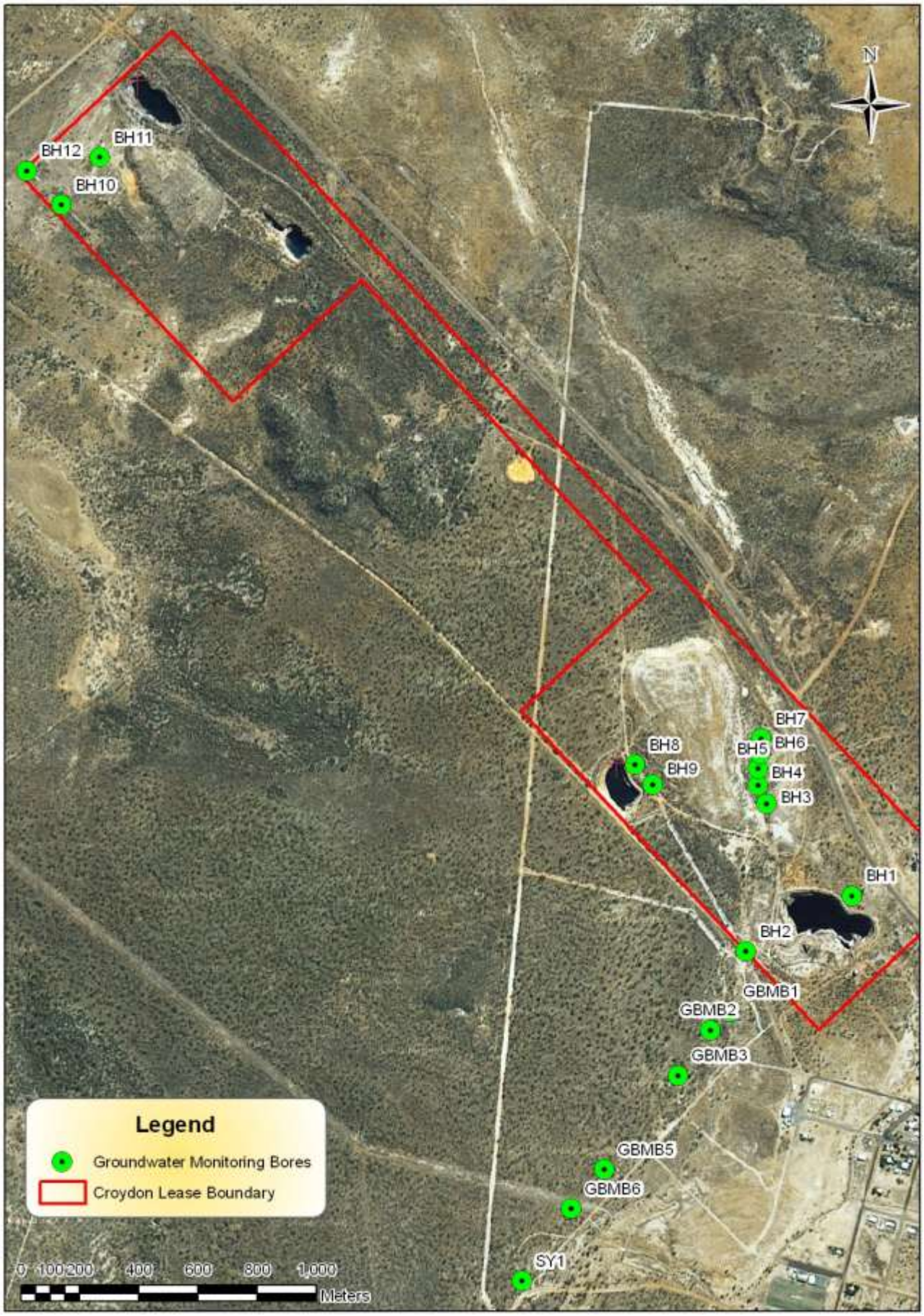


Figure 20: Croydon Groundwater Monitoring Bores

Figure 21: Croydon Groundwater Monitoring Bores– South-Eastern Close-up

4 GROUNDWATER MONITORING PROGRAM

In accordance with EA Condition F4-1 groundwater monitoring is conducted at the locations and frequencies defined in Schedule F - Table 9 of the EA for the parameters identified in Schedule F - Tables 10 and 11 of the EA. A summary of the groundwater monitoring for the Project is provided in Table 3.

In addition, groundwater levels are recorded in all monitoring bores defined Schedule F - Table 9 of the EA as soon as practical after the end of wet season (generally March/April after access roads have opened) and again during the dry season.

Table 3: Groundwater Monitoring Programme

Monitoring Location[1]	Frequency	Parameters
BH1 (North of Golden Butterfly Pit)	Annually during the dry season	pH EC Turbidity Sulphate Fluoride Aluminium Arsenic Boron Cadmium Chromium (CrVI) Cobalt Copper Mercury (inorganic) Nickel Selenium (total) Zinc
BH2 (South-west of Golden Butterfly Pit)		
BH3 (South-east of Golden Butterfly Waste Rock Dump)		
BH5 (East of Golden Butterfly Pit Waste Rock Dump)		
BH7 (East of Golden Butterfly Waste Rock Dump)		
BH8 (West of Golden Butterfly Waste Rock Dump)		
BH9 (West of Golden Butterfly Waste Rock Dump)		
BH10 (West of Content Waste Rock Dump)		
BH11 (West of Content Waste Rock Dump)		
BH12 (West of Content Waste Rock Dump at lease boundary)		
GBMB1 (Slaughteryard Creek)		
GBMB3 (Slaughteryard Creek)		
GBMB6 (Slaughteryard Creek)		
SY1 (Slaughteryard Creek)		

1. See Figure 20 and Figure 21 for locations

5 GROUNDWATER MONITORING RESULTS

Groundwater sampled during 2014 was taken from the monitoring bores defined in Schedule F - Table 9 of the EA and sent to Australian Laboratory Services for analysis.

5.1 GROUNDWATER CHEMISTRY

The groundwater quality results for the EA monitoring bores are provided in Appendix 1 both in tabular format and as a sequence of time series graphs.

Trigger values were calculated as per the instructions in the footnotes to Schedule F – Table 10, of the EA for groundwater monitoring locations specified in Schedule F, Table 9 of the EA. Table 9 of Schedule F of the EA does not specify reference sites as required in the calculation of trigger values. Therefore, trigger values default to the ANZECC (2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems. Table 4 provides a summary of trigger value exceedences for groundwater monitoring locations during the reporting period.

Groundwater from bores identified in Schedule F – Table 9, must not exceed any of the limits defined in Schedule C – Table 11 of the EA. Table 4 provides a summary of contaminant limit exceedences for groundwater monitoring locations during the reporting period.

The various groundwater monitoring bores (see Figure 20 and Figure 21) are strategically located to provide information about possible impacts from various geographical features on the mining lease such as the mining pits and waste rock dumps. Consequently, groundwater quality monitoring results in terms of the various trigger level exceedences are discussed in the following groupings in subsequent sections:

1. Golden Butterfly Pit Monitoring Bores: BH1, BH2, GBMB1, GBMB3, GBMB6 and SY1
2. Golden Butterfly North Pit Monitoring Bores: BH8 and BH9
3. Content Pit Monitoring Bores: BH10, BH11 and BH12
4. Golden Butterfly Dump Monitoring Bores: BH3, BH4, BH5, BH6, BH7

Table 4: Summary of Trigger Level and Contaminant Limit Exceedence for Croydon Groundwater

Parameter[1]	Groundwater Location Exceeding Trigger Level[1,2]	Groundwater Location Exceeding Contaminant Limit[1,2,3]
pH	BH1, BH2, BH9, SY1	BH2
Electrical Conductivity	BH1, BH2, BH3, BH5, BH7, BH10, BH11, BH12, GBMB1, GBMB6	
Aluminium	BH2, BH3, GBMB3	
Arsenic	BH1, BH7, BH11, BH12, GBMB1, GBMB6	
Cadmium	BH5	
Cobalt	BH2, BH7, BH10, GBMB6	
Copper	BH2, BH3, BH7, BH8, BH9, BH10, BH11, BH12, SY1	
Nickel	BH2, BH7	
Zinc	BH1, BH2, BH7, BH8, BH9, BH10, BH12, GBMB1, GBMB3, SY1	
Sulphate		BH5, BH7, BH10
Fluoride		BH1, BH3, BH5, BH7, BH10, BH11, BH12, GBMB1

[1] Parameters and trigger levels defined in Schedule F Table 10

[2] Groundwater monitoring locations defined in Schedule F Table 9

[3] Parameters and contaminant limits defined in Schedule F Table 11

5.1.1 Golden Butterfly Pit Monitoring Bores

The Golden Butterfly Pit Monitoring Bores consist of the following locations BH1, BH2, GBMB1, GBMB3, GBMB6 and SY1 (see Figure 21). Monitoring bore BH1 is located within 50 meters of the north-eastern wall of the Golden Butterfly Pit and monitoring bore BH2 is located approximately 150 meters to the south-west. The remaining bores, GBMB1, GBMB3, GBMB6 and SY1 are located successively further away from the Golden Butterfly Pit towards the south-west, approximately following the course of a tributary to Slaughteryard Creek that drains from the mine lease area. Figure 33 presents time series graphs for all parameters which exceed trigger levels during the reporting period.

Electrical Conductivity

Electrical conductivity observed at the Golden Butterfly Pit Monitoring bores has approximately flat trends when viewed over the greater than fifteen year period for which data is available (Figure 33). Consequently, the observed trigger level exceedence of electrical conductivity at monitoring bores BH1, BH2, GBMB1 and GBMG6 is as per previous reporting periods and not an emergent issue. Although for the shallow alluvial bores GBMB1, GBMB3 and GBMB6 the electrical conductivity time series potential indicates the beginning of an increasing trend since approximately the end of the 2012 dry season. This would be consistent with the low rainfall 2012/2013 wet season producing less recharge of low electrical conductivity rain water via surface infiltration to the shallow surface aquifer in the Slaughteryard Creek drainage.

The major difficulty in assessing the relevance of the observed electrical conductivity trigger level exceedence is that no reference sites have been stipulated against which to judge the results. The default of using the ANZECC(2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems does not appear appropriate considering that groundwater is being assessed, not surface water, and further, the bores are located within a metalliferous area that has hosted mining for over one hundred years. Notwithstanding these difficulties, time series graphs and hydrochemical pattern diagrams such as Piper-Hill Plots and Durov Diagrams in conjunction with information about lithology, rock structural features, groundwater levels and climate factors such as rainfall enable interpretation of the groundwater analysis data in terms of potential environmental impact from mining associated landforms.

Table 8 and Figure 25 present groundwater level for the various bores associated with the Golden Butterfly Pit (see Figure 21 for locations). Figure 25 shows a decreasing trend in groundwater levels within bores in the immediate vicinity of the Golden Butterfly Pit, whereas, groundwater levels in bores located further away downstream in the Slaughteryard Creek drainage remain approximately constant. Figure 29 overlays a graph of bore water level RL versus distance from the Golden Butterfly Pit on the aerial photograph with locations of bores.

This groundwater data supports the conceptual hydrogeological model (see Section 3.2) showing that the Golden Butterfly Pit is a hydrological sink (i.e., groundwater levels within the bores are higher than the pit lake level leading to a hydraulic head towards the pit). Therefore, the trigger level exceedence at monitoring bores BH2, GBMB1 and GBMG6 is not the result of potential input from the Golden Butterfly Pit lake.

Electrical conductivity of a water sample is directly related to the concentration of dissolved anions and cations and the resultant ability to pass an electric current. Hence, waters of entirely different origins with dissimilar anionic and cationic constituents can record comparable electrical conductivity. Therefore, when considering the relevance of the observed trigger level exceedence of electrical conductivity at monitoring bores BH1, BH2, GBMB1 and GBMG6 it is important to also consider the actual concentrations of the contributory cations and anions.

Piper plots and Durov diagrams (see Figure 36 to Figure 42) provide a suitable means to summarise the major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and anions (SO_4^{2-}, HCO_3^{-}/CO_3^{2-}, Cl^{-}) present in groundwater in regards to potential similarity of composition and/or origin. The Piper plot has an advantage of depicting analytical data of a large number of samples in one diagram. It is also used for the classification of water samples into various hydrochemical types depending on the relative concentration of major cations and anions. Further, it is possible to demonstrate changes in water quality due to mixing of water of two extreme types and also the effect of base-exchange[6].

Figure 37 is the Piper Plot for the various bores associated with the Golden Butterfly Pit and the Slaughteryard Creek drainage. The data suggests that the bores GBMB1, GBMB3, GBMB6 and SY1 group as a category distinct from BH1 and BH2. Which in turn are distinct from the composition of water within the Golden Butterfly Pit. This categorisation is supported by the overall lithology with GBMB1, GBMB3, GBMB6 and SY1 being located in flood plain alluvium and or lateritised fine lag gravels/soil overlain by nodular ferricrete. Whereas BH1 and BH2 are within very coarse to medium grained (muscovite) biotite granite, porphyritic in part (see Figure 30) and the Golden Butterfly Pit lake being dominated by sulphate from the oxidation of sulfides.

Consideration of the data points on the Piper Plot for a location versus time can show if a groundwater is mixing between sources. Figure 37 shows no evidence of groundwater within the various bores being influenced or mixing with potential input from the Golden Butterfly Pit lake (which would be indicated by a movement towards increasing proportion of sulphate contributing to the overall dissolved chemical load). This is supported by the earlier conclusion from the groundwater level data that showed the potential hydraulic head is towards the pit lake.

A disadvantage of Piper plot is that it shows the relative concentration of different ions and not their absolute concentration. The Durov diagram overcomes this limitation in that it can provide a better display of different types of water and also some hydrochemical processes such as ion exchange, simple dissolution and mixing of waters of different qualities[7]. The Durov diagram is also a type of tri-linear plot but enables extension from the central square to display other chemical characteristics, in this case pH and total dissolved solids (TDS).

Figure 41 is the Durov diagram for the various bores associated with the Golden Butterfly Pit and the Slaughteryard Creek drainage. Again it can be readily seen that bores GBMB1, GBMB3, GBMB6 and SY1 group as a category distinct from BH1, BH2 and the Golden Butterfly Pit lake water. BH1 and Golden Butterfly Pit lake water appear similar in terms of total anions versus total cations (the central square of the diagram). However, the distinct difference in terms of pH and TDS readily show that BH1 bore water is distinct from Golden Butterfly Pit lake water. Therefore, the observed electrical conductivity trigger level exceedence at BH1 is due to local geological features and not from potential input from Golden Butterfly Pit lake water. Similarly,
Figure 41 again shows BH2 bore water is a distinct composition unrelated to the other locations. The low pH of bore water from BH2 being most readily explained as related to features associated with the immediate localised geology (noting that there is an indicated hydraulic gradient towards the pit lake at the location of BH2).

The preceding discussion is pertinent to the issue that no reference bore sites have been stipulated against which to judge the results. The default of using the ANZECC(2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems does not appear appropriate considering that groundwater is being assessed. The analysis of the Golden Butterfly Pit bores (GBMB1, GBMB3, GBMB6, SY1, BH1 and BH2) using time series graphs, Piper plots and Durov diagrams indicate that bores GBMB1, GBMB3, GBMB6, and SY1 form a potential grouping that is indicative of groundwater undisturbed by landforms associated with the mining lease. A statistical summarisation of groundwater data from these locations to give “reference values” would be initially indicated. However, it has also been demonstrated that bores BH1 and BH2 are similarly

not likely influenced by landforms associated with the mining lease (i.e., the Golden Butterfly Pit lake) but have water quality widely at variance with those within Slaughteryard Creek.

Considering that the area encompassed and surrounding the mine lease is within a metalliferous zone that has hosted mining for over one hundred years (see Figure 31), coupled with the complex localised geology, the concept of a single "reference bore" is perhaps not appropriate. The underlying issue is to identify if landforms associated with the mining lease are impacting off site groundwater quality. Since groundwater levels versus pit lake water level show a potential hydraulic gradient towards the pit, this indicates that the Golden Butterfly Pit cannot be affecting off site bores GBMB1, GBMB3, GBMB6, and SY1. Hence the quality of the groundwater in bores GBMB1, GBMB3, GBMB6, SY1 is moot in terms of impact from on lease sources and comparison to any potential standards.

In terms of bores BH1 and BH2, the immediate localised geology is indicated as the significant factor influencing observed groundwater quality from these locations (and in terms of BH2, again the potential hydraulic gradient towards the pit shows no possible interaction with the Golden Butterfly Pit lake). Since both BH1 and BH2 appear to be from difference hydrochemical facies, it would appear that a number of sets of "reference values" based upon the existing data from the relevant bores, each applicable to a particular hydrogeological regime would be necessary.

However, an alternative proposition is to assess the available hydrological, geochemical, geological and climatological data holistically to determine the likelihood and or extent of possible impact of landforms associated with the mining lease on off-site groundwater quality. This is in contrast to the existing restricted approach, which due to the absence of appropriate baseline data, is focussed solely on the attainment of necessarily arbitrary water quality criteria (which may or may not be appropriate to the situation at hand).

pH Value

Bores BH1, BH2 and SY1 also exceeded the trigger levels for pH, and in the case of BH2 pH contaminant limits, during the reporting period. Again with reference to the relevant time series for pH (Figure 33) such exceedences are not indicative of emergent issues, but in line with the long term monitoring record and highlight the lack of suitable reference sites and or baseline data.

Discussion in the previous section regarding electrical conductivity showed that observed groundwater levels in the bores versus the Golden Butterfly Pit lake level indicate a hydraulic gradient towards the pit lake. Hence this negates the possibility of Golden Butterfly Pit lake water as a casual factor in the observed pH trigger level exceedence at bores BH1, BH2 and SY1. Further, it was shown via the use of hydrochemical pattern diagrams that these locations belong to separate facies. Therefore, the observed pH is due to localised hydrogeochemical factors.

Trace Metals

Groundwater from bore BH2 exceeded the trigger levels for aluminium, cobalt, copper, nickel and zinc. The observed median groundwater pH of 3.6 (range 3.1 – 6.5, $\overline{x}$ =3.7, n=50) in bore BH2, which spans the period from 1995 to present, favours the dissolution of mineral phases and increased concentrations of metals in the groundwater is expected (see Figure 22).

Discussion in the previous sections regarding pH and electrical conductivity showed that observed groundwater levels in the bores versus the Golden Butterfly Pit lake level indicate a hydraulic gradient towards the pit lake. Hence this negates the possibility of Golden Butterfly Pit lake water as a casual factor in the observed pH trigger level exceedence at bore BH2 and by extension the elevated metal concentrations.

Further, it was shown via the use of hydrochemical pattern diagrams that the location in the vicinity of bore BH2 belongs to a separate geochemical facies compared to other bores in the area. Therefore,

the observed pH and hence elevated metal concentrations are due to localised hydrogeochemical factors.

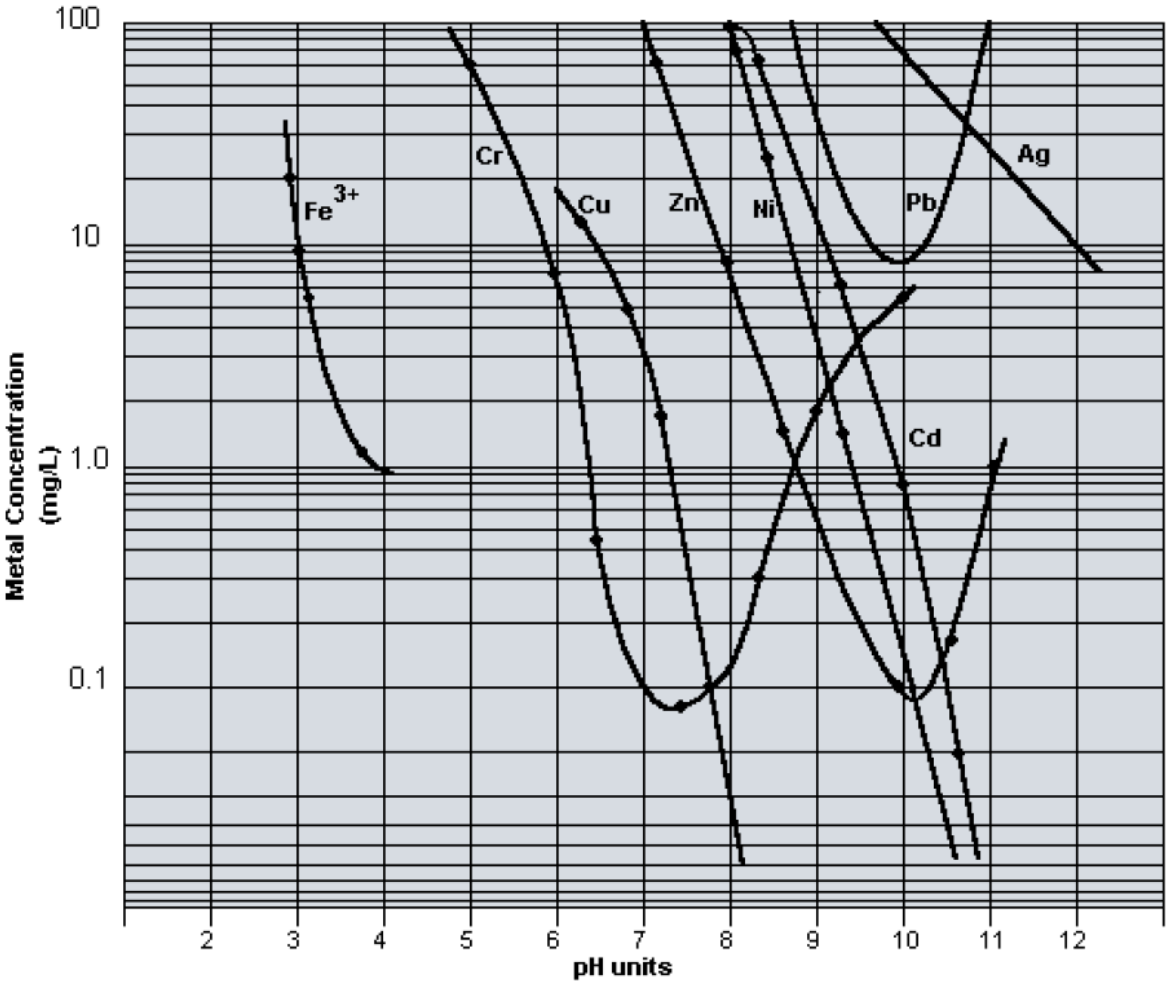


Figure 22: Metal Hydroxide Solubility Curves versus pH

In addition to bore BH2, the following bores showed trigger level exceedence for the listed metals:

Bore Location	Metal	Observed Concentration (mg/L)	Trigger Limit (mg/L)
SY1	Copper	0.004	0.0014
	Zinc	0.016	0.008
BH1	Arsenic	0.015	0.013
	Zinc	0.026	0.008
GBMB1	Arsenic	0.019	0.013
	Zinc	0.014	0.008
GBMB3	Aluminium	2.2	0.055
	Zinc	0.018	0.008
GBMB6	Arsenic	0.116	0.013
	Cobalt	0.002	0.0014

In each case the trigger level exceedence is in the order of parts-per-billion, being within the limits of analytical method/sampling variability and of no significance to the potential for environmental harm.

The GBMB series bores also recorded trigger level exceedence for arsenic (and aluminium in bore GBMB3). Figure 33 presents the time series graph for arsenic in the GBMB series bores which show no discernible trend over time, which demonstrates that the elevated arsenic concentrations is not an emergent issue. During field sampling of the GBMB series bores, depending upon time of year and

previous rainfall pattern, a strong odour of hydrogen sulfide is evident. This indicates reducing conditions which in turn influence the speciation of arsenic (As^{3+} being more soluble in reducing conditions). The redox condition of the groundwater therefore presents a mechanism to explain the observed variability (notably in the series for GBMB3 and GBMB6).

Discussion in the previous sections regarding pH and electrical conductivity showed that observed groundwater levels in the bores versus the Golden Butterfly Pit lake level indicate a hydraulic gradient towards the pit lake. Hence this negates the possibility of Golden Butterfly Pit lake water as a casual factor in the observed arsenic trigger level exceedence at the GBMB series bores. Further, it was shown via the use of hydrochemical pattern diagrams that the GBMB series bores belongs to a separate geochemical facies compared to other bores in the area. Therefore, the observed arsenic concentrations are due to localised hydrogeochemical factors.

Fluoride

Groundwater bore BH1 exceed the contaminant limit of 2 mg/L for fluoride (range 3.3 – 4.7 mg/L, $\overline{x}$ =3.8 mg/L, median= 3.7 mg/L, n=9). Figure 33 presents the time series graph for fluoride in bore BH1 which show no discernible trend over time for the previous five year period which data is available. This demonstrates that the elevated fluoride concentration in bore BH1 is not an emergent issue.

The concentration of fluoride within the Golden Butterfly Pit lake water is observed to be approximately 0.5 mg/L. This is significantly lower than the observed concentration in the adjacent bore BH1. Therefore, the observed contaminant limit exceedence for fluoride in BH1 is not the result of potential input from the pit lake. This is supported by the earlier discussion regarding the vicinity of BH1 belonging to a different geochemical facies to that of other adjacent areas. Therefore, the observed fluoride concentration in BH1 is due to localised hydrogeochemical factors.

5.1.2 Golden Butterfly North Pit Monitoring Bores

The Golden Butterfly Pit Monitoring Bores consist of the locations BH8 and BH9 (see Figure 21). Both these monitoring bores are located within 50 meters of the north-eastern wall of the Golden Butterfly North Pit approximately 100 meters apart. Figure 35 presents time series graphs for all parameters which exceed trigger levels during the reporting period.

Bores BH8 and BH9 showed trigger level exceedence for the listed metals:

Bore Location	Metal	Observed Concentration (mg/L)	Trigger Limit (mg/L)
BH8	Copper	0.004	0.0014
	Zinc	0.04	0.008
BH9	Copper	0.008	0.0014
	Zinc	0.017	0.008

In each case the trigger level exceedence is in the order of parts-per-billion, being within the limits of analytical method/sampling variability and of no significance to the potential for environmental harm.

Further, observed groundwater levels at bore BH8 and BH9 were 111.42m RL and 111.39m RL respectively, compared to the Golden Butterfly North Pit lake level of 110.08m RL (see Figure 28). This shows that the Golden Butterfly North Pit is a hydrological sink and hence cannot influence groundwater at bore BH8 and BH9. Consequently, the observed pH trigger limit exceedence at BH9 is also due to localised hydrogeochemical factors. Similar to the discussion in the previous sections, the trigger level exceedences at BH8 and BH9 are more indicative of inappropriate limits, lack of suitable reference sites and or baseline data.

5.1.3 Content Pit Monitoring Bores

The Content Pit Monitoring Bores consist of the locations BH10, BH11 and BH12 (see Figure 20). Monitoring bore BH11 is located approximately 250 meters from the south-western wall of the Content Pit. Bores BH10 and BH12 are also located to the south-west of the Content Pit but at a distance of approximately 500 meters. Bores BH10 and BH12 are approximately 150 meters apart. Figure 34 presents time series graphs for all parameters which exceed trigger levels during the reporting period.

Electrical Conductivity

Electrical conductivity observed at the Content Pit Monitoring bores has approximately flat trends when viewed over the five year period for which data is available (Figure 33). Consequently, the observed trigger level exceedence of electrical conductivity at monitoring bores BH10, BH11 and BH12 is as per previous reporting periods and not an emergent issue. Further, the flat trend lines for electrical conductivity versus time in the groundwater at these bore locations indicates pseudo-equilibrium or static conditions prevail (i.e., no evident mixing).

Electrical conductivity of a water sample is directly related to the concentration of dissolved anions and cations and the resultant ability to pass an electric current. Hence, waters of entirely different origins with dissimilar anionic and cationic constituents can record comparable electrical conductivity. Therefore, when considering the relevance of the observed trigger level exceedence of electrical conductivity at monitoring bores BH10, BH11 and BH12 it is important to also consider the actual concentrations of the contributory cations and anions. As previously discussed, Piper plots and Durov diagrams (see Figure 36 to Figure 42) provide a suitable means to summarise the major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and anions (SO_4^{2-}, HCO_3^{-}/CO_3^{2-}, Cl^{-}) present in groundwater in regards to potential similarity of composition and/or origin.

Figure 38 is the Piper Plot for the various bores associated with the Content Pit. The data suggests that the bores BH11 and BH12 group as a category distinct from BH10 and the composition of water within the Content Pit lake. Note for bore BH10, the data for the two data points in 2010 appear anomalous (pH > 11.5). The grouping of bore BH10 together with the Content Pit lake water potentially infers an influence on groundwater quality from the pit lake.

However, BH10 is in close proximity to BH12 (~150 m) and further from the pit lake than the intervening bore BH11 (see Figure 20). Therefore, if a solvent plume from the pit is inferred to explain the similarity between groundwater at bore BH10 and the Content Pit lake water, it would be expected to observed similar composition at both BH11 and BH12. Since this is not the case, the elevated electrical conductivity at BH10 is likely due to localised hydrogeochemical factors. This is notwithstanding the potential hydraulic gradient from the Content Pit lake (see Figure 27); which however due to recent poor rainfall and water abstraction is now reversed toward the pit void.

The composition of Content Pit lake water is dominated by sulphate, which is as expected from the oxidation of sulfides exposed during previous mining (as would be any potential inputs from the Content waste rock dump). However, the Piper Plot (see Figure 38) shows the composition of BH11 and BH12 has higher proportion of carbonate and chloride. The Durov Diagram (see Figure 42) shows groundwater at bore BH12 has significantly higher TDS and is alkaline compared to the pit lake water which is acidic.

Further, the time series for electrical conductivity (and for sulphate which is the predominant indicator of any potential ARD influence and contributory anionic component toward electrical conductivity if present) show no increasing trends over the five year monitoring period to date. Therefore, the elevated electrical conductivity at bores BH11 and BH12 is clearly shown to be not related to potential input from the Content Pit or waste rock dump. Similar to the discussion in the previous sections, the

trigger level electrical conductivity exceedences at BH10, BH11 and BH12 are more indicative of inappropriate limits, lack of suitable reference sites and or baseline data.

Trace Metals

Bores BH10, BH11 and BH12 showed trigger level exceedence for the listed metals:

Bore Location	Metal	Observed Concentration (mg/L)	Trigger Limit (mg/L)
BH10	Cobalt	0.015	0.0014
	Copper	0.002	0.0014
	Zinc	0.015	0.008
BH11	Arsenic	0.082	0.013
	Copper	0.004	0.0014
BH12	Arsenic	0.094	0.013
	Copper	0.002	0.0014
	Zinc	0.009	0.008

In each case the trigger level exceedence is in the order of parts-per-billion, being within the limits of analytical method/sampling variability and of no significance to the potential for environmental harm.

Arsenic

Bores BH11 and BH12 exceeded the arsenic trigger levels. Arsenic concentration observed at the Content Pit Monitoring bores has approximately flat trends when viewed over the five year period for which data is available (Figure 33). Consequently, the observed trigger level exceedence for arsenic at monitoring bores BH11 and BH12 is as per previous reporting periods and not an emergent issue.

Previous discussion of electrical conductivity of groundwater at bores BH10, BH11 and BH12, via the use of hydrochemical pattern diagrams and consideration of anionic constituents, indicated that the bores are not being influenced by potential inputs from the Content Pit lake. Hence elevated arsenic concentration at BH11 and BH12 are due to localised hydrogeochemical factors.

This is further supported by comparison of the arsenic concentration in the Content Pit lake water (range 0.002 – 0.068mg/L, $\overline{x}$ = 0.023 mg/L, median = 0.012 mg/L, n=63, monitoring period 2000-2014) to that observed at BH11 (range 0.025 – 0.082 mg/L, $\overline{x}$ = 0.055 mg/L, median = 0.058 mg/L, n=11, monitoring period 2009-2014) and BH12 (range 0.015 – 0.094 mg/L, $\overline{x}$ = 0.029 mg/L, median = 0.019, n=11) . Arsenic concentration within the pit lake is significantly lower than observed at bore BH11, which shows that the pit lake cannot be the source of arsenic at BH11. Therefore, the arsenic trigger level exceedence at BH11 and BH12 bores is the result of local geology.

Fluoride

The contaminant limit of 2mg/L for fluoride was exceeded at each of the Content Pit Monitoring bores during the reporting period. Fluoride concentration observed at bore BH11 has an approximately flat trend when viewed over the five year period for which data is available (Figure 33). Fluoride concentration in groundwater at bores BH10 and BH12 started at elevated levels and is showing a potential upward trend over the five year period for which data is available (Figure 33). Consequently, the observed trigger level exceedence for fluoride at monitoring bores BH11 and BH12 is as per previous reporting periods and not an emergent issue.

The previous discussion regarding electrical conductivity and the relative positions of the bores in relation to the pit void shows that the Content Pit Lake does not impact down gradient groundwater at bores BH10, BH11 and BH12. This is further supported by the observed fluoride concentration in the Content Pit Lake (range 1.1 - 2.6 mg/L, $\overline{x}$ = 1.55 mg/L, median=1.55 mg/L, n=48) during the monitoring period being significantly lower than that observed in BH10, BH11 and BH12. Therefore,

the fluoride contaminant limit exceedence at the Content Pit Monitoring bores is the result of local geology.

Sulfate

The contaminant limit of 1000mg/L for sulphate was exceeded at bore BH10 during the reporting period. Sulfate concentration observed at bore BH10 has an approximately flat trend when viewed over the five year period for which data is available (Figure 33). Consequently, the contaminant limit l exceedence for sulfate at monitoring bore BH10 is as per previous reporting periods and not an emergent issue.

Bore BH10 is in close proximity to bore BH12 (~150 m) and further from the pit lake than the intervening bore BH11 (see Figure 20). Therefore, if a solvent plume from the pit is inferred to explain the similarity between groundwater at bore BH10 and the Content Pit lake water, it would be expected to observed similar composition at both BH11 and BH12. Since this is not the case, the elevated sulfate at BH10 is likely due to localised hydrogeochemical factors.

This is further supported by the observed sulfate concentration in the Content Pit Lake (range 276 - 490 mg/L, $\overline{x}$ = 362 mg/L, median=343.5 mg/L, n=46, monitoring period 2009-2014) during the monitoring period being significantly lower than that observed in BH10 (range 503 - 1290 mg/L, $\overline{x}$ = 988 mg/L, median=1230 mg/L, n=11, monitoring period 2009-2014).

5.1.4 Golden Butterfly Waste Rock Dump Monitoring Bores

The Golden Butterfly Waste Rock Dump Monitoring Bores consist of the locations BH3, BH4, BH5, BH6, and BH7 (see Figure 21). These bores are located approximately 100 meters from the toe of the north-eastern side of the Golden Butterfly Waste Rock Dump. Each bore is approximately 75 meters apart trending on a straight line running parallel with the toe of the waste rock dump. Figure 32 presents time series graphs for all parameters which exceed trigger levels during the reporting period.

Electrical Conductivity

Electrical conductivity of groundwater at bores BH3, BH5 and BH7 exceeded the 250 µS/cm trigger level during the reporting period. There are two additional bores BH4 and BH6 at this location (see Figure 21). Even though these two bores are not listed in EA Schedule F Table 9 as part of the stipulated programme, are nevertheless monitored regularly to provide additional data to aid interpretation of groundwater results. The electrical conductivity of groundwater at bores BH4 and BH6 also exceeds the electrical conductivity trigger level.

Figure 32 shows that the electrical conductivity time series data indicates a decreasing trend for electrical conductivity at BH7 which has plateaued in recent years whereas, the other monitoring bores show flat trends over the approximately eighteen year record. Consequently, the observed electrical conductivity trigger level exceedence at monitoring bores BH3, BH5 and BH7 is as per previous reporting periods and not an emergent issue.

Electrical conductivity of a water sample is directly related to the concentration of dissolved anions and cations and the resultant ability to pass an electric current. Hence, waters of entirely different origins with dissimilar anionic and cationic constituents can record comparable electrical conductivity. Therefore, when considering the relevance of the observed trigger level exceedence of electrical conductivity at monitoring bores BH3, BH5 and BH7 it is important to also consider the actual concentrations of the contributory cations and anions. As previously discussed, Piper plots and Durov diagrams (see Figure 36 to Figure 42) provide a suitable means to summarise the major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and anions (SO_4^{2-}, HCO_3^{-}/CO_3^{2-}, Cl^{-}) present in groundwater in regards to potential similarity of composition and/or origin.

Figure 39 is the Piper Plot for the various bores associated with the Golden Butterfly Waste Rock Dump. The data suggests that the bores BH3 and BH6 group as a category distinct from bores BH4, BH5 and BH7 (i.e., have different geochemical facies). The Durov Diagram (see Figure 43) provides a similar result.

Groundwater levels within the bores BH3, BH4, BH5, BH6 and BH7 (see Figure 26) show an apparent hydraulic gradient from BH7 towards BH3 (i.e. a downwards gradient running north to south approximately parallel to the toe of the Golden Butterfly Waste Rock Dump). This hydraulic gradient is evident within the groundwater level data over the previous four wet/dry season cycles for which data are available. Further, bores BH3 and BH6 show increased groundwater levels at the peak of each wet season. The groundwater level data suggests that the bores BH3 and BH6 group as a category (potential shallow, unconfined surface aquifer) distinct from bores BH4, BH5 and BH7 (possible confined aquifer), which corresponds to the groupings identified by the groundwater quality data.

Electrical conductivity of groundwater from the grouping of bores BH4, BH5 and BH7 (possible confined aquifer) is greater than 4000 µS/cm, whereas, in bores BH3 and BH6 (potential shallow, unconfined surface aquifer) the electrical conductivity is below approximately 500 µS/cm. This indicates that the Golden Butterfly Waste Rock Dump, which was built on the existing ground surface, is not the source of elevated electrical conductivity in bores BH4, BH5 and BH7. Similar to the discussion in the previous sections, the trigger level electrical conductivity exceedences at BH3, BH5 and BH7 are more indicative of inappropriate limits, lack of suitable reference sites and or baseline data.

Trace Metals

Bores BH3, BH5 and BH7 showed trigger level exceedence for the listed metals:

Bore Location	Metal	Observed Concentration (mg/L)	Trigger Limit (mg/L)
BH3	aluminium	0.36	0.055
	copper	0.002	0.0014
BH5	cadmium	0.0003	0.0002
BH7	arsenic	0.017	0.013
	cobalt	0.003	0.0014
	copper	0.002	0.0014
	nickel	0.002	0.011
	zinc	0.024	0.008

In each case the trigger level exceedence is in the order of parts-per-billion, being within the limits of analytical method/sampling variability and of no significance to the potential for environmental harm.

Aluminium concentration within groundwater from bore BH3 of 0.36 mg/L exceeded the trigger limit of 0.055 mg/L. At the corresponding time the pH of groundwater at BH3 was observed to be 7.25. With reference to Figure 23 which shows the sum of soluble aluminium species versus pH, at neutral pH as observed for bore BH3 dissolved aluminium concentration can only be in the order of a few parts-per-billion. A solution pH of below approximately 4 would be necessary to observe dissolved aluminium concentrations in the range of 3 mg/L.

“As a rule, water samples collected for the determination of dissolved metal concentrations are filtered in the field through a 0.45µm filter. Most of the regulatory programmes recognise this procedure as the industry standard. This practice, however, has been scrutinized as a source of errors in estimating the mobile or truly dissolved species”[8]. Field sampling for the reported groundwater samples were field filtered using 0.45µm filter. Further, it is noted that the groundwater sample from bore BH3 was very turbid (95 NTU) compared to the other bores in the vicinity. The highly turbid sample clogs the 0.45µm

filter membrane potentially causing application of high pressure during the filtration process resulting in failure of the membrane and passing of colloids/solids. The field filtered samples are subsequently acidified in the laboratory which dissolves these colloids/solids, consequently causing anomalously high "dissolved' metal concentrations.

Sulphate and Fluoride

Sulphate and fluoride concentrations at bores BH5 and BH7 exceeded the contaminant limits during the reporting period. Sulphate and fluoride concentrations observed at bores BH5 and BH7 have approximately flat trends when viewed over the period for which data is available (Figure 32). Consequently, the contaminant limit exceedence for sulfate and fluoride at monitoring bores BH5 and BH7 is as per previous reporting periods and not an emergent issue.

Previous discussion regarding electrical conductivity of groundwater at the Golden Butterfly Waste Rock Dump Monitoring Bores showed that the bores are categorised into two groups (bores BH4, BH5 and BH7 [possible confined aquifer] and bores BH3 and BH6 [potential shallow, unconfined surface aquifer]) by consideration of both groundwater levels and water quality data. Further, that the Golden Butterfly Waste Rock Dump, which was built on the existing ground surface, is not the source of elevated electrical conductivity in bores BH4, BH5 and BH7.

Since sulphate and fluoride constitute the major anions contributing to the observed electrical conductivity of the bore water, the sulfate and fluoride contaminant limit exceedence at bores BH5 and BH7 is the result of local geology. Similar to the discussion in the previous sections, the sulfate and fluoride contaminant limit exceedence at bores BH5 and BH7 is more indicative of inappropriate limits, lack of suitable reference sites and or baseline data.

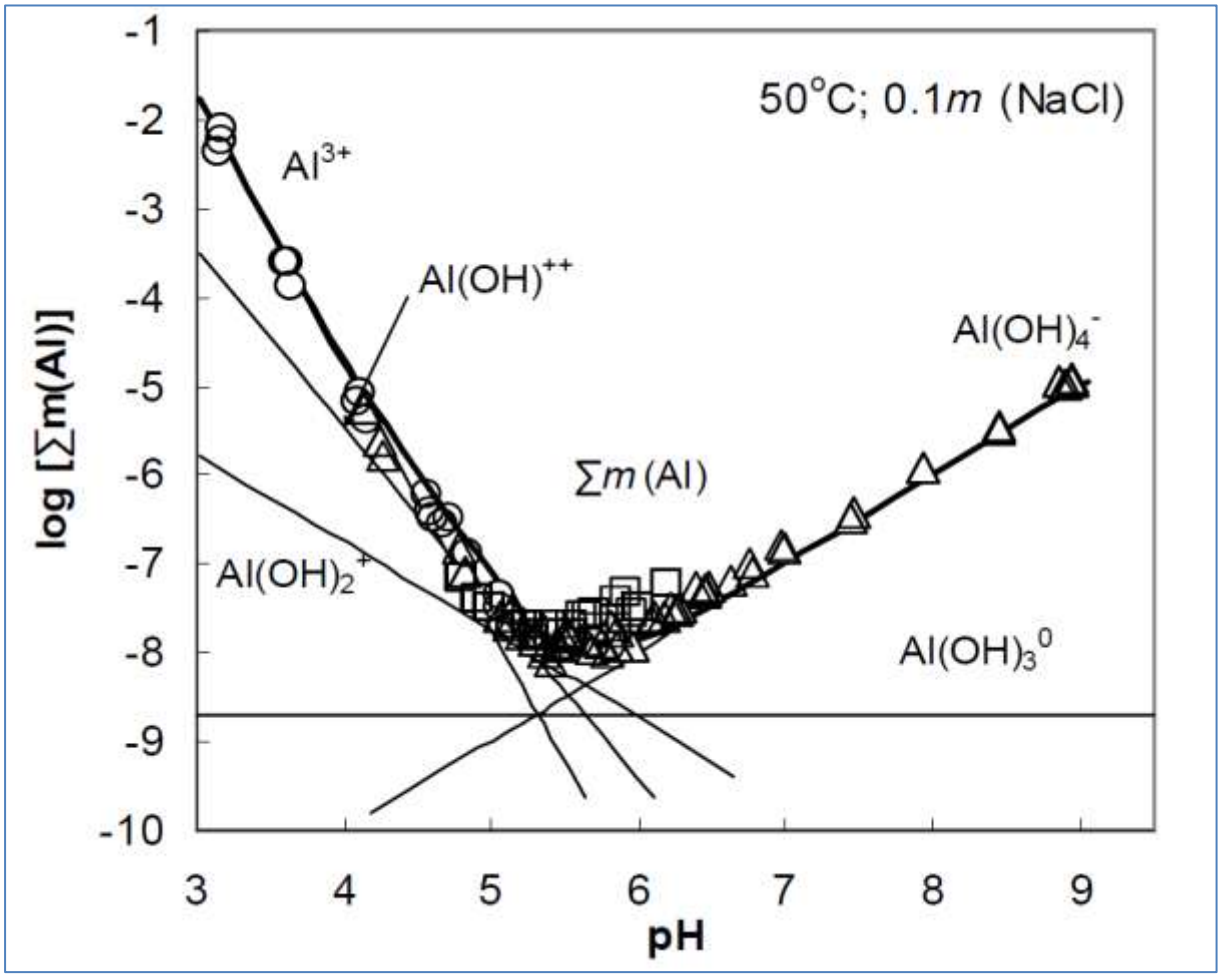


Figure 23: Aluminium Soluble Species versus pH
From Moller et al[9]

5.2 GROUNDWATER CONDITIONS

Details of the dimensions of the various groundwater monitoring bores is given in Table 5. The groundwater levels for the monitoring bores defined in Schedule F – Table 9 of the EA are provided in Table 8.

The various groundwater monitoring bores (see Figure 20 and Figure 21) are strategically located to provide information about possible impacts from various geographical features on the mining lease such as the mining pits and waste rock dumps. Consequently, groundwater level monitoring results are presented as time series graphs in the following groupings in Figure 25 to Figure 28

1. Golden Butterfly Pit Monitoring Bores: BH1, BH2, GBMB1, GBMB3, GBMB6 and SY1
2. Golden Butterfly North Pit Monitoring Bores: BH8 and BH9
3. Content Pit Monitoring Bores: BH10, BH11 and BH12
4. Golden Butterfly Dump Monitoring Bores: BH3, BH4, BH5, BH6, BH7

Table 5: Groundwater monitoring bore details

Monitoring Bore	**Bore Depth** (m)	**Elevation** (AHD)	**Monitoring Bore**	**Bore Depth** (m)	**Elevation** (AHD)
BH 1	55	117*	BH 10	21	103.95
BH 2	26	112*	BH 11	36	104.13
BH 3	20	113*	BH 12	17	102.08
BH 5	16	114*	GBMB 1	17	109*
BH 7	16	116*	GBMB 3	49	113*
BH 8	29	123.92	GBMB 6	27	113*
BH 9	29	122.29	SY 1	17	107.48

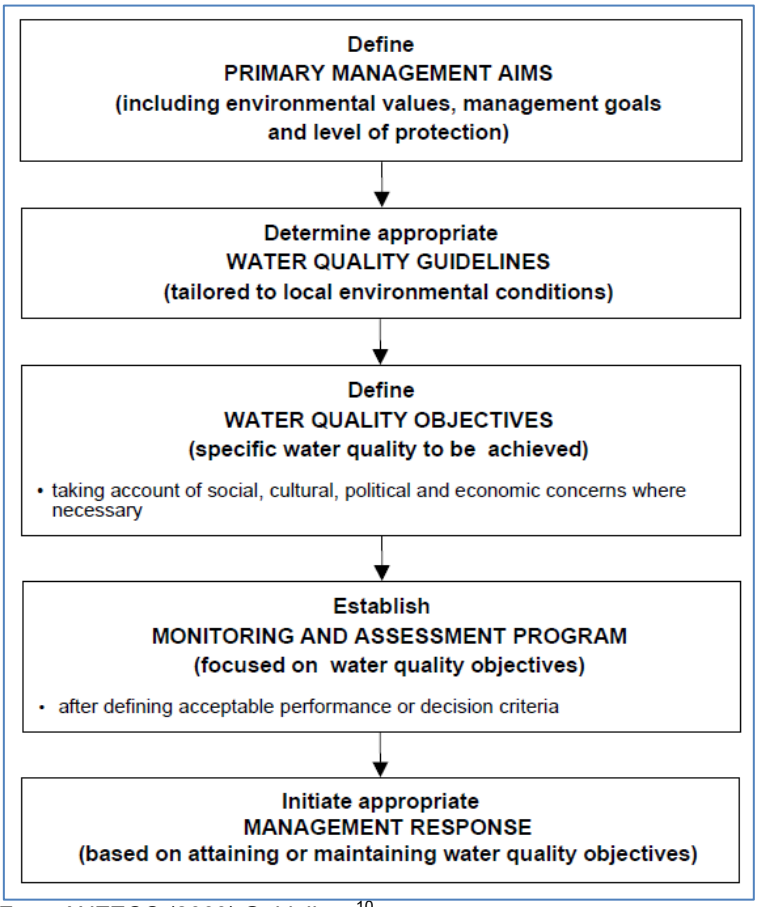
Notes: AHD = Australian Height Datum, * Elevations derived from available topographic mapping and are therefore approximate

6 Trigger Level Exceedence ANZECC Framework Assessment

The EA does not specify reference bore sites and accordingly the trigger values default to the ANZECC (2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems. The default of using the ANZECC (2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems does not appear appropriate considering that groundwater is being assessed, not surface water, and further, the bores are located within a metalliferous area that has hosted mining for over one hundred years.

Section 5.1 provides a detailed assessment of the various trigger level and contaminant limit exceedences using time series graphs, hydrochemical pattern diagrams such as Piper-Hill Plots and Durov Diagrams in conjunction with information about lithology, rock structural features, groundwater levels and climatic factors such as rainfall to enable interpretation of the groundwater analysis data in terms of potential environmental impact from mining associated landforms.

This assessment concluded that the various trigger level and contaminant limit exceedences are most readily explained as related to features associated with the immediate localised geology, as opposed to indicating adverse input from mining related landforms such as the pit void lakes and waste rock dumps. Nevertheless, EA clause F7-2 requires an investigation in accordance with ANZECC (2000) methodology if groundwaters at the bores identified in EA Schedule F Table 9 exceed any of the trigger levels stated in EA Schedule F Table 10.



From ANZECC (2000) Guidelines[10]

Figure 24: ANZECC Framework for Applying Guidelines

The ANZECC Framework is depicted schematically in Figure 24 and begins with defining the environmental values, management goals and level of protection relevant to groundwaters in the vicinity of the mining lease area at Croydon.

"Environmental values are particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits. They were often called 'beneficial uses' in the water quality literature"[11]

The following environmental values are recognised in ANZECC guidelines:

- aquatic ecosystems,
- primary industries (irrigation and general water uses, stock drinking water, aquaculture and human consumption of aquatic foods),
- recreation and aesthetics,
- drinking water,
- industrial water (no water quality guidelines are provided for this environmental value), and
- cultural and spiritual values (no water quality guidelines are provided for this environmental value).

As previously discussed in Section 3.3, ML 5248 contains no springs or groundwater supported surface drainage features. Groundwater occurs in deep fractured rock aquifers, but is not utilised as a water resource on or adjacent to ML 5248. Any aquifers linked to the main mineralised zones are expected to have elevated concentrations of metals and sulphate. This assumption is supported by water quality analysis from the monitoring bores located in this area detailed in Section 5.1. Further, it has been shown that the groundwater quality likely naturally varies significantly between individual fractured rock aquifers (although there are no baseline data available). These aquifers would therefore not be considered potential potable water supplies, irrespective of potential yields.

"The original Croydon town borefield, decommissioned more than 15 years ago, was located within Slaughteryard Creek approximately 1 km south-west of Golden Butterfly Pit (Figure 21). "It is considered that the borefield exploits both an unconfined alluvial aquifer and deeper fractured rock aquifers in the underlying sandstone units. Bore yields were never more than 1.25 litres per second (L/sec) and over time dropped to less than 0.25 L/sec resulting in their abandonment".[12]

Therefore, in relation to the environmental values are recognised in ANZECC guidelines:

- aquatic ecosystems: not applicable as ML 5248 contains no springs or groundwater supported surface drainage features;
- primary industries (in particular irrigation and stock drinking water): potentially applicable dependent upon exact location of individual bores in relation to background aquifer condition
- recreation and aesthetics; not applicable as ML 5248 contains no springs or groundwater supported surface drainage features;
- drinking water: not applicable as prior exploitation for drinking water was abandoned due to poor bore yields (subsequent construction of Lake Belmore provides municipal drinking water);
- industrial water (no water quality guidelines are provided for this environmental value), and
- cultural and spiritual values (no water quality guidelines are provided for this environmental value).

The next step in application of the ANZECC Framework is determining appropriate water quality guidelines (i.e., trigger levels and contaminant limits) focussed on protection of the identified environmental values tailored to the local environmental conditions. This step (as for all stages in the application of the ANZECC Framework) necessarily requires relevant stakeholder participation. However, in the first instance a reasonable assumption would be water quality guidelines for Croydon groundwaters focussed on potential irrigation and stock drinking water, dependent upon background aquifer condition.

Consequently, it can be readily seen that the existing trigger levels based upon ANZECC (2000) trigger levels for aquatic ecosystems indicative of slightly disturbed tropical Australian upland river ecosystems, are not likely relevant to providing the appropriate level of protection for the identified environmental risk and beneficial use.

Trigger levels for the protection of irrigation and stock drinking water environmental values are reasonably assumed to be significantly higher than the necessarily low concentrations for potential toxicants and stressors in order to protect water suitable for sustaining slightly disturbed tropical Australian upland river ecosystems. Therefore, the observed concentration of the various chemical constituents that create trigger level exceedence in groundwater using the current definition in the EA do not indicate an environmental risk to the assumed relevant environmental values of irrigation and stock drinking water.

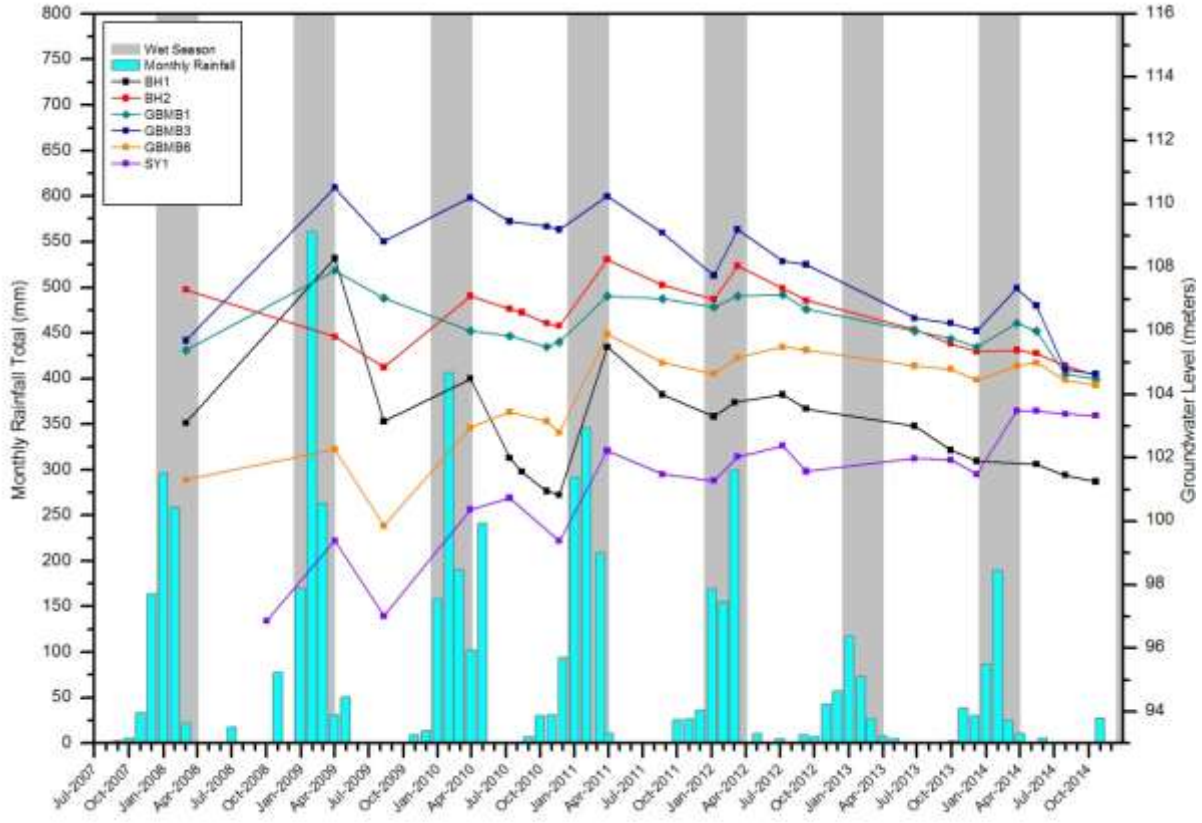


Figure 25: Water Levels - Golden Butterfly Pit Monitoring Bores

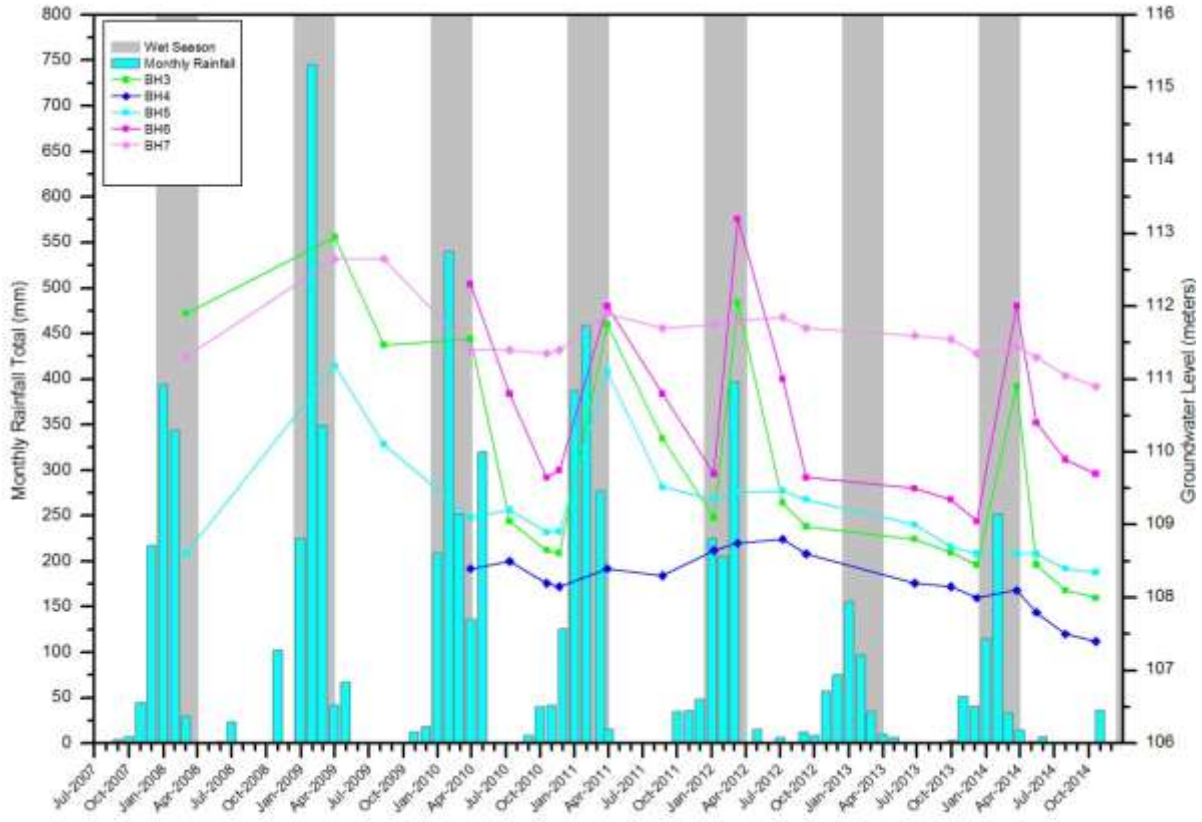


Figure 26: Water Levels - Golden Butterfly Dump Monitoring Bores

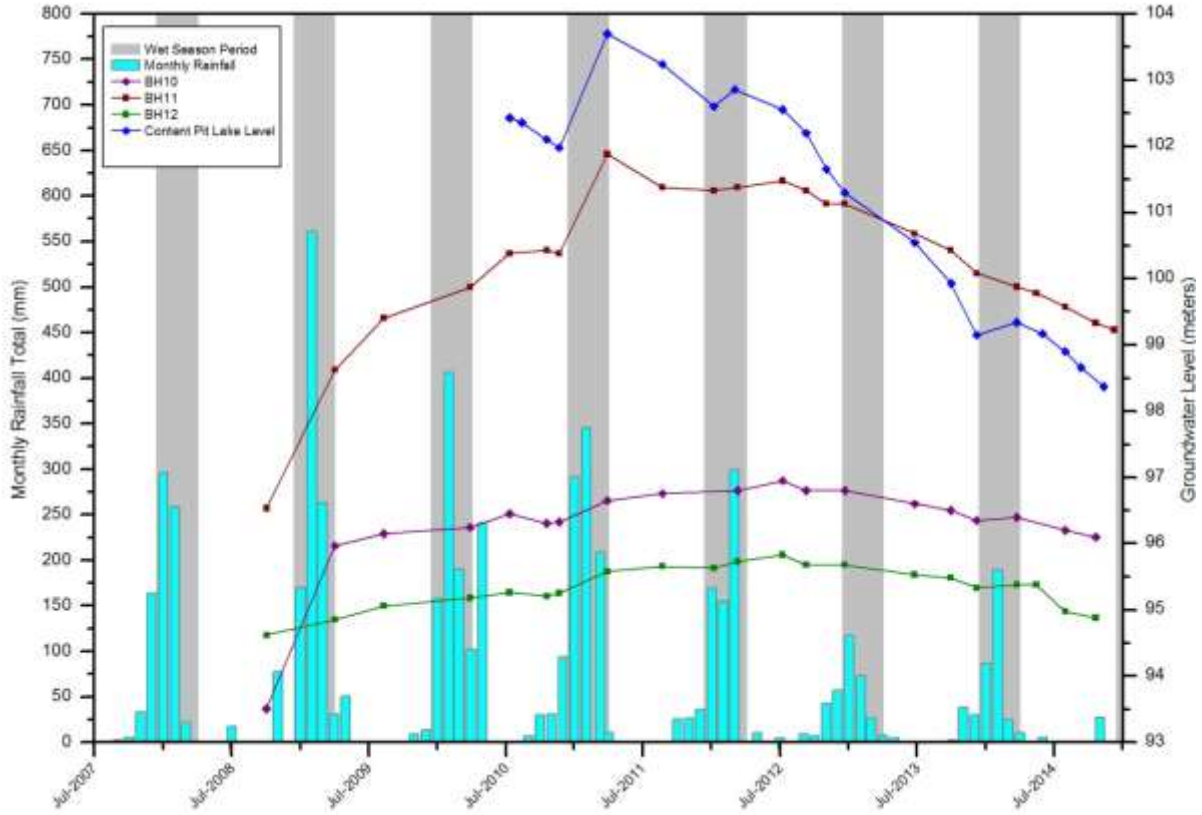


Figure 27: Water Levels - Content Pit Monitoring Bores

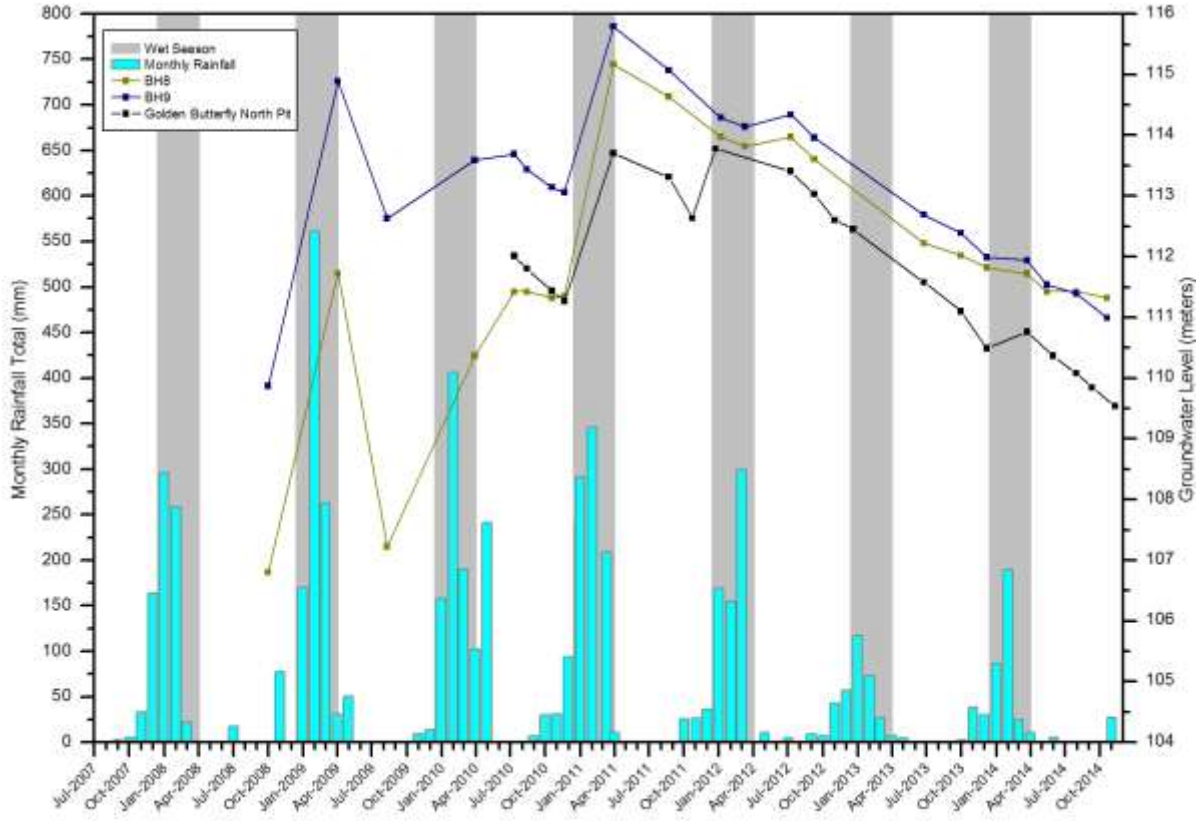


Figure 28: Water Levels - Golden Butterfly North Pit Monitoring Bores

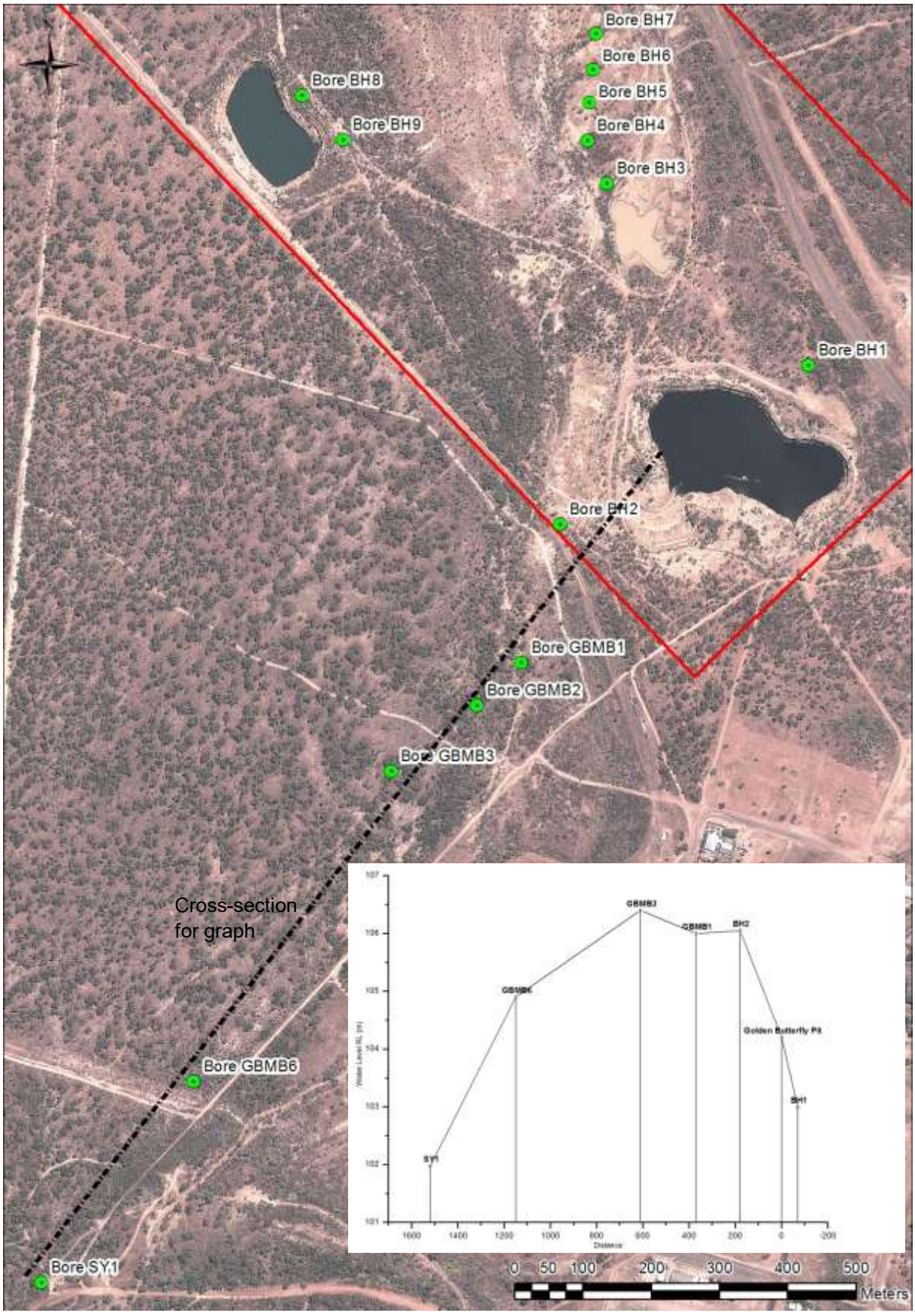
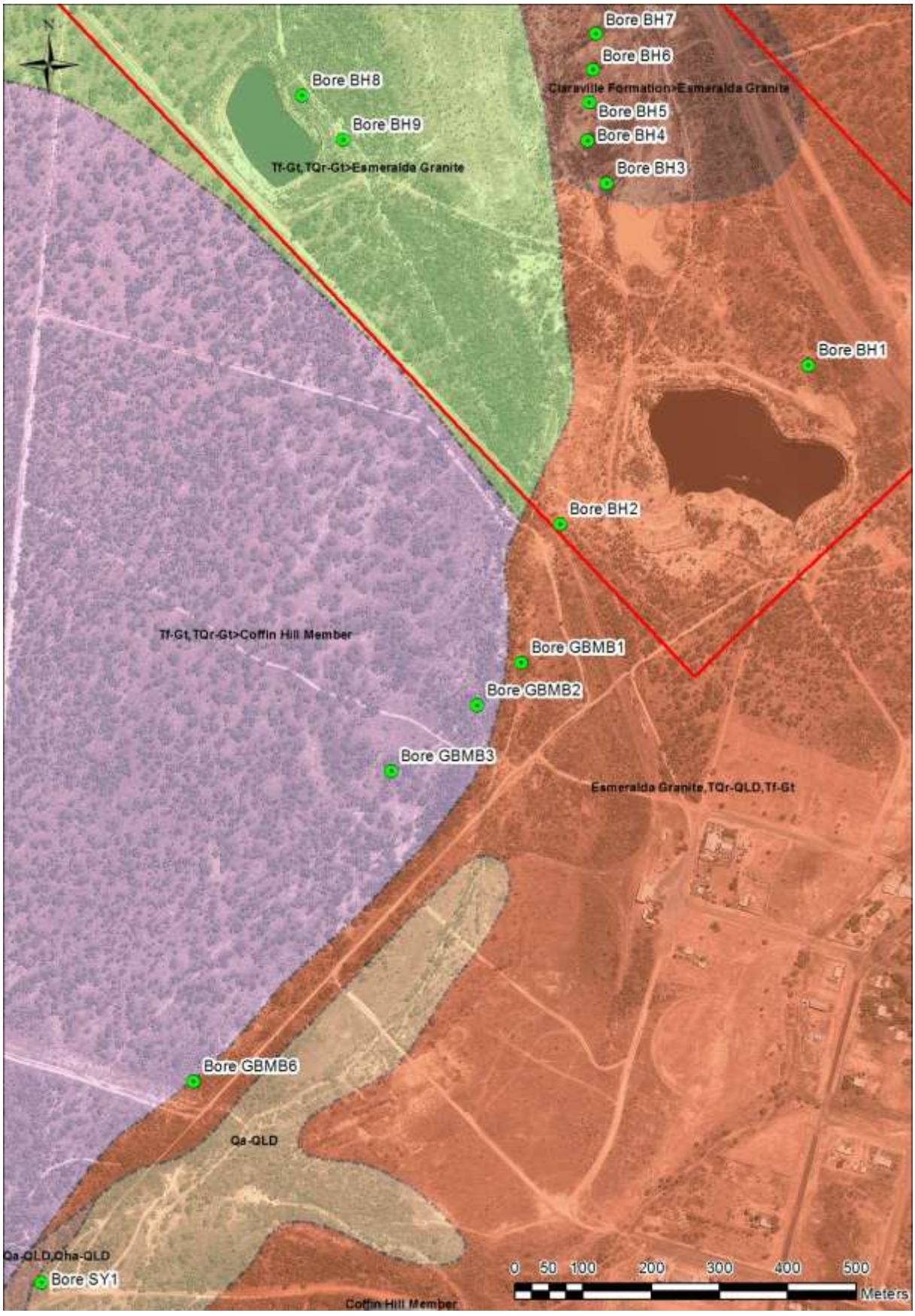
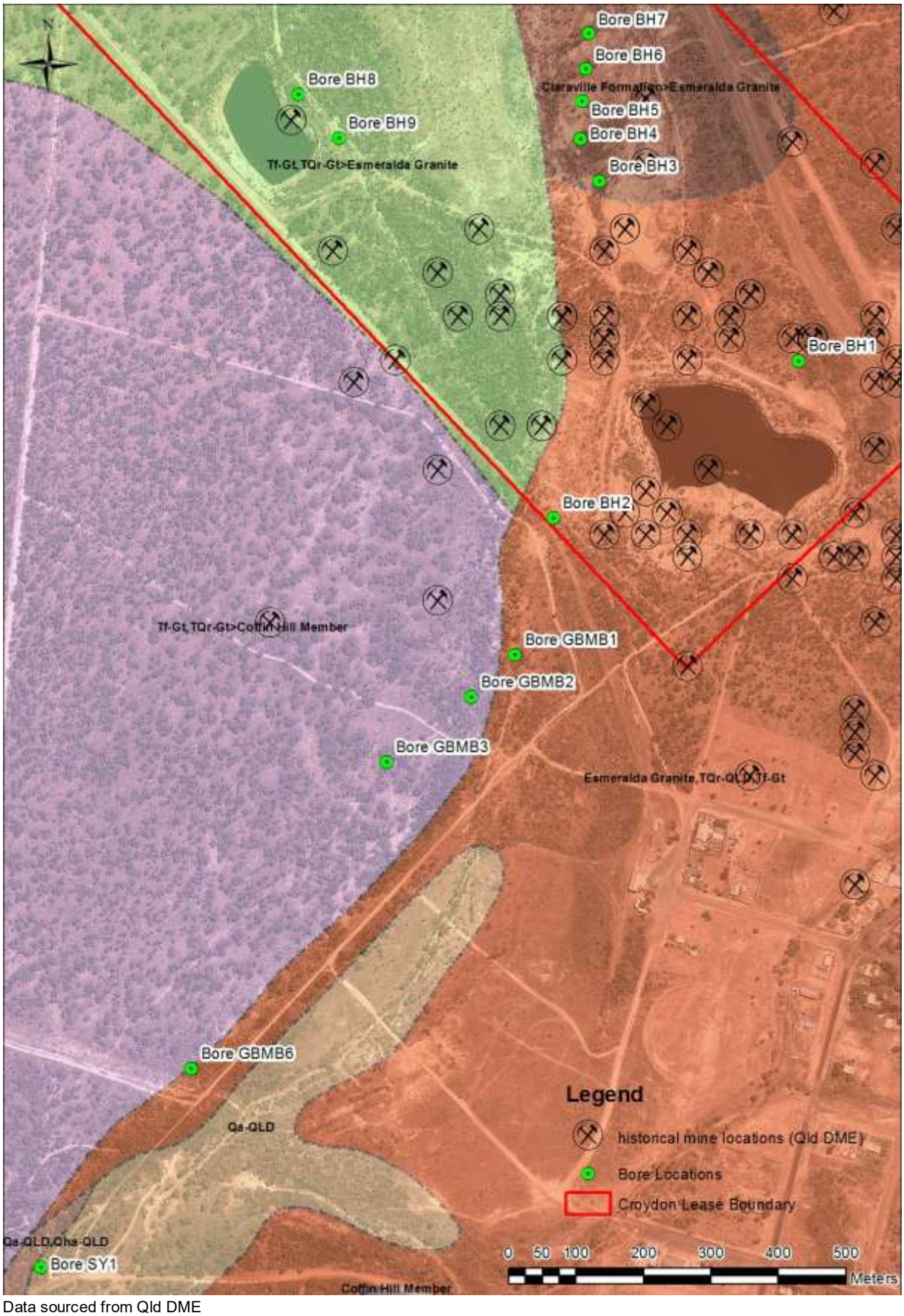


Figure 29: Golden Butterfly Pit Bores – Cross Section Distance versus Water Level



Data sourced from Qld DME

Figure 30: Croydon Surface Geology – Golden Butterfly Pit/Slaughteryard Creek Area



Data sourced from Qld DME

Figure 31: Croydon Lease Area – Location of Historical Mining Activity

7 Appendix 1: Monitoring Results

Table 6: Groundwater monitoring results 2014 – Metals/Trace Elements

Site	Date	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Iron (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH01	31/7/2014	<0.01	0.015	<0.05	<0.0001	<0.001	<0.001	0.003	<0.05	<0.0001	<0.001	<0.01	0.026
BH02	31/7/2014	1.45	0.004	<0.05	0.0001	<0.001	0.016	0.026	0.1	<0.0001	0.028	<0.01	0.198
BH03	31/7/2014	0.36	0.0086	<0.05	<0.0001	<0.001	0.006	0.002	0.63	<0.0001	<0.001	<0.01	0.006
BH04	31/7/2014	<0.01	0.002	<0.05	0.0002	<0.001	<0.001	0.002	<0.05	<0.0001	<0.001	<0.01	0.01
BH05	31/7/2014	<0.01	0.005	<0.05	0.0003	<0.001	<0.001	0.002	<0.05	<0.0001	<0.001	<0.01	0.008
BH06	31/7/2014	3.14	0.018	<0.05	<0.0001	<0.001	0.002	0.005	1.5	<0.0001	0.003	<0.01	0.006
BH07	31/7/2014	<0.01	0.017	<0.05	<0.0001	<0.001	0.003	0.002	0.14	<0.0001	0.002	<0.01	0.024
BH08	31/7/2014	<0.01	0.022	<0.05	<0.0001	<0.001	<0.001	0.004	<0.05	<0.0001	0.005	<0.01	0.04
BH09	31/7/2014	<0.01	0.002	<0.05	<0.0001	<0.001	<0.001	0.008	<0.05	<0.0001	<0.001	<0.01	0.017
BH10	31/7/2014	<0.01	0.047	<0.05	<0.0001	<0.001	0.015	0.002	3.6	<0.0001	0.007	<0.01	0.015
BH11	31/7/2014	<0.01	0.082	<0.05	<0.0001	<0.001	<0.001	0.004	<0.05	<0.0001	<0.001	<0.01	0.008
BH12	31/7/2014	<0.01	0.094	<0.05	<0.0001	<0.001	0.015	0.002	3.62	<0.0001	0.003	<0.01	0.009
SY1	31/7/2014	<0.01	0.001	<0.05	<0.0001	<0.001	0.001	0.004	<0.05	<0.0001	<0.001	<0.01	0.016
GBMB1	31/7/2014	<0.01	0.019	<0.05	<0.0001	<0.001	<0.001	0.002	<0.05	<0.0001	<0.001	<0.01	0.014
GBMB3	31/7/2014	2.2	0.038	<0.05	<0.0001	<0.001	0.007	0.001	18.2	<0.0001	0.004	<0.01	0.018
GBMB6	31/7/2014	<0.01	0.116	<0.05	<0.0001	<0.001	0.002	<0.001	1.95	<0.0001	0.002	<0.01	0.016
EA Trigger Level		0.055	0.013	0.37	0.0002	0.001	0.0014	0.0014	-	0.0006	0.011	0.011	0.008
EA Contaminant Limit		5	0.5	5	0.01	1	1	1	-	0.002	1	0.02	20

EA Trigger Level and EA Contaminant Limit as per EA Schedule F Table 10 and 11 respectively

Table 7: Groundwater monitoring results 2014 – Cations/Anions/Physicochemical

Site	Date	pH	EC (µS/cm)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity (mg/L as $CaCO_3$)				Turbidity (NTU)
											Hydroxide	Carbonate	Bicarbonate	Total	
BH01	31/7/2014	7.58	1360	18	4.7	563	146	28	168	21	<1	<1	241	241	0.5
BH02	31/7/2014	4.04	931	22	1.5	415	18	10	153	28	<1	<1	<1	<1	25
BH03	31/7/2014	6.83	800	55	5.3	188	11	3	162	9	<1	<1	115	115	20
BH04	31/7/2014	7.3	4600	516	4.9	1920	142	51	1130	23	<1	<1	250	250	3
BH05	31/7/2014	7.43	5170	613	10.9	2080	98	40	1300	24	<1	<1	200	200	0.7
BH06	31/7/2014	7.29	1500	195	15.2	320	7	3	386	5	<1	<1	193	193	357
BH07	31/7/2014	7.25	5360	934	12.8	1740	300	125	1070	35	<1	<1	275	275	3.2
BH08	31/7/2014	6.56	210	15	1.4	35	3	1	37	7	<1	<1	35	35	0.9
BH09	31/7/2014	5.64	107	24	<0.1	2	<1	<1	21	<1	<1	<1	4	4	46
BH10	31/7/2014	7.26	2530	37	3.7	1230	327	40	331	20	<1	<1	281	281	7.9
BH11	31/7/2014	7.37	343	14	3.8	53	8	2	60	12	<1	<1	96	96	0.4
BH12	31/7/2014	7.39	1540	231	5.2	200	30	10	337	26	<1	<1	265	265	5.7
SY1	31/7/2014	6.66	65	12	<0.1	2	<1	<1	10	3	<1	<1	8	8	0.3
GBMB1	31/7/2014	7.17	580	33	2.4	143	7	5	100	21	<1	<1	88	88	4.4
GBMB3	31/7/2014	6.52	218	11	<0.1	1	2	2	14	5	<1	<1	71	71	180
GBMB6	31/7/2014	6.93	233	10	<0.1	<1	2	3	24	13	<1	<1	98	98	3.9
EA Trigger Level		6.0 to 7.5	250	-	-	-	-	-	-	-	-	-	-	-	-
EA Contaminant Limit		5 to 9	5970	-	2	1000	-	-	-	-	-	-	-	-	4000

EA Trigger Level and EA Contaminant Limit as per EA Schedule F Table 10 and 11 respectively

Table 8: Groundwater levels in monitoring bores

Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)	Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)
BH1	117	1/03/2008	13.90	103.10	BH3	113	10/03/2012	0.95	112.05
BH1	117	2/04/2009	8.71	108.29	BH3	113	8/07/2012	3.70	109.30
BH1	117	10/08/2009	13.85	103.15	BH3	113	8/09/2012	4.02	108.98
BH1	117	29/03/2010	12.50	104.50	BH3	113	24/06/2013	4.20	108.80
BH1	117	11/07/2010	15.00	102.00	BH3	113	29/09/2013	4.38	108.62
BH1	117	13/08/2010	15.44	101.56	BH3	113	7/12/2013	4.55	108.45
BH1	117	18/10/2010	16.05	100.95	BH3	113	23/03/2014	2.10	110.90
BH1	117	20/11/2010	16.17	100.83	BH3	113	14/05/2014	4.55	108.45
BH1	117	29/03/2011	11.50	105.50	BH3	113	31/07/2014	4.90	108.10
BH1	117	22/08/2011	13.00	104.00	BH3	113	20/10/2014	5.00	108.00
BH1	117	10/03/2012	13.25	103.75					
BH1	117	8/07/2012	13.00	104.00	BH4	113	29/03/2010	4.60	108.40
BH1	117	8/09/2012	13.45	103.55	BH4	113	11/07/2010	4.50	108.50
BH1	117	24/06/2013	14.00	103.00	BH4	113	18/10/2010	4.80	108.20
BH1	117	29/09/2013	14.75	102.25	BH4	113	20/11/2010	4.85	108.15
BH1	117	7/12/2013	15.10	101.90	BH4	113	29/03/2011	4.60	108.40
BH1	117	23/03/2014	15.00	102.00	BH4	113	22/08/2011	4.70	108.30
BH1	117	14/05/2014	15.20	101.80	BH4	113	10/03/2012	4.25	108.75
BH1	117	31/07/2014	15.55	101.45	BH4	113	8/07/2012	4.20	108.80
BH1	117	20/10/2014	15.75	101.25	BH4	113	8/09/2012	4.40	108.60
					BH4	113	24/06/2013	4.80	108.20
BH2	112	1/03/2008	4.70	107.30	BH4	113	29/09/2013	4.85	108.15
BH2	112	2/04/2009	6.17	105.83	BH4	113	7/12/2013	5.00	108.00
BH2	112	10/08/2009	7.14	104.86	BH4	113	23/03/2014	4.90	108.10
BH2	112	29/03/2010	4.90	107.10	BH4	113	14/05/2014	5.20	107.80
BH2	112	11/07/2010	5.30	106.70	BH4	113	31/07/2014	5.50	107.50
BH2	112	13/08/2010	5.41	106.59	BH4	113	20/10/2014	5.60	107.40
BH2	112	18/10/2010	5.75	106.25					
BH2	112	20/11/2010	5.84	106.16	BH5	114	1/03/2008	5.40	108.60
BH2	112	29/03/2011	3.75	108.25	BH5	114	2/04/2009	2.82	111.18
BH2	112	22/08/2011	4.55	107.45	BH5	114	10/08/2009	3.89	110.11
BH2	112	10/03/2012	3.95	108.05	BH5	114	29/03/2010	4.90	109.10
BH2	112	8/07/2012	4.65	107.35	BH5	114	11/07/2010	4.80	109.20
BH2	112	8/09/2012	5.03	106.97	BH5	114	18/10/2010	5.10	108.90
BH2	112	24/06/2013	5.95	106.05	BH5	114	20/11/2010	5.09	108.91
BH2	112	29/09/2013	6.40	105.60	BH5	114	29/03/2011	2.90	111.10
BH2	112	7/12/2013	6.65	105.35	BH5	114	22/08/2011	4.48	109.52
BH2	112	23/03/2014	6.60	105.40	BH5	114	10/03/2012	4.55	109.45
BH2	112	14/05/2014	6.70	105.30	BH5	114	8/07/2012	4.53	109.47
BH2	112	31/07/2014	7.10	104.90	BH5	114	8/09/2012	4.65	109.35
BH2	112	20/10/2014	7.40	104.60	BH5	114	24/06/2013	5.00	109.00
					BH5	114	29/09/2013	5.30	108.70
BH3	113	1/03/2008	1.10	111.90	BH5	114	7/12/2013	5.40	108.60
BH3	113	2/04/2009	0.05	112.95	BH5	114	23/03/2014	5.40	108.60
BH3	113	10/08/2009	1.53	111.47	BH5	114	14/05/2014	5.40	108.60
BH3	113	29/03/2010	1.45	111.55	BH5	114	31/07/2014	5.60	108.40
BH3	113	11/07/2010	3.95	109.05	BH5	114	20/10/2014	5.65	108.35
BH3	113	18/10/2010	4.35	108.65					
BH3	113	20/11/2010	4.39	108.61	BH6	114	29/03/2010	1.70	112.30
BH3	113	29/03/2011	1.25	111.75	BH6	114	11/07/2010	3.20	110.80
BH3	113	22/08/2011	2.82	110.18	BH6	114	18/10/2010	4.35	109.65

Table 9 Continued: Groundwater levels in monitoring bores

Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)	Bore ID	Collar Elevation (m)	Date	Water Level (m)	Ground water (m)
BH6	114	20/11/2010	4.25	109.75	BH8	123.92	31/07/2014	12.50	111.42
BH6	114	29/03/2011	2.00	112.00	BH8	123.92	20/10/2014	12.60	111.32
BH6	114	22/08/2011	3.20	110.80					
BH6	114	10/03/2012	0.80	113.20	BH9	122.29	1/10/2008	12.42	109.87
BH6	114	8/07/2012	3.00	111.00	BH9	122.29	2/04/2009	7.40	114.89
BH6	114	8/09/2012	4.35	109.65	BH9	122.29	10/08/2009	9.66	112.63
BH6	114	24/06/2013	4.50	109.50	BH9	122.29	29/03/2010	8.70	113.59
BH6	114	29/09/2013	4.65	109.35	BH9	122.29	10/07/2010	8.60	113.69
BH6	114	7/12/2013	4.95	109.05	BH9	122.29	13/08/2010	8.85	113.44
BH6	114	23/03/2014	2.00	112.00	BH9	122.29	18/10/2010	9.15	113.14
BH6	114	14/05/2014	3.60	110.40	BH9	122.29	20/11/2010	9.23	113.06
BH6	114	31/07/2014	4.10	109.90	BH9	122.29	29/03/2011	6.50	115.79
BH6	114	20/10/2014	4.30	109.70	BH9	122.29	22/08/2011	7.22	115.07
					BH9	122.29	10/03/2012	8.15	114.14
BH7	116	1/03/2008	4.70	111.30	BH9	122.29	8/07/2012	7.95	114.34
BH7	116	2/04/2009	3.35	112.65	BH9	122.29	8/09/2012	8.33	113.96
BH7	116	10/08/2009	3.35	112.65	BH9	122.29	24/06/2013	9.60	112.69
BH7	116	29/03/2010	4.60	111.40	BH9	122.29	29/09/2013	9.90	112.39
BH7	116	11/07/2010	4.60	111.40	BH9	122.29	7/12/2013	10.30	111.99
BH7	116	18/10/2010	4.65	111.35	BH9	122.29	23/03/2014	10.35	111.94
BH7	116	20/11/2010	4.60	111.40	BH9	122.29	14/05/2014	10.75	111.54
BH7	116	29/03/2011	4.10	111.90	BH9	122.29	31/07/2014	10.90	111.39
BH7	116	22/08/2011	4.30	111.70	BH9	122.29	20/10/2014	11.30	110.99
BH7	116	10/03/2012	4.20	111.80					
BH7	116	8/07/2012	4.15	111.85	BH10	103.95	1/10/2008	10.44	93.51
BH7	116	8/09/2012	4.30	111.70	BH10	103.95	2/04/2009	7.98	95.97
BH7	116	24/06/2013	4.40	111.60	BH10	103.95	10/08/2009	7.80	96.15
BH7	116	29/09/2013	4.45	111.55	BH10	103.95	28/03/2010	7.70	96.25
BH7	116	7/12/2013	4.65	111.35	BH10	103.95	11/07/2010	7.50	96.45
BH7	116	23/03/2014	4.55	111.45	BH10	103.95	18/10/2010	7.64	96.31
BH7	116	14/05/2014	4.70	111.30	BH10	103.95	20/11/2010	7.62	96.33
BH7	116	31/07/2014	4.95	111.05	BH10	103.95	29/03/2011	7.30	96.65
BH7	116	20/10/2014	5.10	110.90	BH10	103.95	22/08/2011	7.19	96.76
					BH10	103.95	10/03/2012	7.15	96.80
BH8	123.92	1/10/2008	17.12	106.80	BH10	103.95	8/07/2012	7.00	96.95
BH8	123.92	2/04/2009	12.20	111.72	BH10	103.95	8/09/2012	7.15	96.80
BH8	123.92	10/08/2009	16.70	107.22	BH10	103.95	20/12/2012	7.15	96.80
BH8	123.92	29/03/2010	13.55	110.37	BH10	103.95	24/06/2013	7.35	96.60
BH8	123.92	10/07/2010	12.50	111.42	BH10	103.95	29/09/2013	7.45	96.50
BH8	123.92	13/08/2010	12.50	111.42	BH10	103.95	7/12/2013	7.60	96.35
BH8	123.92	18/10/2010	12.60	111.32	BH10	103.95	23/03/2014	7.55	96.40
BH8	123.92	20/11/2010	12.57	111.35	BH10	103.95	14/05/2014	7.55	96.40
BH8	123.92	29/03/2011	8.75	115.17	BH10	103.95	31/07/2014	7.75	96.20
BH8	123.92	22/08/2011	9.28	114.64	BH10	103.95	20/10/2014	7.85	96.10
BH8	123.92	10/03/2012	10.10	113.82					
BH8	123.92	8/07/2012	9.95	113.97	BH11	104.13	1/10/2008	7.60	96.53
BH8	123.92	8/09/2012	10.32	113.60	BH11	104.13	2/04/2009	5.51	98.62
BH8	123.92	24/06/2013	11.70	112.22	BH11	104.13	10/08/2009	4.73	99.40
BH8	123.92	29/09/2013	11.90	112.02	BH11	104.13	28/03/2010	4.26	99.87
BH8	123.92	7/12/2013	12.10	111.82	BH11	104.13	11/07/2010	3.75	100.38
BH8	123.92	23/03/2014	12.20	111.72	BH11	104.13	18/10/2010	3.70	100.43
BH8	123.92	14/05/2014	12.50	111.42	BH11	104.13	20/11/2010	3.75	100.38

Table 9 Continued: Groundwater levels in monitoring bores

BH11	104.13	29/03/2011	2.25	101.88	GBMB1	109	31/07/2014	4.35	104.65
BH11	104.13	22/08/2011	2.75	101.38	GBMB1	109	20/10/2014	4.50	104.50
BH11	104.13	10/03/2012	2.75	101.38					
BH11	104.13	8/07/2012	2.65	101.48	GBMB3	113	1/03/2008	7.30	105.70
BH11	104.13	8/09/2012	2.80	101.33	GBMB3	113	2/04/2009	2.48	110.52
BH11	104.13	1/11/2012	3.00	101.13	GBMB3	113	10/08/2009	4.18	108.82
BH11	104.13	20/12/2012	3.00	101.13	GBMB3	113	29/03/2010	2.80	110.20
BH11	104.13	24/06/2013	3.45	100.68	GBMB3	113	11/07/2010	3.55	109.45
BH11	104.13	29/09/2013	3.70	100.43	GBMB3	113	18/10/2010	3.70	109.30
BH11	104.13	7/12/2013	4.05	100.08	GBMB3	113	20/11/2010	3.80	109.20
BH11	104.13	23/03/2014	4.25	99.88	GBMB3	113	29/03/2011	2.75	110.25
BH11	104.13	14/05/2014	4.35	99.78	GBMB3	113	22/08/2011	3.90	109.10
BH11	104.13	31/07/2014	4.55	99.58	GBMB3	113	10/03/2012	3.80	109.20
BH11	104.13	20/10/2014	4.80	99.33	GBMB3	113	8/07/2012	4.80	108.20
BH11	104.13	8/12/2014	4.90	99.23	GBMB3	113	8/09/2012	4.90	108.10
					GBMB3	113	24/06/2013	6.60	106.40
BH12	102.08	1/10/2008	7.46	94.62	GBMB3	113	29/09/2013	6.75	106.25
BH12	102.08	2/04/2009	7.22	94.86	GBMB3	113	7/12/2013	7.00	106.00
BH12	102.08	10/08/2009	7.02	95.06	GBMB3	113	23/03/2014	5.65	107.35
BH12	102.08	28/03/2010	6.90	95.18	GBMB3	113	14/05/2014	6.20	106.80
BH12	102.08	11/07/2010	6.82	95.26	GBMB3	113	31/07/2014	8.20	104.80
BH12	102.08	18/10/2010	6.87	95.21	GBMB3	113	20/10/2014	8.35	104.65
BH12	102.08	20/11/2010	6.83	95.25					
BH12	102.08	29/03/2011	6.50	95.58	GBMB6	113	1/03/2008	11.70	101.30
BH12	102.08	22/08/2011	6.42	95.66	GBMB6	113	2/04/2009	10.73	102.27
BH12	102.08	10/03/2012	6.35	95.73	GBMB6	113	10/08/2009	13.14	99.86
BH12	102.08	8/07/2012	6.25	95.83	GBMB6	113	29/03/2010	10.05	102.95
BH12	102.08	8/09/2012	6.40	95.68	GBMB6	113	11/07/2010	9.55	103.45
BH12	102.08	20/12/2012	6.40	95.68	GBMB6	113	18/10/2010	9.85	103.15
BH12	102.08	24/06/2013	6.55	95.53	GBMB6	113	20/11/2010	10.20	102.80
BH12	102.08	29/09/2013	6.60	95.48	GBMB6	113	29/03/2011	7.10	105.90
BH12	102.08	7/12/2013	6.75	95.33	GBMB6	113	22/08/2011	8.00	105.00
BH12	102.08	23/03/2014	6.70	95.38	GBMB6	113	10/03/2012	7.85	105.15
BH12	102.08	14/05/2014	6.70	95.38	GBMB6	113	8/07/2012	7.50	105.50
BH12	102.08	31/07/2014	7.10	94.98	GBMB6	113	8/09/2012	7.60	105.40
BH12	102.08	20/10/2014	7.20	94.88	GBMB6	113	24/06/2013	8.10	104.90
					GBMB6	113	29/09/2013	8.20	104.80
GBMB1	109	1/03/2008	3.60	105.40	GBMB6	113	7/12/2013	8.55	104.45
GBMB1	109	2/04/2009	1.09	107.91	GBMB6	113	23/03/2014	8.10	104.90
GBMB1	109	10/08/2009	1.97	107.03	GBMB6	113	14/05/2014	8.00	105.00
GBMB1	109	29/03/2010	3.00	106.00	GBMB6	113	31/07/2014	8.55	104.45
GBMB1	109	11/07/2010	3.15	105.85	GBMB6	113	20/10/2014	8.70	104.30
GBMB1	109	18/10/2010	3.50	105.50					
GBMB1	109	20/11/2010	3.35	105.65	SY1	107.48	1/10/2008	10.62	96.86
GBMB1	109	29/03/2011	1.90	107.10	SY1	107.48	2/04/2009	8.09	99.39
GBMB1	109	22/08/2011	1.98	107.02	SY1	107.48	10/08/2009	10.47	97.01
GBMB1	109	10/03/2012	1.90	107.10	SY1	107.48	29/03/2010	7.10	100.38
GBMB1	109	8/07/2012	1.85	107.15	SY1	107.48	11/07/2010	6.75	100.73
GBMB1	109	8/09/2012	2.30	106.70	SY1	107.48	20/11/2010	8.10	99.38
GBMB1	109	24/06/2013	3.00	106.00	SY1	107.48	29/03/2011	5.25	102.23
GBMB1	109	29/09/2013	3.25	105.75	SY1	107.48	22/08/2011	6.00	101.48
GBMB1	109	7/12/2013	3.50	105.50	SY1	107.48	10/03/2012	5.45	102.03
GBMB1	109	23/03/2014	2.75	106.25	SY1	107.48	8/07/2012	5.10	102.38
GBMB1	109	14/05/2014	3.00	106.00	SY1	107.48	8/09/2012	5.90	101.58

Table 9 Continued: Groundwater levels in monitoring bores

SY1	107.48	24/06/2013	5.50	101.98					
SY1	107.48	29/09/2013	5.55	101.93					
SY1	107.48	7/12/2013	6.00	101.48					
SY1	108.48	23/03/2014	5.00	103.48					
SY1	108.48	14/05/2014	5.00	103.48					
SY1	108.48	31/07/2014	5.10	103.38					
SY1	108.48	20/10/2014	5.15	103.33					

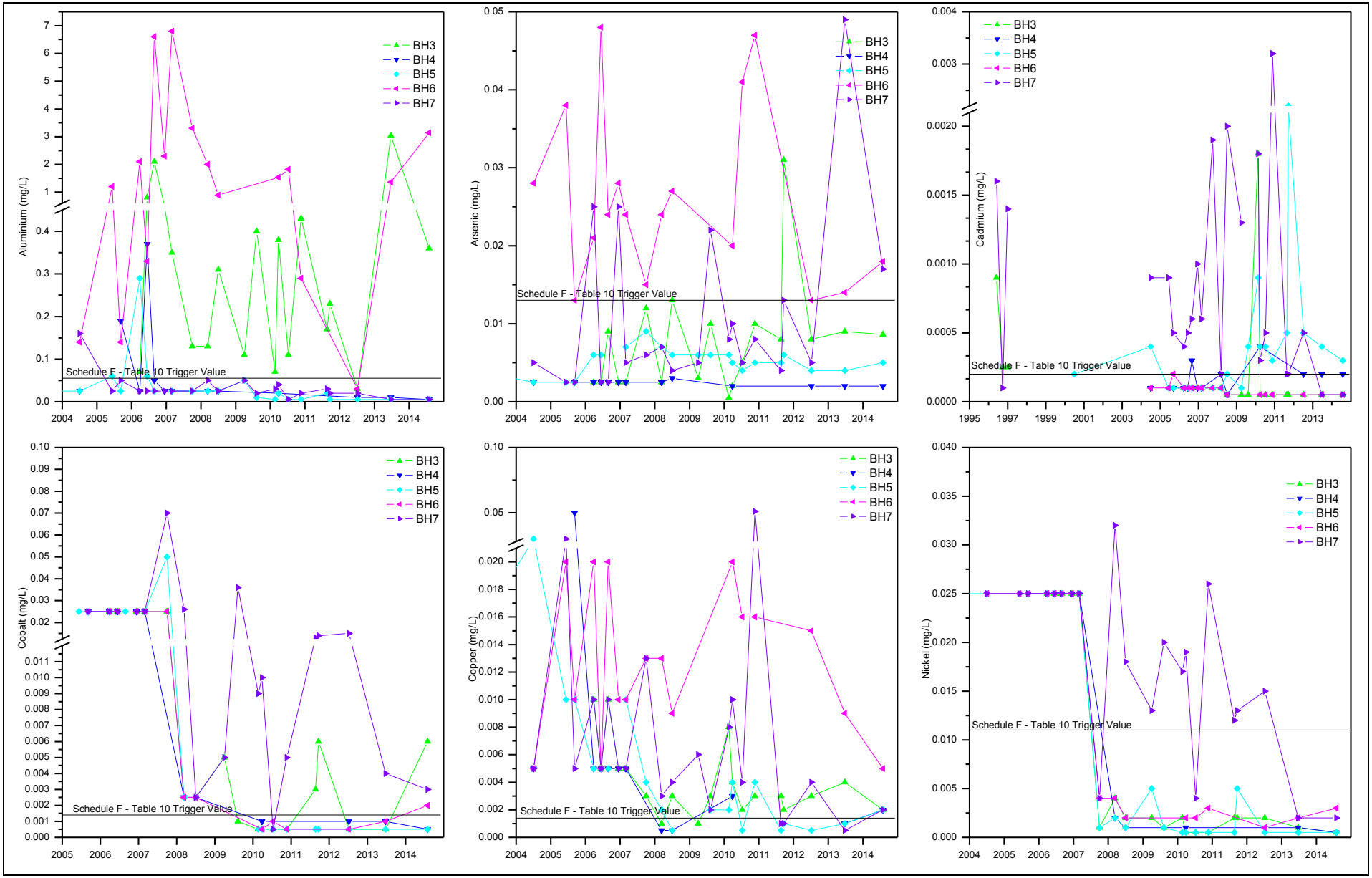


Figure 32: Time Series - Golden Butterfly Dump Monitoring Bores

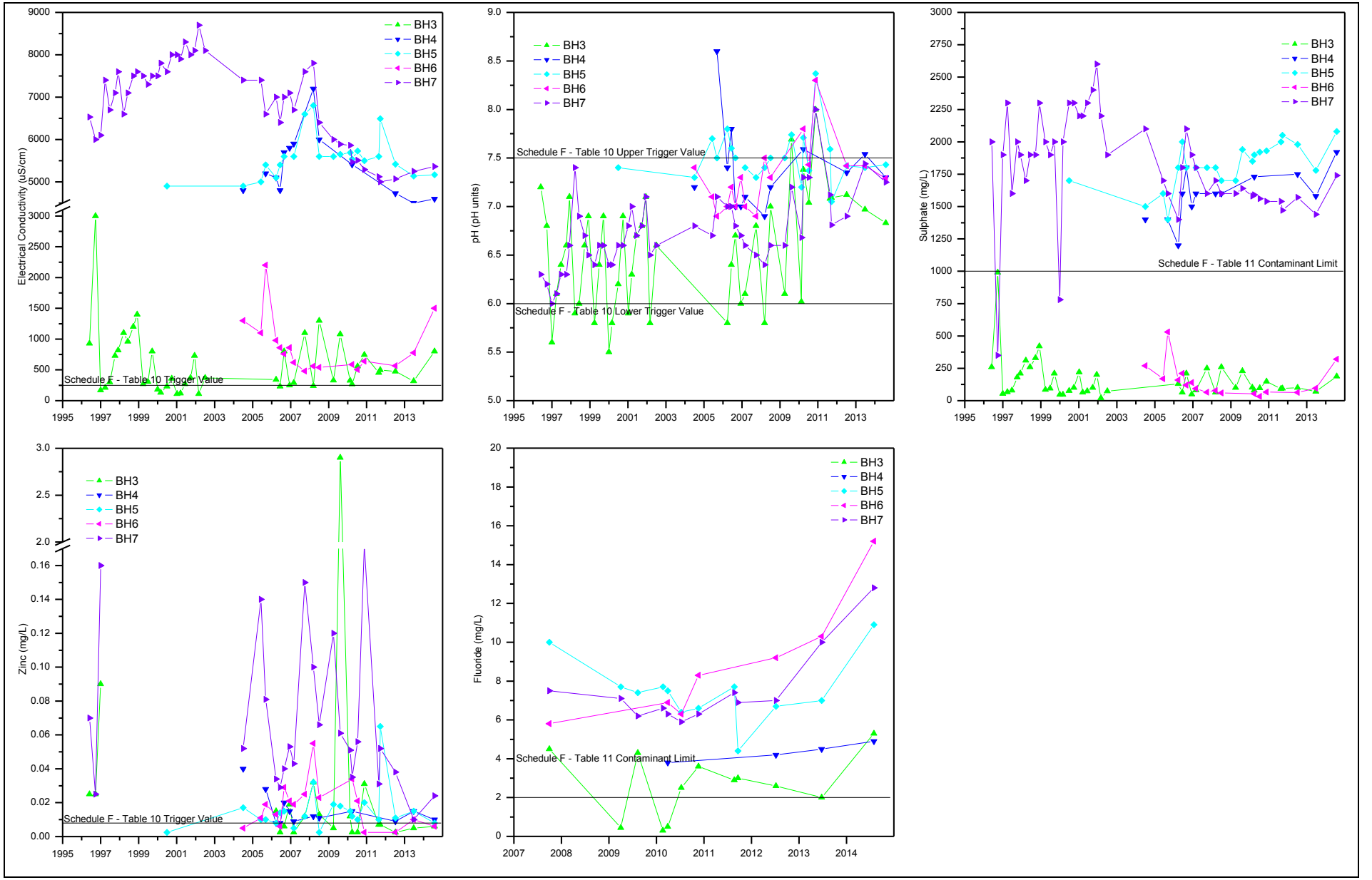


Figure 30 (Continued): Time Series - Golden Butterfly Dump Monitoring Bores

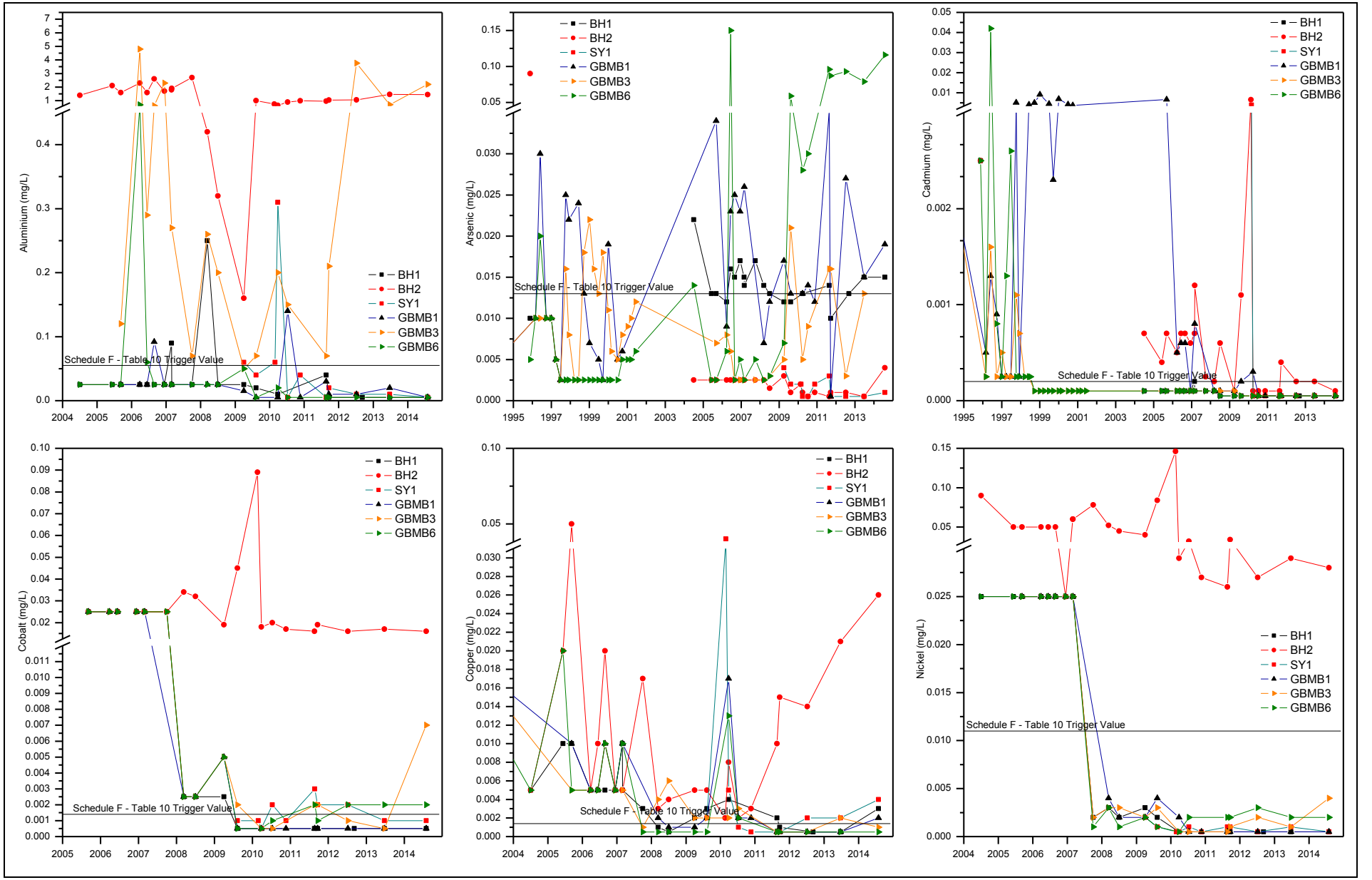


Figure 33: Time Series - Golden Butterfly Pit Monitoring Bores

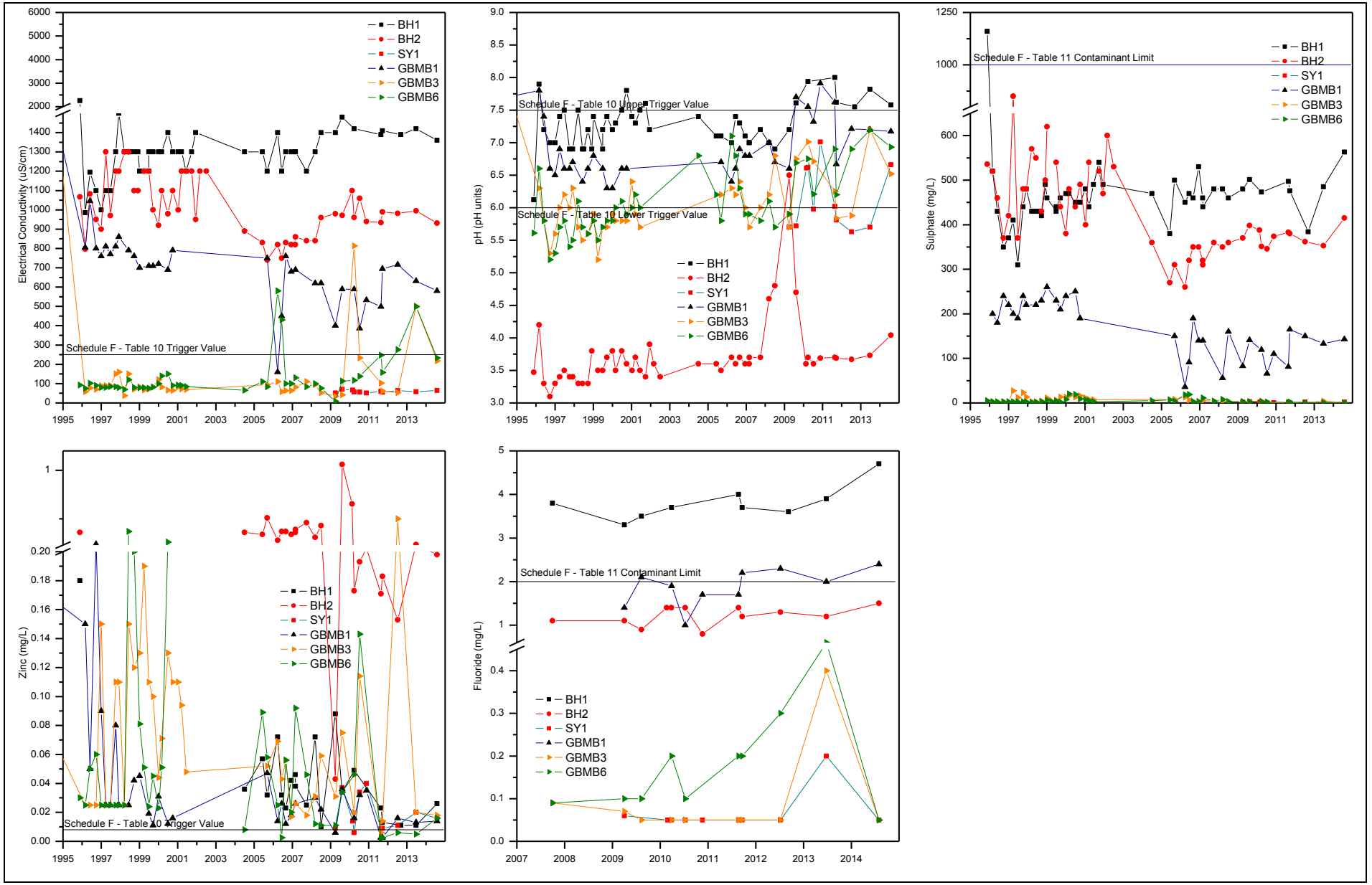


Figure 31 (Continued): Time Series - Golden Butterfly Pit Monitoring Bores

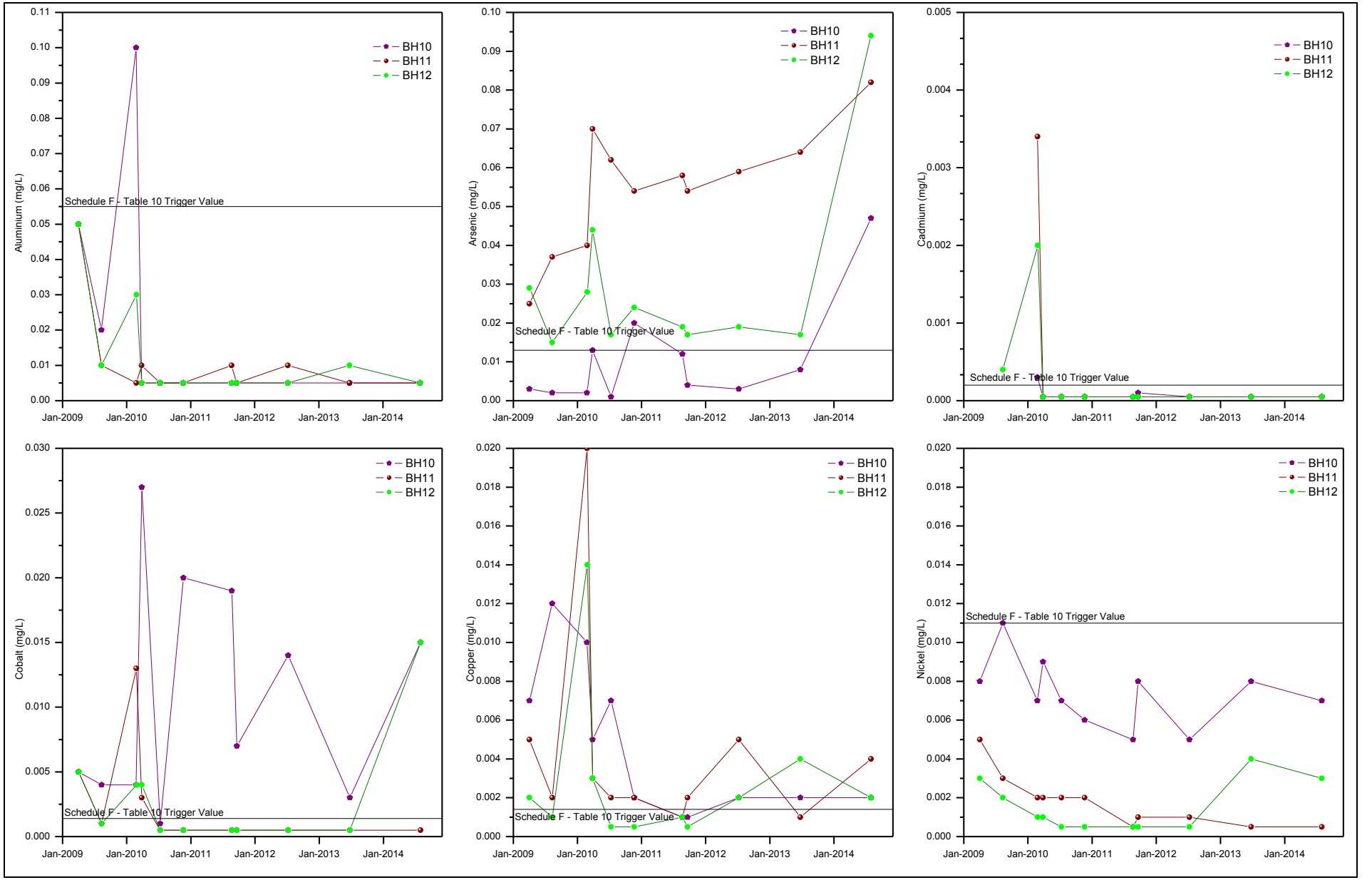


Figure 34: Time Series - Content Pit Monitoring Bores

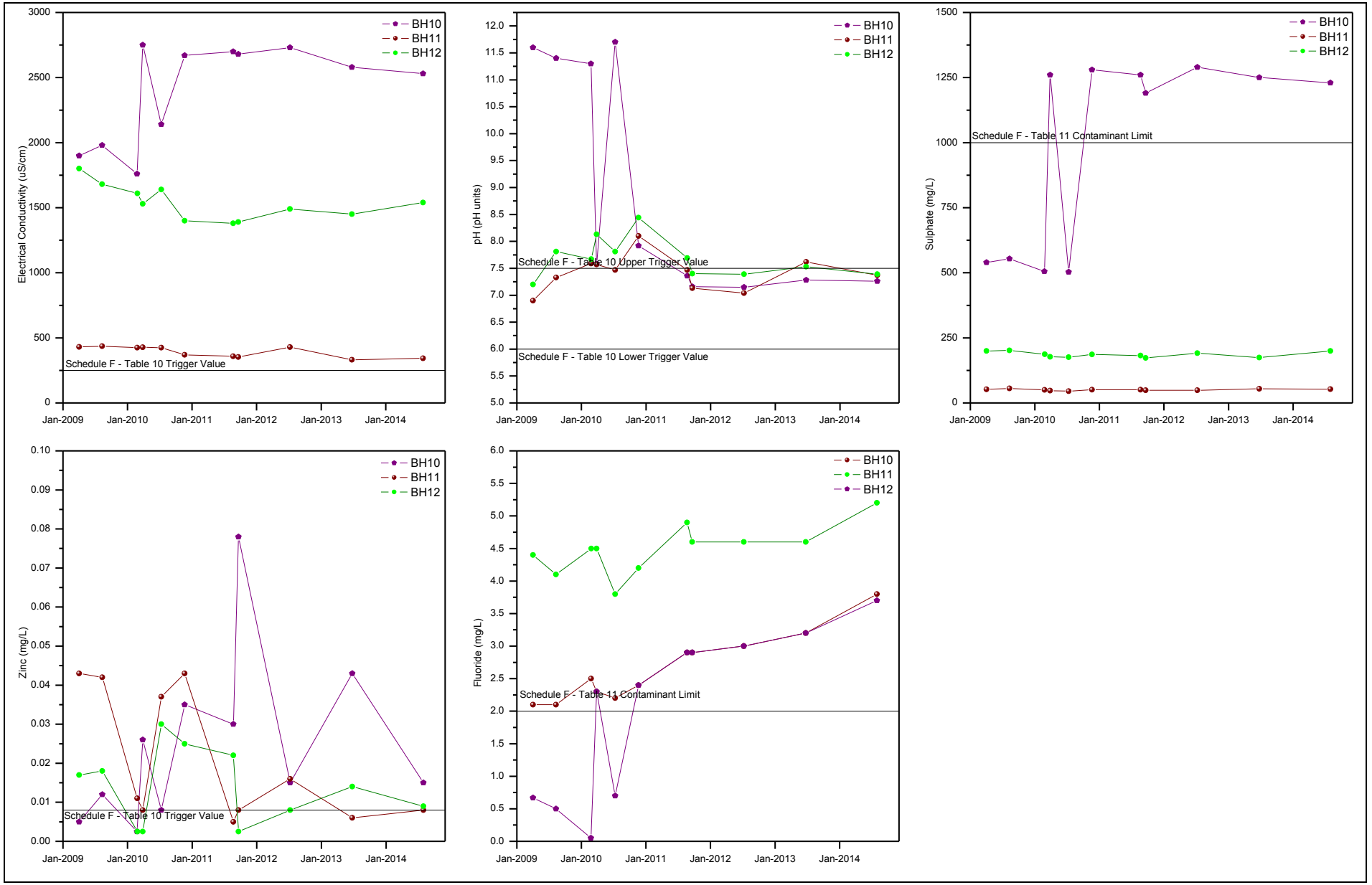


Figure 32 (Continued): Time Series - Content Pit Monitoring Bores

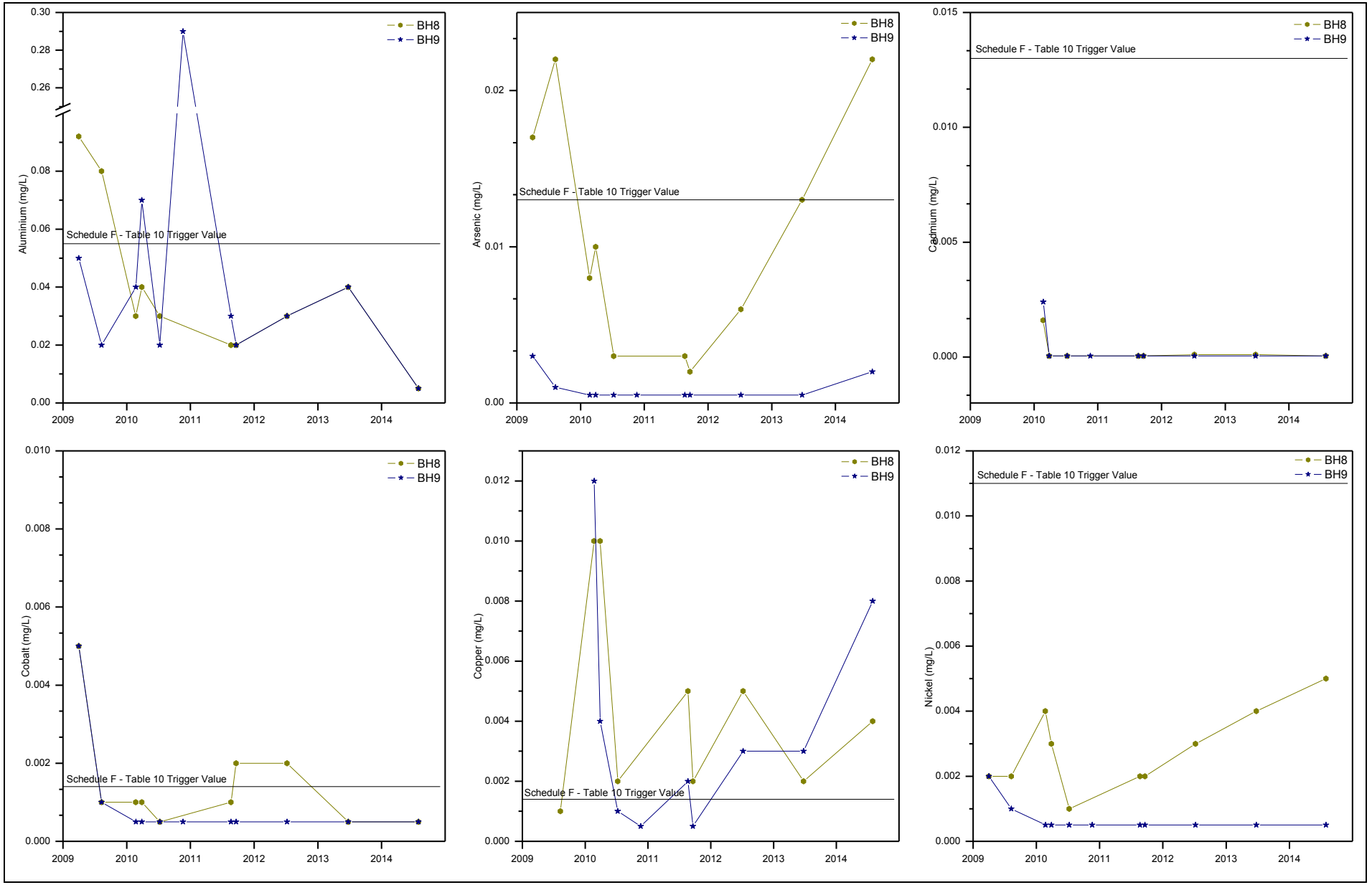


Figure 35: Time Series - Golden Butterfly North Pit Monitoring Bores

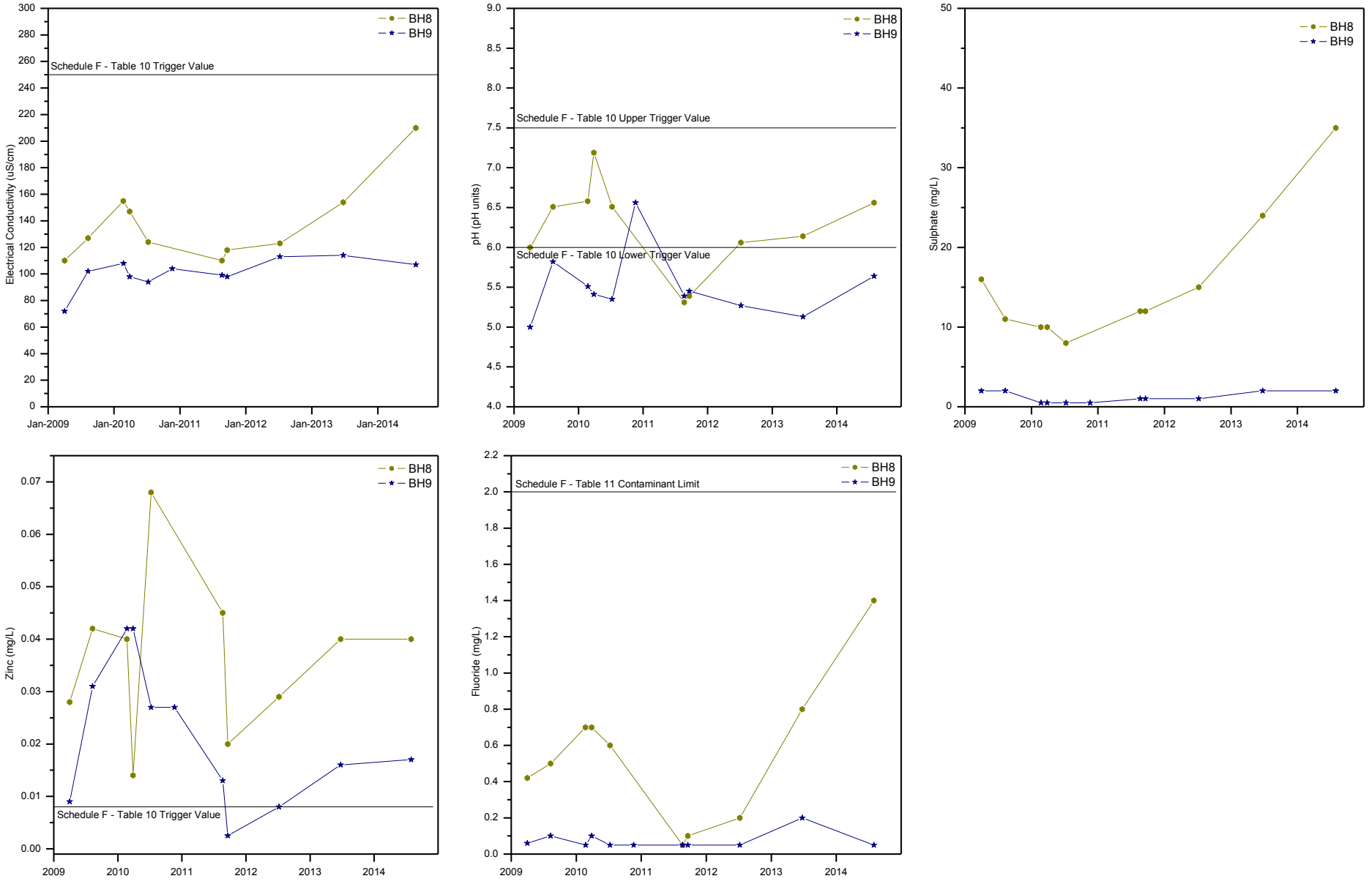


Figure 33 (Continued): Time Series - Golden Butterfly North Pit Monitoring Bores

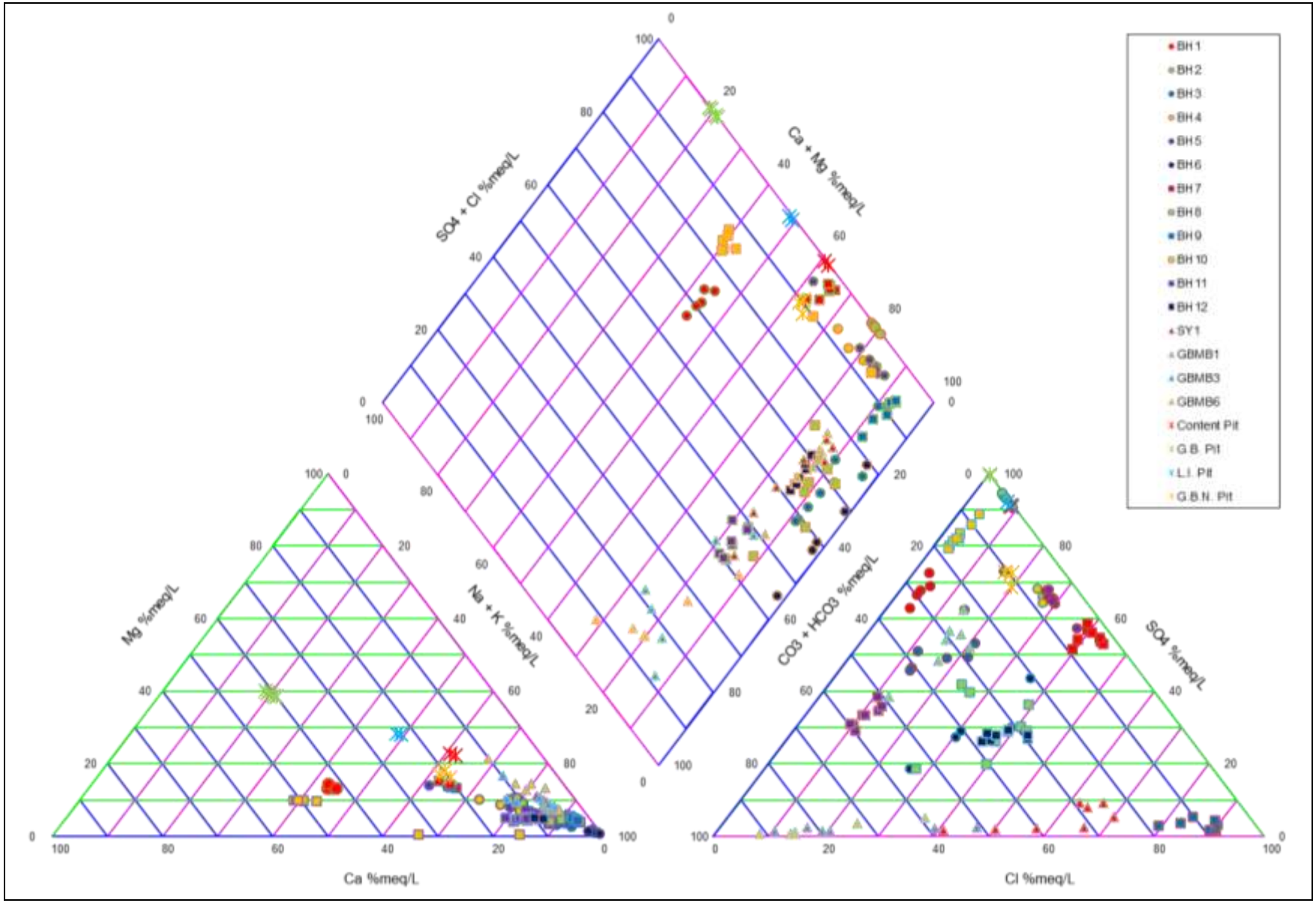


Figure 36: Piper Plot – All Bore Sites

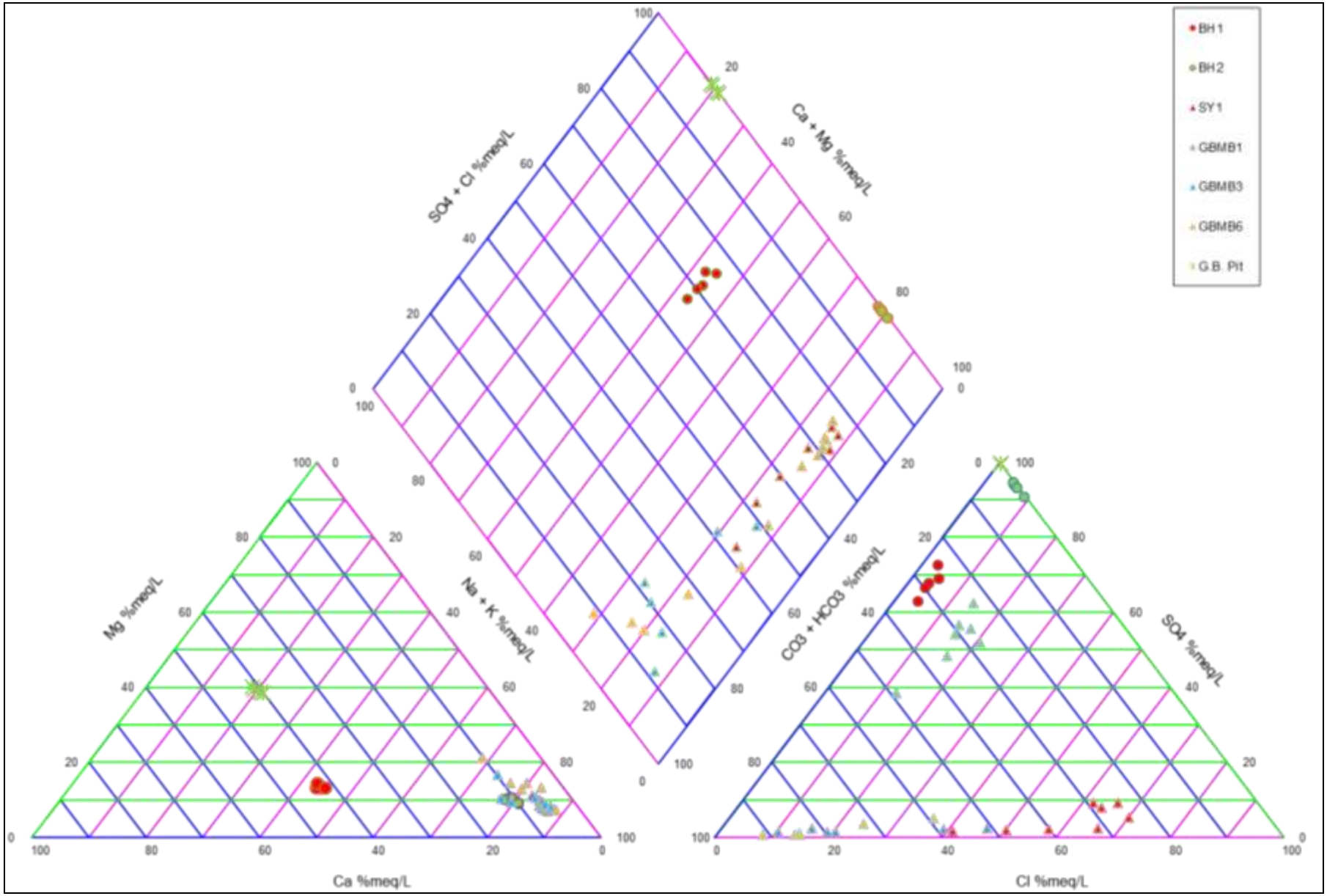


Figure 37: Piper Plot – Golden Butterfly Pit/Slaughteryard Creek Bores

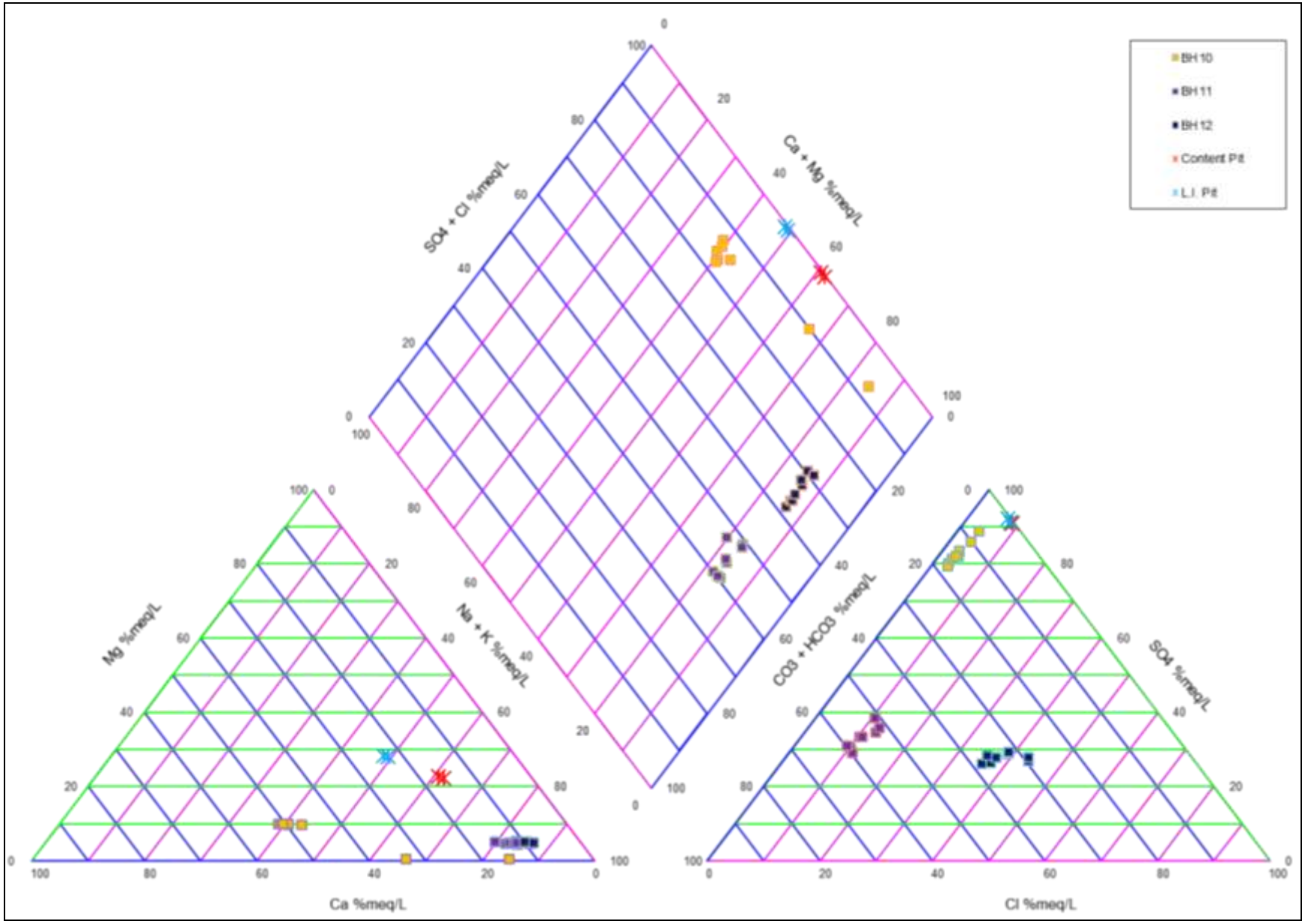


Figure 38: Piper Plot – Content Pit Bores

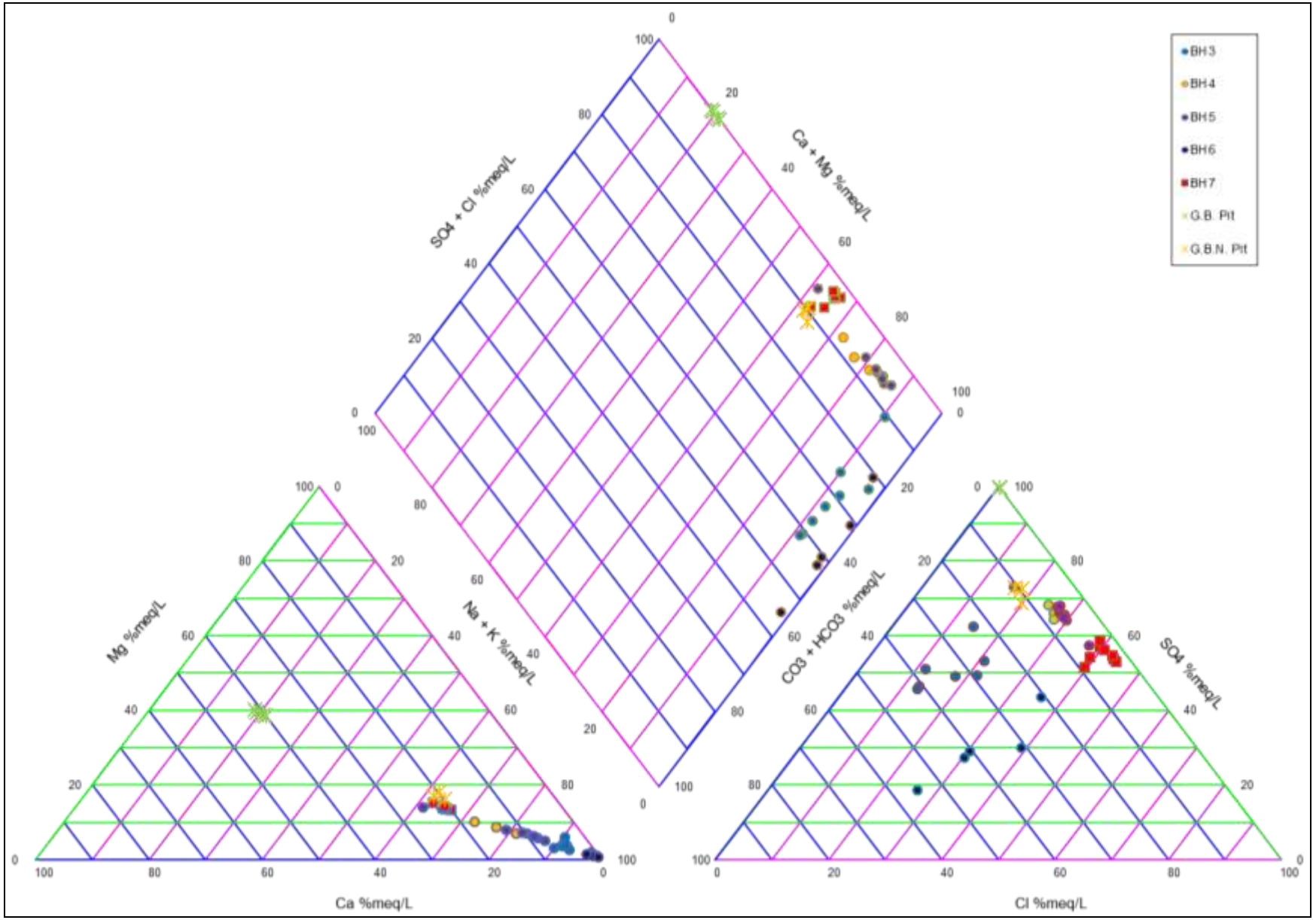


Figure 39: Piper Plot – Golden Butterfly Waste Rock Dump Bores

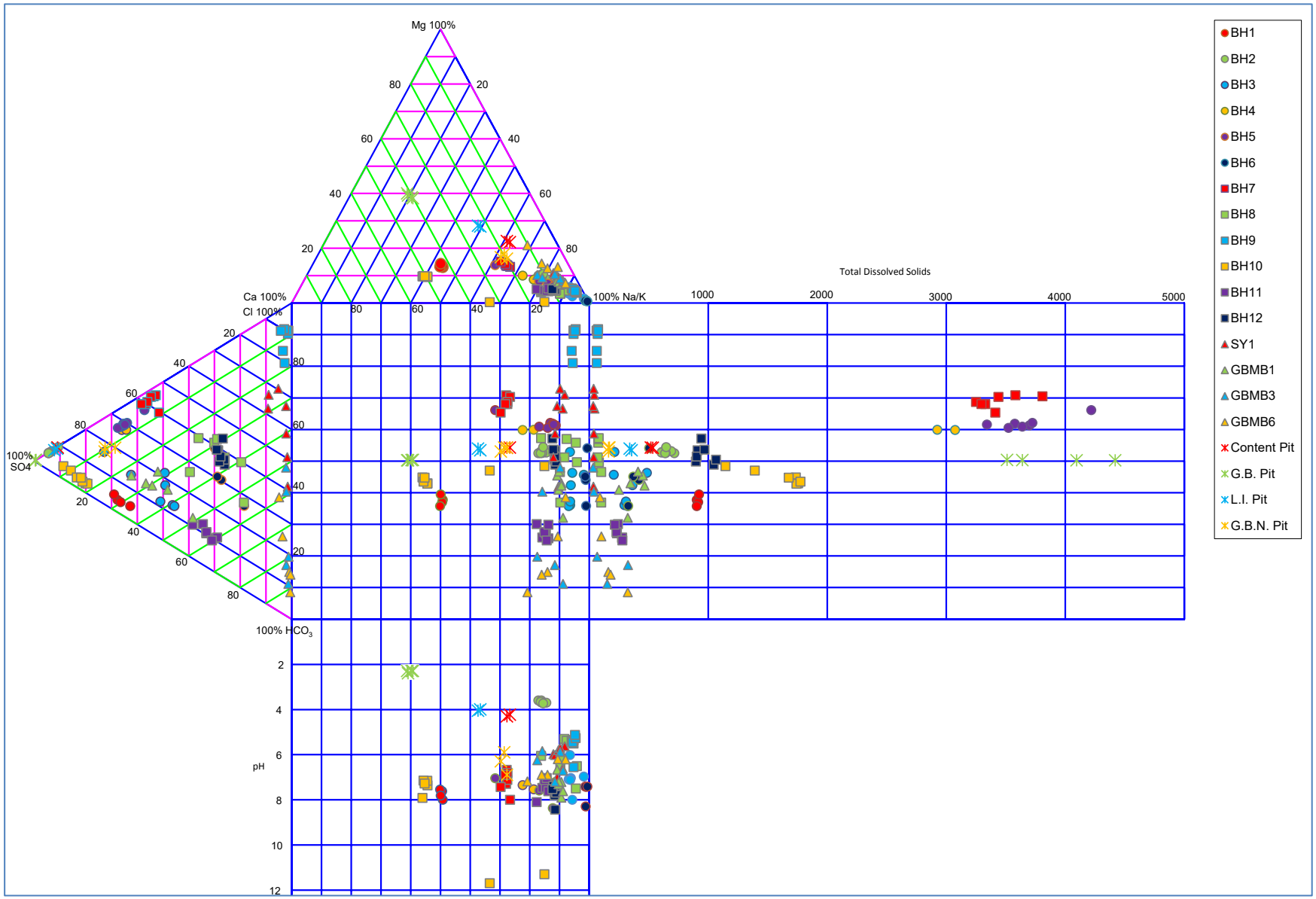


Figure 40: Durov Diagram – All Bore Sites

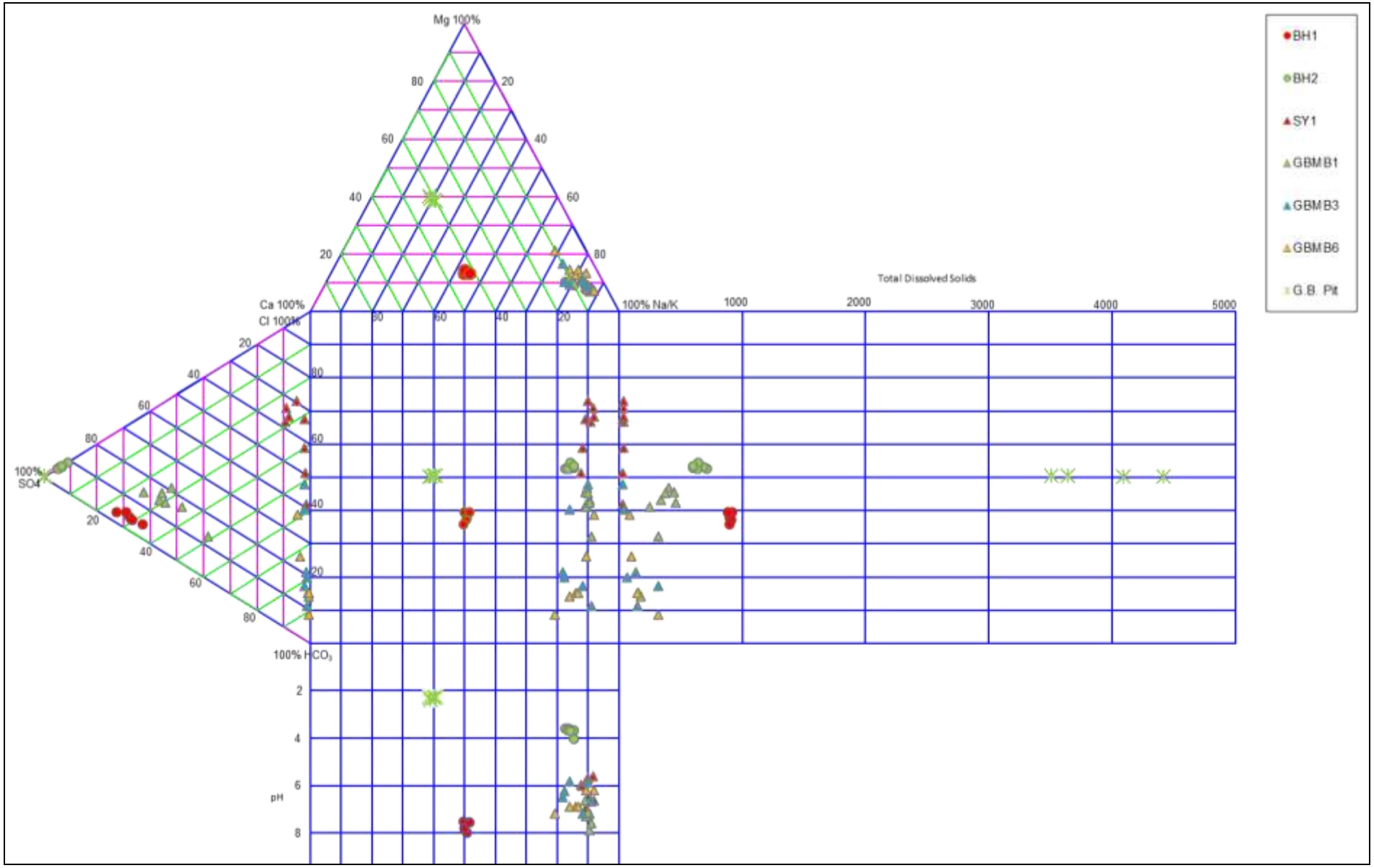


Figure 41: Durov Diagram – Golden Butterfly Pit/Slaughteryard Creek Bores

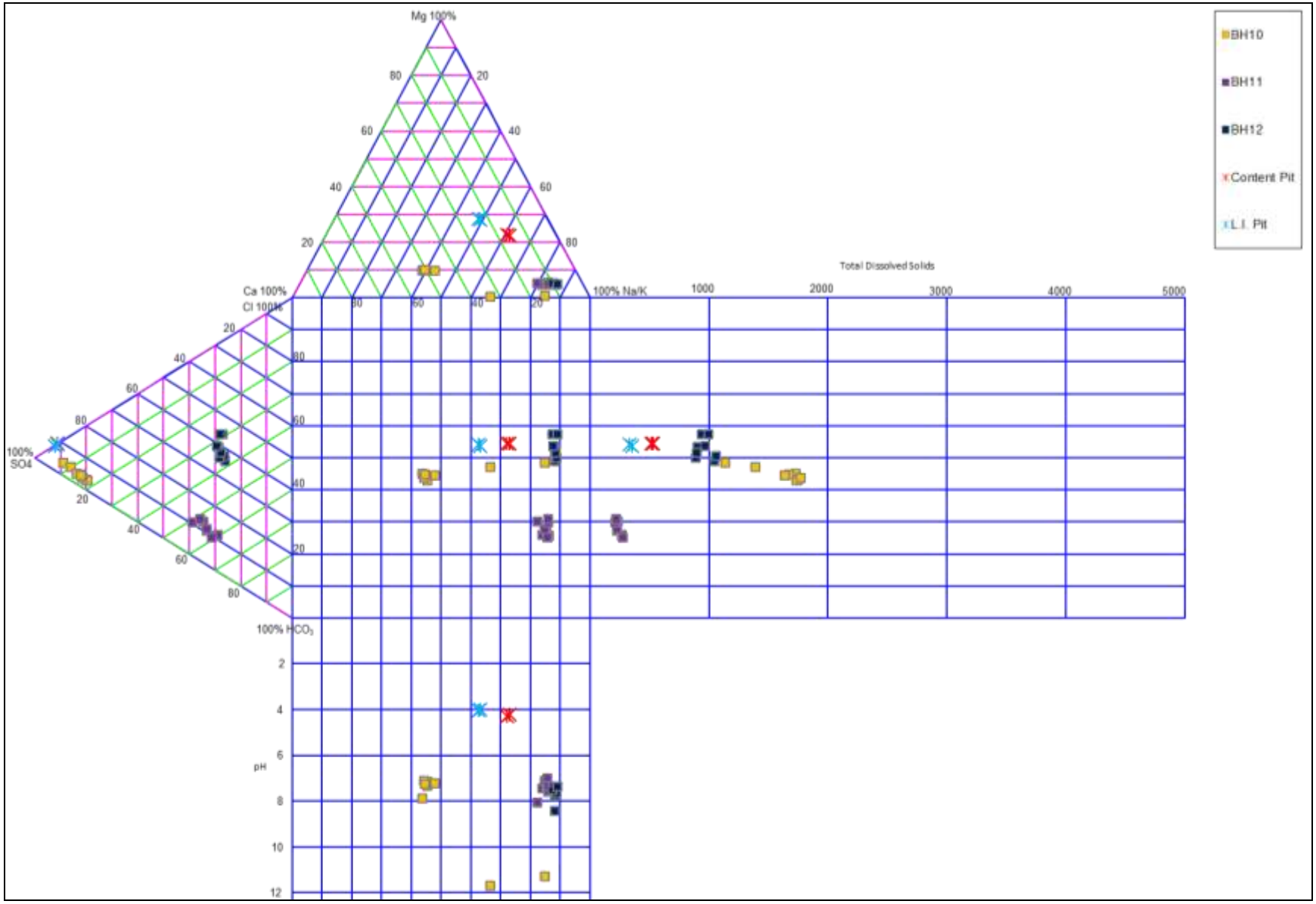


Figure 42: Durov Diagram – Content Pit Bores

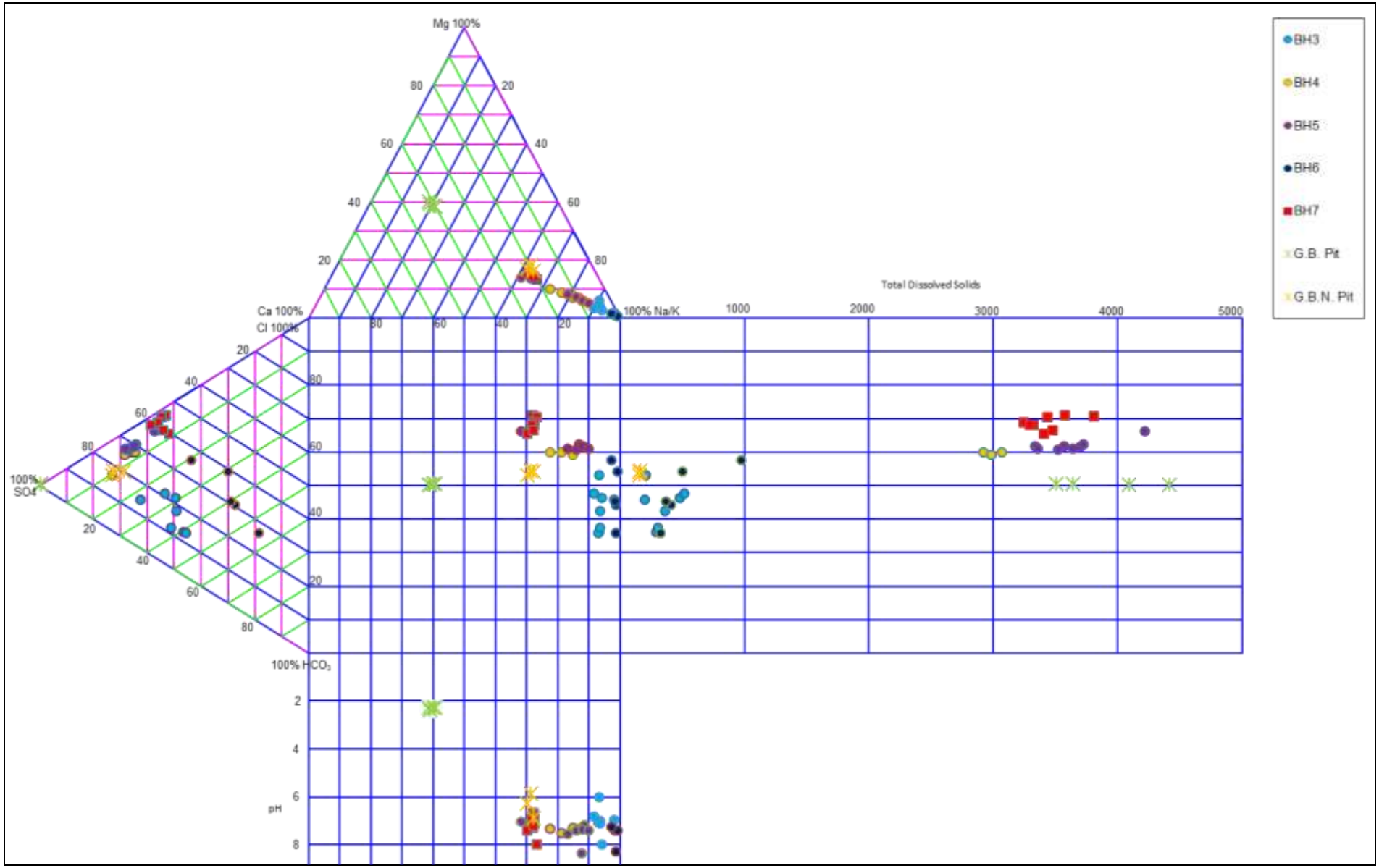


Figure 43: Durov Diagram – Golden Butterfly Waste Rock Dump Bores

8 References

[1] Barrick Gold of Australia (2008) *Croydon Gold Mine Project – Environmental Management Plan*

[2] HLA - Envirosciences (2001) *Water Level Analysis of Golden Butterfly Pit – Croydon Gold Mine*. Report prepared for Goldfields Ltd, May 2001.

[3] Barrick Gold of Australia (2008) *Croydon Gold Mine Project – Environmental Management Plan*

[4] HLA - Envirosciences (2001) *Water Level Analysis of Golden Butterfly Pit – Croydon Gold Mine*. Report prepared for Goldfields Ltd, May 2001.

[5] HLA – Envirosciences, Ibid.

[6] Singhal, B.B.S., Gupta, R.P., p. 211, *Applied Hydrogeology of Fractured Rocks*, 2nd Ed., Springer, 2010.

[7] Ibid, p. 211.

[8] Popek, E.P., p.142, *Sampling and Analysis of Environmental Chemical Pollutants*, Academic Press, 2003.

[9] Moller, N., Christov, C., Weare, J., *Thermodynamic Models of Aluminium Silicate Solubility for Application to Enhanced Geothermal Systems*, Proceedings of the 31st Workshop on Geothermal Reservoir Engineering, Stanford University, 2006.

[10] Australian and New Zealand Environment and Conservation Council (ANZEEC), Vol 1*, Australian and New Zealand Guidelines for Fresh and Marine Waters*, Chapter 2, p. 2-2., October 2000.

[11] Ibid, p. 2-6

[12] Barrick Gold of Australia (2008), *Croydon Gold Mine – Annual Groundwater Monitoring Report 2008*.

APPENDIX M CROYDON GOLD MINE ENVIRONMENTAL COMPLIANCE AUDIT REPORT

Croydon Gold Mine Environmental Compliance Audit Report ML 5428

Prepared By: Envirofin Consulting
Report Number: 1603
Date: 7 December 2016
Prepared For: Barrick (Australia Pacific) Ltd

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ANNEXURES

Annexure 1
Audit Checklist

1 INTRODUCTION

Envirofin PL was commissioned by Barrick (Australia Pacific) Ltd (Barrick) to undertake an Environmental Compliance Audit for Croydon Gold Mine (CGM) located on ML 5248 west of Croydon in Far North West Queensland (**Figure 1**). The audit was conducted over the period of 24-25th November 2016, in accordance with Environmental Authority Condition A6.1. This report provides the findings from the audit.

1.1 Background

This environmental compliance audit was undertaken as a requirement of the mine's Environmental Authority (EA) No. EPML00950913 Condition A6-1, amended 8th October 2014) which states "Compliance with the conditions of this environmental authority must be audited by a suitably qualified third party auditor, nominated by the environmental authority holder and accepted by the administering authority once every two years". The previous audit conducted by RPS in 2014 was based on the 2013 EA MIN10000401906.

The Croydon Gold mine was formerly a large low-grade open cut gold mine which has since been decommissioned and rehabilitated. As shown in **Figure 2**, mining activities commenced 500m west of the Croydon township. The residual landform includes four pits (Content, Lady Isabella, Golden Butterfly and Golden Butterfly North), two capped waste rock dumps (Content and Golden Butterfly) and internal access tracks. Activities at the project include maintenance, monitoring and reclamation works as required. The Croydon Shire Council draws water from the Lady Isabella and Golden Butterfly North pits for road construction/ dust suppression and water supply works. The landowner also grazes cattle on the site from time to time and draws stockwater supplies from the Content pit.

RPS also conducted a similar CGM audit in 2014, based on the 2013 EA (MIN10000401906). Amended conditions primarily relate to Schedule F – Water.

1.2 Audit Scope

The scope of the audit was to determine compliance with the amended (2014) Environmental Authority (EA) No. EPML00950913 and other required statutory documentation such as the Croydon Gold Mine Plan of Operations (2014-2017). Key documents used to assess compliance against statutory requirements includes:

- Annual Groundwater Monitoring Report (2016)
- Rehabilitation Assessment Report (2016)
- Receiving Environment Monitoring Program (July 2016)
- Water Management Strategy (November 2014)
- Post Mine Land Use Plan (Nov 2014)
- Cultural Heritage Management Plan (Nov 2014)
- Grazing Management Plan(Nov 2014)
- Erosion and Sediment Control Plan (Nov 2014)

- Barrick Monthly reports
- Croydon Gold Mine Environmental Compliance Audit, RPS(2014)
- Incident Notifications documentation

The audit was conducted within the lease boundaries of the site (Figure 1) and concentrated on the existing pits, waste rock dumps and the surrounding environment. All ore processing was known to occur offsite and was not within the scope of this audit.

This 2014 audit focuses on the period since the 2014 audit, however conclusions from the 2014 audit were revisited and actions taken to rectify areas of noncompliance were noted and assessed for current compliance. It is noted that Barrick has been in discussion with DEHP for several years to develop workable EA conditions and it is understood that these discussions are still in progress; at the time of the audit the latest request for EA amendment had not been concluded.

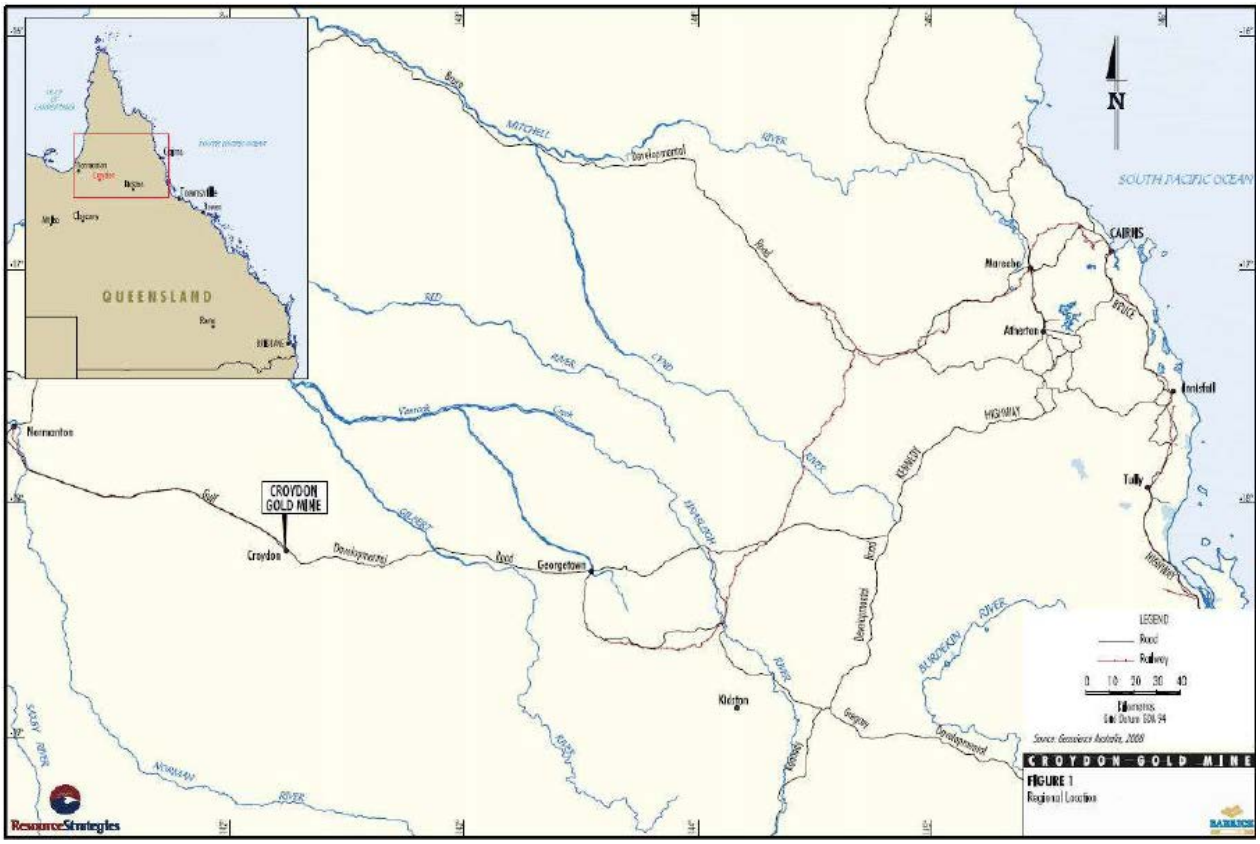

Figure 1 Site Location

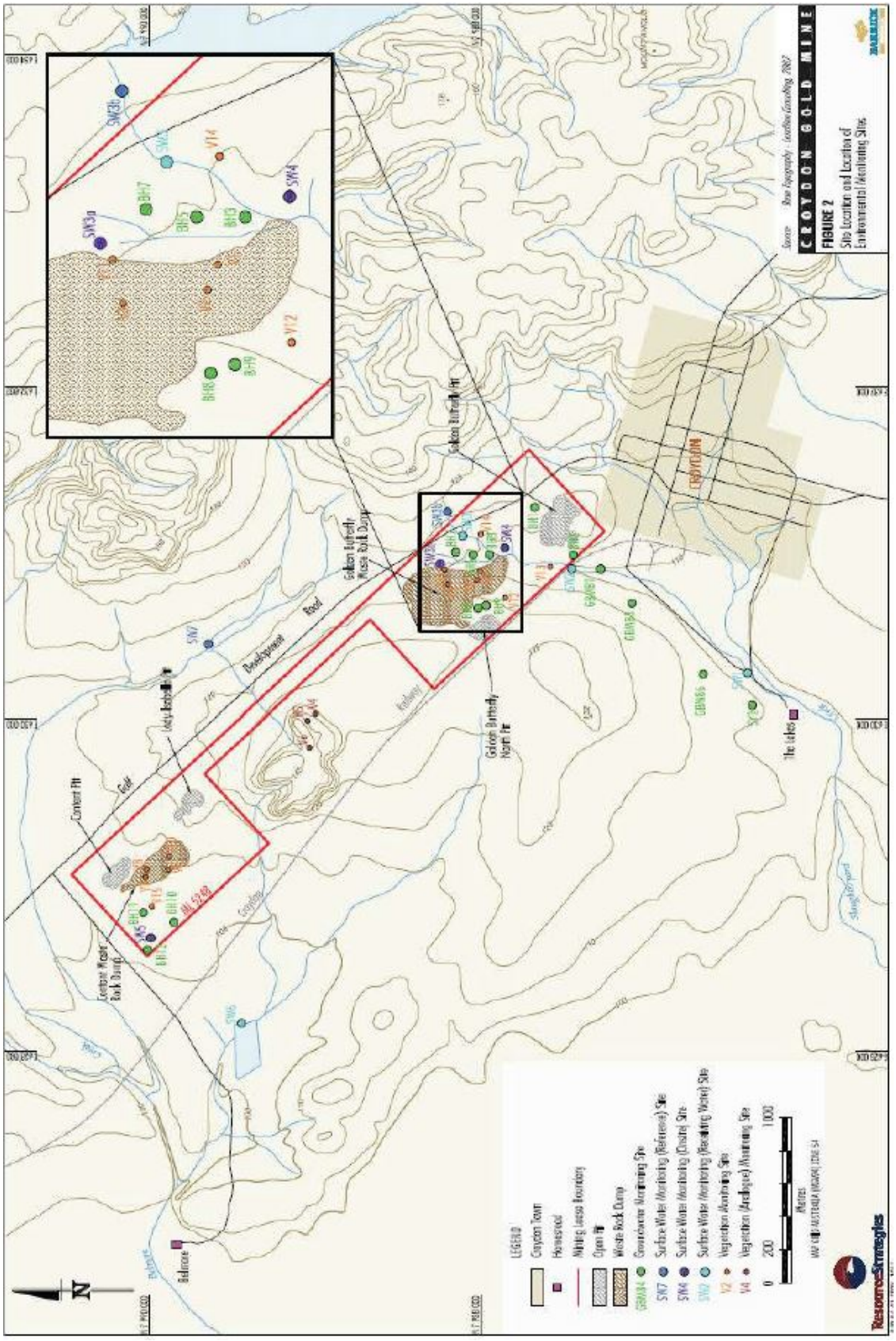

Figure 2 Site Layout and Monitoring Locations

2 AUDIT METHODOLOGY

In preparation for the audit, Envirofin provided Barrick with a requested list of relevant documentation for review prior to audit proceedings, including copies of the most recent Environmental Authority and Plan of Operations and supporting documentation. These documents along with copies of selected legislation and industry standards were used to develop an audit protocol which produced a checklist of items to be reviewed during the audit and questions used to direct the auditor. A copy of the checklist forms the basic template for the presentation of the audits observations, compliance assessments and recommendations (**Annexure 1**).

The audit was completed by Envirofin Auditor David Finney (Exemplar Global Cert No: 12575). During the field component of the audit, Mr Walter Benko, Barrick's environmental site representative, assisted by providing an account of decommissioning, rehabilitation, ongoing monitoring works, insights in site conditions and negotiations with DEHP relating to EA amendments. The field portion was conducted over 24th-25th November 2016. Audit activities included:

- Pre-audit review of amended EA conditions and Croydon Gold Mine Plan of Operations and supporting documents;
- Preparation of audit checklist (spreadsheet of conditions to be audited);
- Initial discussions with Mr Walter Benko to discuss management and monitoring practices and mine closure and post closure activities relevant to the Environmental Authority;
- A one day site inspection of all facilities with Mr Walter Benko;
- Audit close out meeting with Mr Walter Benko;
- Follow up of any outstanding audit issues i.e. lists of records to verify implementation of licence requirements and management plans; and
- Preparation of an audit report including non-compliances and recommendations.

Audit Findings were recorded in the audit checklist as either compliance, non-compliance, potentially non-compliance or opportunity for improvement as defined below:

2.1 Compliance

These conditions were either fully or substantially complied with, in the case of multiple sub conditions, or where there was clearly no evidence of noncompliance; in some instances, these conditions were also noted as Not Applicable (NA).

2.2 Noncompliance

A noncompliance is noted when a regulatory requirement (primarily the environmental authority condition) is not being or cannot be met.

2.3 Potential Noncompliance

A potential noncompliance was identified when there was a prima facie noncompliance with a condition, however there were strong grounds for the approval of a submitted amendment request to the EA condition that would enable compliance with the condition. Should DEHP not approve the amendment request the relevant instance would revert to a noncompliance.

2.4 Opportunity for Improvement

Opportunities for improvement are areas that were identified during the audit where practices may have been in compliance with regulatory and permit requirements but may not meet Best Management Practices (BMP) or would result in improved environmental or administrative performance.

3 FINDINGS

A total of 82 environmental authority audit requirements were assessed. The audit found 72 issues in compliance, six potential non-compliances, one non-compliance and three opportunities for improvement. The findings are presented in detail in **Annexure 1**.

3.1 Potential Noncompliance

3.1.1 Groundwaters (Conditions F7-2, F7-3)

The 2014 audit noted that "As a result of greater than 100 years of water balance data and groundwater level and quality monitoring since 1994, specialist hydrogeological consensus is that all four pits on site are functioning as groundwater sinks thereby restricting off site groundwater quality impacts. Groundwater quality monitoring indicates that monitoring (reference) bore chemistry differs substantially from pit waters; highly likely to be a function of complex hydrogeochemical conditions surrounding the pits not from migration of pit waters. Consequently, off site impact is likely to be minimal."

In the 2014 audit, two non-compliances with groundwater conditions F7-2 and F7-3 were noted, however it is understood that because of the difficulty in establishing representative reference bores in locally mineralised areas and in view of the likely absence of offsite impacts, Barrick has lodged an application to amend these conditions, which the auditor considers has substantial merit. The current required method of calculation of compliance triggers and limits will continue to result in technical breaches, whereas hydrogeological studies have shown that resultant environmental harm is not likely to occur.

Should the applications be unsuccessful, some groundwater monitoring data would constitute a technical noncompliance.

3.1.2 Surface Waters (F1-1, F1-2, F2-3, F4-1)

In January 2016 Croydon Shire Council installed a water pipeline to the Lady Isabella pit for the purposes of drawing roads construction/dust suppression water, however insufficient erosion and sediment control works may have resulted in an offsite sediment discharge. At the time of scheduled water monitoring at SW2, turbid residual pools were noticed and sampled, however it was uncertain whether the water quality was representative of discharge conditions (refer **Figure 2**). Laboratory data indicated various metals were noncompliant, particularly aluminium, which reflected the inability of field filtering to remove high clay colloid levels. In the event that the sampled pools were representative, contaminant limit calculation anomalies resulted in exceedance of some parameter contaminant limits by trigger values which would indicate environmental harm was unlikely.

The current EA (2014) contains several anomalies which can result in contaminant limits for some parameters being exceeded by trigger levels ,which could compromise the ability to comply with Conditions F1-1, F2-3 and F4-1 during the 2016/2017 wet season.

It is noted that in response to the incident notification report (January 2016), DEHP requested submission of an EA amendment request to correct these anomalies; at the time of auditing this matter

was unresolved. The January 2016 incident has therefore been noted as a potential noncompliance with conditions F1-1, F1-2, F2-3 and F4-1.

3.2 Non-Compliance

Contaminant Release to Waters (F2-1)

As noted above, the CSC sediment discharge incident occurred at a location not specified in Schedule F- Table 1, therefore was in breach of Condition F2-1. Potential noncompliance with water quality conditions is discussed above in Section 3.1.

3.3 Opportunity for Improvement

Three opportunities for improvement were noted (C2-2d, A3-3, C2-2m).

Risk Management (Condition A3-3)

Hydrological modelling has confirmed that the only pits with an overflow risk are Content and Lady Isabella. It is noted that the overflow risk for these pits and potential for environmental harm has been substantially reduced because of stockwater quality compliance and beneficial use of pit waters by CSC and the landowner for road construction and cattle water supply respectively. Notwithstanding, it is recommended that the telemetry link to the Content pit water level sensor is re-established to enable timely confirmatory discharge sampling, as required.

Post Mine Landuse Plan- Erosion Control (Condition C2-2d)

It is recommended that erosion control could be improved in the small “scalded” to the west of the Content waste rock dump by targeted revegetation works. The Rehabilitation Monitoring report (2016) recommended that further attempts to establish vegetation on this area could be assisted by using irrigation; alternatively, it could also be achieved by tailored fertiliser applications and synchronisation with early wet season rains to increase vegetation establishment success.

Post Mine Landuse Plan- Measurable Completion Criteria (Condition C2-2m)

As noted in the 2014 audit, it is recommended that quantitative targets are developed for rehabilitation success criteria such as vegetation floristics, erosional stability, post mine landuse capability, physical, chemical and biological soil properties to facilitate site closure.

4 CERTIFICATION

I, David Finney being aware that it is an offence under section 480 of the Environmental Protection Act 1994 to provide false or misleading information, state that:

- I am authorised to sign on behalf of the person (meaning a corporation or individual) holding the environmental authority;
- all information provided is true and complete; and
- I understand that information given with this audit statement could become available to the public in accordance with the Right to Information Act 2009.

Signed Date: 7th December 2016

ANNEXURE 1

AUDIT CHECKLIST

Project:	Barrick Australia – Croydon Gold Mine	Date of Audit :	24-26 November 2016
Audit Team:	David Finney, Walter Benko		
Attendees & Roles:	Lead Auditor – David Finney ; Walter Benko – Barrick Representative		

Schedule / Reference	Commitment/requirement	Compliance	Not Compliance	Opportunities for Improvement	Potential Non Compliance	Finding/Evidence	Recommendation/ Discussion
SCHEDULE A – GENERAL							
Maintenance of Measures, Plant and Equipment							
(A1-1)	The environmental authority holder must:						
	(a) install all measures, plant and equipment necessary to ensure compliance with the conditions of this environmental authority and the general environmental duty;	✓				Mine closed and decommissioned. As such all plant and infrastructure has been removed. All necessary monitoring infrastructure is in place.	
	(b) maintain such measures, plant and equipment in a proper condition;	✓				Equipment is checked approximately on a monthly basis	
	(c) operate such measures, plant and equipment in a proper manner; and	✓					
	(d) ensure that all instruments and devices used for the measurement or monitoring of any parameter under any condition of this environmental authority must be calibrated and appropriately operated and maintained.	✓				Water level meters, rain gauges, WQ meters were calibrated and viewed in good working order.	Pressure sensors only now present at Content pit. Calibrated yearly. pH/ EC meter is calibrated before each monitoring event and blanks forwarded to laboratory.
(A1-2)	No change, replacement or alteration of any plant or equipment is permitted if the change, replacement or alteration increases, or is likely to substantially increase, the risk of environmental harm caused by the mining activities.	✓				Mine closed and decommissioned. As such all plant and infrastructure has been removed.	
Activity							
(A2-1)	This environmental authority does not authorise environmental harm unless a condition contained within this authority explicitly authorises that harm. Where there is no condition or the authority is silent on a matter, the lack of a condition or silence shall not be construed as authorising harm.	✓				Monitoring programs currently indicate absence of offsite environmental harm.	
(A2-2)	In carrying out the mining activity, reasonable and practicable measures must be taken to prevent or minimise the likelihood of environmental harm being caused.	✓				Pumping of Content Pit to increase freeboard was undertaken in 2010 to increase capacity for pending wet season rains. Agreement in place for Council to take water from Lady Isabella pit for road construction/ dust suppression.	
(A2-3)	All land subject to mining activities must be rehabilitated to a nonpolluting, stable and self-sustaining landform	✓				Review of: 2016 Groundwater Monitoring Report 2016 REMP 2016 Rehabilitation Monitoring Report	Waste rock dump landforms were stable with no evidence of significant erosion noted.

Schedule / Reference	Commitment/requirement	Compliance	Not Compliance	Opportunities for Improvement	Potential Non Compliance	Finding/Evidence	Recommendation/ Discussion
(A2-4)	Any management or monitoring plans, systems or programs required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm as often as necessary but at least every two years and amended promptly if required.	✓				The following documents were reviewed and found to provide effective management of environmental harm: Plan of Operations (2014-2017) updated Nov 2014 Annual Groundwater Monitoring Report November 2016 REMP 2016 Other plans including Grazing Management Plan 2014, Cultural Heritage Management Plan 2014, Water Management Plan 2014 and Post Mine Land Use Plan 2014 were reviewed by Barrick and considered current, with no requirement for updating (as per October Monthly Barrick Site report).	It is recommended that the following amendments are made during the next document updates: PMLP • Remove reference to drainage works to the Golden Butterfly pit area as they have been undertaken; • p12 drainage works at toe of content waste rock dump which to be installed following review of pit hydrological model. This has been undertaken and it was determined that the works were not necessary as the toe drain was to report to the content pit which may overflow in response to sequential above average wet seasons. • P13 remove reference to reclamation works on Content waste rock dump which have been undertaken WMP • p 14,15 Remove reference to proposed additional water balance modelling which has was undertaken in 2010 (Metago)
(A2-5)	The environmental authority holder must record, compile, evaluate and keep all monitoring results, records and documents for a period of at least 5 years required by this environmental authority, and any complaints received about the mining activity, and produce copies, or make available for inspection all or any of these records upon request by the administering authority.	✓				Previous monitoring records were made available for review in 2012 and 2014 audits. Documents identified in A2-5 provided an effective analysis of environmental monitoring data collected over the last 5 years.	
Risk Management							
(A3-1)	The environmental authority holder must conduct a risk assessment for mining activities which conforms to the Australian Standard for Risk Management (AS/NZ 4360:2004) by 31 July 2009.	✓				A review of paperwork revealed a formal risk assessment of mining activities according to the Australian Standard for Risk Management (AS/NZ 4360:2004) documented as *Barrick Croydon Gold Mine - Mining Activities Risk Assessment.*	
(A3-2)	The environmental authority holder must not implement risk control measures that contravenes or prevents the implementation of any condition of this environmental authority.	✓					
(A3-3)	An emergency response/contingency plan must be developed and implemented within the current plan of operations to manage the high risk categories identified in the risk assessment.			✓		The current *Croydon Gold Mine Emergency Response/Contingency Plan* (within the current Plan of Operations2014-2017) operates according to the Barrick Croydon Gold Mine mining activities risk assessment.	Whilst overflow of the Content and Lady Isabella pits is still technically possible despite council extraction, associated risks are likely to be low to moderate; notwithstanding it is suggested that procedures for such an event are documented in the Emergency Response/Contingency Plan when it is next revised. It is also recommended that telemetry links with the water level sensors in these pits are re-established to enable timely sampling and observation of any pit discharges and flow conditions in Belmore creek.
Notification							
(A4-1)	The environmental authority holder must notify the administering authority by telephone or facsimile immediately after becoming aware of any emergency or incident resulting in, or having the potential to cause, environmental harm or any breach of condition of this environmental authority concerning releases of contaminants to the environment.	✓				Review of: DEHP notification of surface water trigger value exceedance (19 February 2016); exceedance caused by Croydon Shire Council water pipeline works that resulted in sediment discharge upstream of SW 2 monitoring site. DEHP response to February 2016 incident	
(A4-2)	The notification in condition (A4-1) must include the following:						
	(a) the environmental authority number and name of holder;	✓					
	(b) the name and telephone number of the designated contact person;	✓					
	(c) the location of the emergency or incident;	✓					
	(d) the date and time of the incident;	✓					

Schedule / Reference	Commitment/requirement	Compliance	Not Compliance	Opportunities for Improvement	Potential Non Compliance	Finding/Evidence	Recommendation/ Discussion
	(e) the time the holder of the environmental authority became aware of the incident;	✓					
	(f) the estimated quantity and type of any substances involved in the incident;	✓					
	(g) a description of the nature and effects of the incident including environmental harm caused, threatened, or suspected to be caused by the incident	✓					
	(h) any sampling conducted or proposed, relevant to the emergency or incident; and	✓					
	(i) immediate actions taken to prevent any further release and mitigate any environmental harm caused by the release.	✓					
(A4-3)	Within fourteen (14) days following the initial notification of an emergency or incident, further written advice must be provided to the administering authority, including the following:	✓				Reviewed Paperwork – January 2016 exceedance of surface water trigger values- Response to DERM dated 11 March 2016 and adequately addressed all notification requirements. No other notifications were noted.	
	(a) results and interpretation of all samples taken and analysed (if available, if not yet available nominate a timeframe);	✓					
	(b) outcomes of actions taken at the time to prevent or minimise environmental harm; and	✓					
	(c) proposed actions to prevent a recurrence of the emergency or incidence.	✓					
(A4-4)	As soon as practicable, but not more than six (6) weeks following the conduct of any environmental monitoring performed in relation to the emergency or incident, which results in the release of contaminants not in accordance, or reasonably expected to be not in accordance with the conditions of this environmental authority, written advice must be provided of the results of any such monitoring performed to the administering authority.	✓				Response to DERM dated 11 March 2016 and adequately addressed all notification requirements.	
Complaints							
(A5-1)	All records must be kept of all environmental complaints received about the mining activities including the following details:	✓				No Complaints have been received. Barrick complaints procedures are specified in the current Plan of Operations.	
	(a) name, address and contact number for complainant (if not available record - not identified);	✓					
	(b) time and date of complaint;	✓					
	(c) reasons for the complaint;	✓					
	(d) investigations undertaken;	✓					
	(e) conclusions formed;	✓					
	(f) actions taken to resolve complaint;	✓					
	(g) any abatement measures implemented; and	✓					
	(h) person responsible for resolving the complaint. This information must be made available for inspection by the administering authority on request.	✓					
(A5-2)	When requested by the administering authority, the environmental authority holder must undertake relevant specified monitoring within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint of environmental harm at any sensitive place or commercial place. The results of the investigation (including an analysis and interpretation of the monitoring results) and abatement measures	✓				Investigation procedures outlined in 2016 REMP. No further monitoring required by DEHP following the January 2016 surface water trigger value exceedance.	

Schedule / Reference	Commitment/requirement	Compliance	Not Compliance	Opportunities for Improvement	Potential Non Compliance	Finding/Evidence	Recommendation/ Discussion
	implemented must be provided to the administering authority within fourteen (14) days of completion of the investigation						
Third Party Auditing							
(A6-1)	Compliance with the conditions of this environmental authority must be audited by a suitably qualified third party auditor, nominated by the environmental authority holder and accepted by the administering authority once every two years.	✓				As per December 2016 – *Envirofin PL Environmental Compliance Audit Report*	
(A6-2)	The third party auditor must submit a final version of the auditors' report to the administering authority within twenty-eight (28) days of completing the audit.	✓					
(A6-3)	The third party auditor must certify the independent findings of the audit in the report.	✓					
(A6-4)	The financial cost of the third party audit is the responsibility of the holder of this environmental authority.	✓					
Financial Assurance							
(A7-1)	Prior to the commencement of mining activities under this environmental authority, the environmental authority holder must provide a financial assurance of an amount and in a form determined in accordance with the Queensland Environmental Protection Agency's Guideline Financial assurance for mining activities, as approved and requested by the administering authority.	✓				The Financial Assurance has been outlined in the *Croydon Gold Mine Plan of Operations – 2017-2017* Basis of Financial Assurance	
(A7-2)	The financial assurance must remain in force until the administering authority notifies the environmental authority holder that it is satisfied that no claim on the assurance will be required.	✓				Financial Assurance is in place	
Community							
(A8-1)	The holder of this environmental authority must establish, promote and maintain easily accessible lines of communication between residents and land owners to the satisfaction of the Administering Authority and provide evidence of this on an annual basis.	✓				Review of emails and letters sent to council concerning water quality/water supply activities. Review of W. Benko site inspection reports/ monthly reports to Barrick. W.Benko on site monthly W. Benko regular phone and email communications with landholders	It is recommended that a notice is placed on the council and community noticeboard nominating contact details for local Barrick representative.
Cultural Heritage							
(A9-1)	The holder of the environmental authority must develop and implement a Cultural Heritage Management Program covering European cultural heritage for all mining leases.	✓				NA. No items of Cultural Heritage significance remain on site (Jane Lennon and Assoc. March 2009)	
(A9-2)	The Cultural Heritage Management Program must be included in the Plan of Operations.	✓				Reviewed in *Barrick Croydon Gold Mine - Plan of Operations2014-2017*	
SCHEDULE B - AIR							
(B1-1)	The release of dust or any other airborne contaminant resulting from the mining activities must not cause environmental harm at any sensitive place or commercial place.	✓				No Mining activities are being conducted on site. No dust monitoring is being conducted onsite.	
(B1-2)	In the event of a complaint, the environmental authority holder must ensure that dust generated by the mining activities does not cause any of the following criteria at any sensitive place or commercial place to be exceeded:					NA No complaints received regarding dust.	
	(a) dust deposition of 120 milligrams per square meter per day, averaged over one month, when monitored in accordance with the most recent					NA No complaints received regarding dust.	

Schedule / Reference	Commitment/requirement	Compliance	Not Compliance	Opportunities for Improvement	Potential Non Compliance	Finding/Evidence	Recommendation/ Discussion
	version of Australian Standard AS 3580.10.1 Methods for sampling and analysis of ambient air - Determination of particulate matter - Deposited matter - Gravimetric method;						
	(b) total suspended particulates (TSP) of 130 micrograms per cubic metre expressed as an 24 hour average, when monitored in accordance with any method for measuring TSP recommended in the latest edition of the Environmental Protection Agency's Air Quality Sampling Manual;					NA No complaints received regarding dust.	
	(c) a concentration of particulate matter with an aerodynamic diameter of less than 10 micrometres (PM10) suspended in the atmosphere of 150 micrograms per cubic metre over a 24 hour averaging time, when monitored in accordance with the most recent version of Australian Standard AS 3580.9.6 Determination of suspended particulate matter - PM (sub) 10 high volume sampler with size-selective inlet - Gravimetric method;					NA No complaints received regarding dust.	
	(d) total suspended particulates (TSP) of 200 micrograms per cubic metre expressed as a one hour average, when monitored in accordance with any method for measuring TSP recommended in the latest edition of the Environmental Protection Agency's Air Quality Sampling Manual.					NA No complaints received regarding dust.	
(B1-3)	If monitoring indicates limits in condition (B1-2) have been exceeded and is attributable to the licensed activity, the environmental authority holder must implement dust abatement measures so that emissions of dust generated by the mining activities cease to exceed limits in condition (B1-2).					NA No complaints received regarding dust.	
SCHEDULE C - LAND							
(C1-1)	Land disturbed by mining activities must be rehabilitated in accordance with Schedule C – Table 1	✓				Review of Barrick Gold *(Vegetation Management Science*)report August 2016 provide descriptions consistent with post mine land classification criteria listed in Schedule C Table 1.	
(C1-2)	Drain the surface of the Content Waste Rock Dump to Content Pit, fill low-lying areas on the Content Waste Rock Dump and import additional growth medium to the Content Waste Rock Dump.	✓				No ponding was noticed upon the surface of the Content waste rock dump during 2014 audit following rain. Additional civil work on Content WRD noted in 2013 Rehabilitation Monitoring Report.	
(C1-3)	All waste rock dump slopes must be covered with a regrowth medium to support vegetation regrowth and limit erosion.	✓				Observation of acceptable ground cover upon both waste rock dump site supports the finding in the *Croydon Rehabilitation Assessment Report 2016* notwithstanding late dry season audit timing. Capping material observed on all waste rock dumps.	
Post Mine Land Use Plan							
(C2-1)	A Post Mine land Use Plan for the licensed place must be developed and implemented for a nominal period of:	✓				The Barrick Gold PMLP has been developed (updated in current Plan of Ops 2014-17) and implemented to date.	Refer recommendations in condition A2-4. 2014 PMLP reviewed by Barrick and deemed still current- reissue not required.
	(a) at least thirty (30) years following the cessation of mining activities on the licensed place; or					NA	
	(b) a shorter period if the licensed place is proven to be geo-technically and geo-chemically stable and it can be demonstrated to the satisfaction of the administering authority that no release of contaminants from the site will result in environmental harm and be prepared at least 18 months prior to cessation of mining activities on the licensed place.					NA	

Schedule / Reference	Commitment/requirement	Compliance	Not Compliance	Opportunities for Improvement	Potential Non Compliance	Finding/Evidence	Recommendation/ Discussion
(C2-2)	The Post Mine Land Use Plan must be included in the Plan of Operations and updated with each subsequent Plan of Operations, describing how the rehabilitation objectives in Schedule C – Table 1 will be achieved. The Post Mine Land Use Plan must include:	✓				Review of: • Plan of Operations (2014-2016) • PMLP (2016) for items a) to i) • WMP (2014- 2017) • Annual groundwater monitoring report (2016) • REMP (2016) • Croydon Mine Rehabilitation Assessment Report (2016)	Refer recommendations in condition A2-4.
	(a) schematic representation of final land form inclusive of drainage features; and	✓				2014 PMLP reviewed by Barrick and deemed still current- reissue not required. The 2014 PMLP states that a decision to install a drain at the toe of the Content waste rock dump to direct seepage to the pit is contingent on the outcome of further refinement of the Content Pit hydrological modelling. W. Benko noted that these works are no longer planned because: • testing of the "scald" adjacent to the western toe confirmed that it is not a scald but is imported fill material on which previous rehabilitation has failed; • Content pit water quality is fully compliant with the adopted stock water quality objective, therefore run off from the western batter is not causing offsite environmental harm; • Flat landform in the area would prevent construction of sufficient fall to allow drain to function	
	(b) slope designs; and	✓					
	(c) cover design including a report on the effectiveness of existing cover systems; and	✓					
	(d) drainage design; and			✓			
	(e) erosion controls on reformed land; and	✓					It is suggested that further attempts to revegetate the "scald" are made when conditions are favorable. It is recommended that the PLMP is amended to remove and clarify these undertakings.
	(f) description of experimental design for monitoring of analogue and rehabilitated areas inclusive of statistical design; and	✓					
	(g) proposed revegetation criteria including: (i) species diversity, abundance and composition, (ii) projective cover, (iii) dry matter production and (iv) stocking rates to ensure self-sustaining vegetation is maintained; and	✓					It is recommended that the currently proposed revegetation criteria be developed further into quantitative targets to facilitate assessment of final rehabilitation success.
	(h) proposed revegetation methods inclusive of plant species selection, re-profiling, respreading soil, soil ameliorants/amendments, surface preparation and method of propagation; and	✓					
	(i) materials balance including available top soil and low permeability encapsulation media for capping; and					NA Final rehabilitation earthworks completed	
	(j) research program and associated milestones.					NA No current Research programs University flume study apparatus noted onsite to determine content pit overflow loadings.	
	(k) geotechnical, geochemical and hydrological studies;	✓				Also review of: • PMLP (2016) • WMP (2014- 2017) • Annual groundwater monitoring report (2016) • REMP (2016)	
	(l) chemical, physical and biological properties of soil and water;	✓					
	(m)measurable completion criteria for each rehabilitation indicator that enables determination of rehabilitation success for each disturbance type; and			✓			Quantitative targets are available for surface and groundwater and sediment but not for a number of other success criteria such as vegetation floristics, erosional stability, post mine land use capability, physical, chemical and biological soil properties

Schedule / Reference	Commitment/requirement	Compliance	Not Compliance	Opportunities for Improvement	Potential Non Compliance	Finding/Evidence	Recommendation/ Discussion
	(n) rehabilitation monitoring program, including the monitoring of: i. surface water quality; ii. groundwater quality; iii. erosion rates; iv. integrity and effectiveness of final cover of final cover systems; and v. health and resilience of vegetative cover	✓				Also review of: • Annual groundwater monitoring report (2016) • Croydon Gold Mine Rehabilitation Assessment (2016)	
	(o) grazing management plan, and;.	✓				Review of Barrick Gold –Grazing Management Plan 2014-2017.	
	(p) Operation and maintenance of: i. the surface water management system; ii. groundwater monitoring network; iii. final cover systems; and iv. vegetative cover	✓				Also review of: • PMLP (2016) • WMP (2014- 2017) • Annual groundwater monitoring report (2016) • REMP (2016) • Croydon Gold Mine Rehabilitation Assessment (2016)	
Rehabilitation Monitoring Program							
(C3-1)	The holder of the environmental authority must conduct a Rehabilitation Monitoring Program on at least a yearly basis, which must include sufficient spatial and temporal replication to enable scientifically justifiable conclusions as established under the rehabilitation program or other methodology to the satisfaction of the Administering Authority.	✓				Review *of:* • Croydon Gold Mine Rehabilitation Monitoring Program November 2014 • Croydon Gold Mine Rehabilitation Assessment (2016)	Based on the outcome of the last three years of rehabilitation monitoring, it is recommended that Barrick initiate the development of quantifiable targets for all rehabilitation success criteria including those identified in C2-2 (m)
(C3-2)	The rehabilitation monitoring program must be developed by 1 October 2008 and be implemented by a person nominated by the environmental authority holder possessing appropriate qualifications and experience in the field of rehabilitation management.	✓					
(C3-3)	Verification of rehabilitation success is to be determined by comparison with the criteria documented in the Post Mine Land Use Plan required under Condition C2-1.	✓					Based on the outcome of the last three years of rehabilitation monitoring, it is recommended that Barrick initiate the development of quantifiable targets for all rehabilitation success criteria including those identified in C2-2 (m)
Infrastructure							
(C4-1)	All infrastructure, mining equipment and plant erected and/or used for the mining activities must be removed from the licensed place prior to surrender, except where agreed in writing by the administering authority, landowner and the Minister administering the *Mineral Resources Act 1989.*	✓				All infrastructure, mining equipment and plant erected and/or used for the mining activities has been removed from the licensed place.	
Residual Voids							
(C5-1)	Residual voids, or the contents of residual voids, must not cause any environmental harm other than the environmental harm caused within the footprint of the residual void itself.	✓				The aquatic monitoring undertaken by FRC (2011) did not indicate any significant downstream impacts following a discharge event. Council is taking water from the Lady Isabella pit which will significantly reduce the risk of pit discharge in the vent of sequential extreme rain events. The Content pit is an approved discharge location; pit water quality meets stock water standards and discharge would occur when receiving waters flows are seasonally enhanced.	Preliminary hydrological model and subsequent groundwater monitoring has confirmed that the voids are groundwater sinks not sources so off site impacts would be minimal or limited.
Chemicals and Flammable or Combustible Liquids							
(C6-1)	All explosives, hazardous chemicals, corrosive substances, toxic substances, gases and dangerous goods must be stored and handled in					NA No Chemical storage on-site.	

Schedule / Reference	Commitment/requirement	Compliance	Not Compliance	Opportunities for Improvement	Potential Non Compliance	Finding/Evidence	Recommendation/ Discussion
	accordance with the relevant Australian Standard.						
(C6-2)	Flammable and combustible liquids, including petroleum products and associated piping and infrastructure, must be stored and handled in accordance with the latest edition of Australian Standard 1940 – The Storage and Handling of Flammable and Combustible Liquids.						
(C6-3)	Any chemicals and flammable or combustible liquids stored on the licensed place that have the potential to cause environmental harm must be stored in or serviced by an effective containment system that is impervious to the materials stored and managed to prevent the release of liquids to waters or land. Where no relevant Australian Standard is available, the following must be applied:						
	(a) storage tanks must be bunded so that the capacity and construction of the bund is sufficient to contain at least 110% of a single storage tank or 100% of the largest storage tank plus 10% of the second largest storage tank in multiple storage areas; and						
	(b) drum storages must be bunded so that the capacity and construction of the bund is sufficient to contain at least 25% of the maximum design storage volume within the bund.						
(C6-4)	All containment systems for chemicals and flammable or combustible liquids must be designed to minimise rainfall collection within the system.						
Contaminated Land							
(C7-1)	Undertake a contaminated land assessment / investigation of the licensed place in accordance with the EPA Guidelines for the Assessment & Management of Contaminated Land in Queensland.	✓				Cited HLA – Envirosciences - *Site investigation and Geochemical Assessment* -10 Sept 2002 for Aurion Gold in accordance with the EPA Guidelines for the Assessment & Management of Contaminated Land in Queensland	
SCHEDULE D – WASTE							
General Waste Disposal							
(D1-1)	The environmental authority holder shall not cause, allow or permit any waste generated outside the mine to be received at the mine for storage, treatment, processing or disposal.	✓				No stored wastes observed on site.	
Off Site Movement of Regulated Wastes							
(D2-1)	Where regulated waste is removed from the licensed place (other than by a release as permitted under another schedule of this environmental authority), the holder of this environmental authority must ensure that:					NA No off site movement of regulated wastes noted or planned.	
	(a) the removal and transport of such wastes, where it constitutes an environmentally relevant activity under the Environmental Protection Regulation 1998, is carried out by a person licensed for carrying out this activity under the Environmental Protection Act 1994; and						
	(b) records are kept of the following: (i) the date, quantity and type of waste removed; and (ii) name of the regulated waste transporters that removed the waste; and (iii) the intended treatment/disposal destination of the waste. Note: Records of documents maintained in compliance with a waste tracking system established under the Environmental Protection Act 1994 or any other law for regulated waste will be deemed to satisfy this environmental authority condition.						

Schedule / Reference	Commitment/requirement	Compliance	Not Compliance	Opportunities for Improvement	Potential Non Compliance	Finding/Evidence	Recommendation/ Discussion
Notification of Improper Disposal of Regulated Waste							
(D3-1)	If the holder of this environmental authority becomes aware that a person has removed regulated waste from the licensed place and disposed of the regulated waste in a manner which is not authorised by this environmental authority or improper or unlawful, then the holder of this environmental authority must, as soon as practicable, notify the administering authority of all relevant facts, matters and circumstances known concerning the disposal.					NA No regulated waste noted onsite.	
(D3-2)	Regulated waste generated by maintenance of plant and equipment and absorbent materials used to clean up spills must only be disposed of at a facility whose operator is permitted to accept such waste in accordance with the requirements of the Environmental Protection Act 1994.						
SCHEDULE E – NOISE AND VIBRATION							
(E1-1)	Noise from the mining activity must not cause environmental harm at any sensitive place or commercial place.	✓				No Noise complaints. Reduced likelihood of noise occurrence due to mine closure.	
(E1-2)	In the event of a complaint made to the administering authority (which is neither frivolous or vexatious) about noise generated in carrying out the licensed activity, and the noise is considered by the administering authority to be an unreasonable noise, the holder of this Environmental Authority must take action to ensure that it is no longer an unreasonable noise.					NA	
SCHEDULE F – WATER							
General							
(F1-1)	Contaminant that will, or have the potential to cause environmental harm, must not be released directly or indirectly to any water except as permitted under the conditions of this EA				✓	Review of: • Water Management Plan (2016) • Annual Groundwater Monitoring Report (2014-2017) • Receiving Environmental Monitoring Program (2016) • February 2016 EA Exceedance Report Review of DEHP incident close out response to February 2016 incident.	Content and Lady Isabella pits are the only pits that could overflow in the future. Both have improving water quality (min stock water quality). Pumping of Content Pit to increase freeboard was undertaken in 2010 to increase capacity for pending wet season rains. Improved quality of Lady Isabella pit waters will allow level reduction through DEHP agreed use by Council for road construction/ dust suppression. Environmental harm from discharge is considered unlikely. No off-site releases from any pits have occurred since 2011. DEHP notification of surface water trigger value exceedance in (19 February 2016); exceedance caused by Croydon Shire Council water pipeline works that resulted in sedimentation discharge upstream of SW 2 monitoring site. It is noted that routine sampling was taken in a stagnant pool which is unlikely to have been representative of any site discharge. In the event that the discharge was representative, exceedance of some parameter contaminant limits by trigger values would indicate environmental harm was unlikely.
(F1-2)	The release of contaminants directly or indirectly to waters must not:						
	(a) produce any visible discoloration of receiving waters; or				✓	Refer F1-1	
	(b) produce any slick or other visible or odorous evidence of oil, grease or petrochemicals nor contain visible floating oil, grease, scum, litter or other objectionable matter.	✓				W.Benko pers comm. There have been no pit discharges observed since the 2011 event identified in discussion of F1-1 above.	
(F1-3)	All determinations of water quality must be:	✓				Review of: • Water Management Plan (2016) • Annual Groundwater Monitoring Report (2014-2017)	
	(a) performed by a person or body possessing appropriate experience and qualifications to perform the required measurements;	✓					
	(b) made in accordance with methods prescribed in the latest edition of the	✓					

Schedule / Reference	Commitment/requirement	Compliance	Not Compliance	Opportunities for Improvement	Potential Non Compliance	Finding/Evidence	Recommendation/ Discussion
	Administering Authority's monitoring and sampling manual;					• Receiving Environmental Monitoring Program (2016)	
	(c) collected from the monitoring locations identified within this environmental authority, within 2 hours of each other (reference/downstream) where possible;	✓					
	(d) carried out on representative samples; and,	✓					
	(e) laboratory testing must be undertaken using a laboratory accredited (e.g. NATA) for the method of analysis being used.	✓					
(F1-4)	The following information must be recorded in relation to all water monitoring required under the conditions of this environmental authority and submitted to the administering authority in the specified format when requested:	✓				Review of: • Water Management Plan (2016) • Annual Groundwater Monitoring Report (2014-2017) • Receiving Environmental Monitoring Program (2016) Flow monitoring flume in place at Content Pit overflow point.	
	(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;	✓					
	(d) the measured or estimated daily quantity of the contaminants released from all release points;	✓					
	(e) the release flow rate at the time of sampling for each release point;	✓					
	(f) the results of all monitoring and details of any exceedances with the conditions of this environmental authority; and	✓					
	(g) water quality monitoring data must be provided to the administering authority in the specified electronic format upon request.	✓				Annual Groundwater Monitoring Report (2016) 2016 EA amendment Application report REMP (2016)	
Contaminant Release to Waters							
(F2-1)	The release of contaminants to waters must only occur from the release points specified in Schedule F – Table 1 (Contaminant Release Points) and depicted in Schedule H – Map 3 (Location of Monitoring sites on Belmore Creek).		✓			Refer condition discussion F1-1 No pit discharges observed since 2014 audit	
(F2-2)	The release of contaminants to waters from the release points must be monitored at the locations specified in Schedule F – Table 1 (Contaminated Release Points) for each quality characteristic and a the monitoring frequency specified in Schedule F – Table 2 (Contaminant Release Limits).	✓				No pit discharges observed since 2014 audit	
(F2-3)	The release of contaminant to waters must not exceed the contaminant release limits stated in Schedule F – Table 2 (Contaminant Release Limits) for each quality characteristic.				✓	No pit discharges observed since 2014 audit It is noted that DEHP have not prevented Croydon Shire Council taking water from Golden Butterfly North and Lady Isabella Pits for the purposes of town water and road construction/dust suppression.	
Stream Flow Monitoring							
(F3-1)	The holder of this environmental authority must install, operate and maintain a stream flow gauging station to determine and record stream flows at the locations upstream of each release point as specified in Schedule F – Table 1 (Contaminant Release Points) for any receiving water into which a release occurs.	✓				Gauge board observed in place on Belmore Creek. Survey of Belmore Creek cross section completed.	
(F3-2)	At the time of release the water flow volume in the respective receiving water must be at least twenty (20) times the volume at which respective mine affected waters are released.					NA	

Schedule / Reference	Commitment/requirement	Compliance	Not Compliance	Opportunities for Improvement	Potential Non Compliance	Finding/Evidence	Recommendation/ Discussion
Receiving Environment Monitoring and Contaminant Trigger Levels							
(F4-1)	Receiving waters must be monitored at the locations and frequencies defined in Schedule F – Table 3 (Receiving Water Monitoring Locations and Frequency), Schedule H – Map 2 (Surface Water, Sediment and Groundwater Monitoring Sites) and Map 3 (Location of Monitoring Sites on Belmore Creek) and comply with the trigger and contaminant limits defined in Schedule F – Table 4 (Receiving Water Trigger and Contaminant Limits)				✓	Review of: Water Management Strategy 2016 Annual Groundwater Monitoring Report 2016 Receiving Environmental Monitoring Program 2016 REMP (2016) February 2016 exceedance Incident report No pit discharges observed since 2014 audit	Refer to discussion at F1-1 The current EA (2014) contains a number of anomalies which can result in contaminant limits for some parameters being exceeded by trigger levels which could make compliance with this condition not possible during the 2016/2017 wet season. In response to the incident notification report(January 2016) it is noted that DEHP requested submission of an EA amendment request to correct these anomalies
(F4-2)	If quality characteristics of the receiving water at the downstream monitoring points identified in Schedule F – Table 3 exceed any of the trigger levels specified in Schedule F – Table 4 the holder of this environmental authority must compare the downstream results to the reference site results in the receiving waters and:	✓				Review of: Water Management Strategy 2016 Annual Groundwater Monitoring Report 2016 Receiving Environmental Monitoring Program 2016 February 2016 Exceedance Incident report	Refer F4-1 discussion
	(a) where the downstream result is the same or a lower level value than the reference site value for the quality characteristic during the same sampling event then no action is to be taken; or	✓				No pit discharges observed since 2014 audit	
	(b) where the downstream results exceed the reference site complete an investigation in accordance with the ANZECC & ARMCANZ 2000 methodology, into the potential for environmental harm and provide a written report to the administering authority within 3 months outlining: i. details of the investigations carried out; ii. details of the environmental impacts observed; and iii. actions taken to prevent environmental harm. Note: where an exceedance of a trigger level has occurred and is being investigated, in accordance with (F4-2)(b) of this condition, no further reporting is required for subsequent trigger events for that quality characteristic during the reporting period.	✓					
(F4-3)	The release of contaminants to waters must not exceed the contaminant release limits stated in Schedule F – Table 4 (Receiving Water Trigger and Contaminant Limits) for each quality characteristic.	✓				No pit discharges observed since 2014 audit	
Stream Sediment Contaminant Levels							
(F5-1)	Sediment quality of receiving waters and reference waters must be monitored at the monitoring locations and frequency defined in Schedule F – Table 5 (Receiving Water Monitoring Locations) and identified on Schedule H – Map 2 (Surface Water, Sediment and Groundwater Monitoring Sites) and Map 3 (Location of Monitoring Sites on Belmore Creek) for the parameters defined in Schedule F – Table 6 (Stream Sediment Trigger and Contaminant Levels).	✓				Review of Receiving Environmental Monitoring Program (2016)	.
(F5-2)	If the bed of the receiving water exceed any of the trigger levels specified in Schedule C – Table 6 (Stream Sediment Trigger and Contaminant Levels), the holder of this environmental authority must compare the results of the downstream site to the data from reference monitoring sites and:	✓				Review of Receiving Environmental Monitoring Program (2016)	
	(a) if the level of contaminants at the downstream site does not exceed the reference monitoring site data, then no action is to be taken; or	✓					

Schedule / Reference	Commitment/requirement	Compliance	Not Compliance	Opportunities for Improvement	Potential Non Compliance	Finding/Evidence	Recommendation/ Discussion
	(b) if the level of contaminants at the downstream site is greater than the reference monitoring site data, complete an investigation in accordance with the ANZECC & ARMCANZ 2000 methodology, into the potential form environmental harm and provide a written report to the administering authority within three (3) months, outlining: i. details of the investigations carried out; ii. details of the environmental impacts observed; and iii. actions taken to prevent environmental harm. Note: where an exceedance of a trigger level has occurred, and is being investigated, in accordance with F5-2(b) of this condition, no further reporting is required for subsequent trigger events for that quality characteristic during the reporting period.	✓				Review of Receiving Environmental Monitoring Program (2016)	
(F5-3)	Releases of contaminants must not result in an exceedance of sediment contaminant limits stated in Schedule F – Table 6 (Stream Sediment Trigger and Contaminant Levels).	✓				Review of Receiving Environmental Monitoring Program (2016)	
(F5-4)	All stream sediment sampling must be undertaken in accordance with the most recent version of Australian Standard AD 5667.12 Guidance on Sampling of Bottom Sediments of 1998.	✓				Review of Receiving Environmental Monitoring Program (2016)	
Onsite Water Storages							
(F6-1)	Water storages stated in Schedule F – Table 7 (Water Storage Monitoring) must be monitored for the water quality characteristics specified in Schedule F – Table 8 (Onsite Water Storage Contaminant Limits).	✓				Review of Receiving Environmental Monitoring Program (2016) Fencing in place	
(F6-2)	In the event that waters defined in Schedule F – Table 7 exceed the contaminant limits defined in Schedule F – Table 8, the holder of the environmental authority must implement measures to prevent access to waters by all livestock and minimize access by native fauna.	✓				Review of Receiving Environmental Monitoring Program (2016) Fencing in place	
Groundwater							
(F7-1)	Groundwaters must be monitored at the locations and frequencies defined in Schedule F – Table 9 & Schedule H – Map 2 for parameters identified in Schedule F – Table 10.	✓				Review of: Water Management Plan (2016) Annual Groundwater Monitoring Report (2016) Receiving Environmental Monitoring Program(2016)	
(F7-2)	If groundwaters from compliance bores identified in Schedule F – Table 9 exceed any of the trigger levels stated in Schedule F – Table 10, the environmental authority holder must complete an investigation in accordance with the ANZECC (2000) methodology, into the potential for environmental harm, and provide a written report to the administering authority within 3 months of the date of the original exceedance, outlining: i. details of the investigations carried out; and ii. actions taken to prevent environmental harm. Note: a period of greater than 3 months may be approved if authorised by the administering authority.				✓	Review of *Groundwater Monitoring Report 2013 and 2016* indicates that observed trigger exceedances are unlikely to result in environmental harm and are as a result of localised hydrogeochemical variability, not from migration of pit waters- studies have confirmed that all pits are operating predominantly as groundwater sinks thereby preventing extensive off lease impacts on groundwater quality. Content and Lady Isabella pit waters have been lime treated resulting in improvement of pit water quality to ANZECC stock water quality.	In light of the difficulty in obtaining suitable representative background groundwater sites because of complex geological conditions and improbability of overflow of Golden Butterfly and Golden Butterfly North pits, it is understood that Barrick have lodged an EA amendment request which amongst other matters, requests a more site specific approach and reduction in breadth of analytes, based on a large data set and consistently low and non-detectable concentrations. The current EA creates ongoing trigger exceedances requiring formal investigations, whereas environmental harm is not likely to be occurring.

Schedule / Reference	Commitment/requirement	Compliance	Not Compliance	Opportunities for Improvement	Potential Non Compliance	Finding/Evidence	Recommendation/ Discussion
(F7-3)	Groundwaters from bores identified in Schedule F – Table 9, must not exceed any of the limits defined in Schedule F – Table 11.				✓	A review of Barrick Australia – Croydon Gold Mine Annual groundwater monitoring report (Nov 2016) noted elevated Fluoride, Sulphates and pH outside limits recorded within groundwater bores inside mining lease boundaries, however these exceedances are unlikely to result in environmental harm and are as a result of localised complex hydrogeochemical conditions, not from migration of pit waters- studies have confirmed that all pits are operating predominantly as groundwater sinks thereby preventing extensive off lease impacts on groundwater quality (and potentially surface water)	Refer discussion in F7-2
(F7-4)	Annual groundwater monitoring reports analysing groundwater chemistry and hydrogeological status of all groundwater bores and groundwater conditions are to be prepared by November each year as an element of the water management strategy review.	✓				Review of Groundwater Monitoring Report (2016)	Prepared in July as data was utilized in the August 2016 EA amendment application.
(F7-5)	Construct additional monitoring bores BH10, BH11 & BH12 to the west of the Content Waste Rock Dump and BH8 & BH9 between the Golden Butterfly North Pit and the Golden Butterfly Waste Rock Dump and SY1 on Slaughteryard Creek.	✓				Review of Groundwater Monitoring Report (2016)	
(F7-6)	Before 30 June 2009 conduct additional investigations / monitoring to confirm the conceptual licensed place hydro-geological model including:	✓				Review of: Groundwater Monitoring Report (2016) REMP (2016) Site observations	
	(a) obtaining additional hydro-geological information (e.g. geological information, bore and pit water levels).	✓					
	(b) compile and analyse existing groundwater quality data from the town water supply bores.	✓					
	(c) installing an additional deep monitoring bore (SY1) between the Golden Butterfly Pit and Slaughteryard Creek to supplement the existing monitoring network.	✓					
	(d) surveying of pit lake water levels and erection of water level gauging stages.	✓					
	(e) investigate the state of equilibrium of pit water levels.	✓					
	(f) include the latest information obtained from the additional hydro-geological investigations / monitoring in subsequent amendments to the Croydon Gold Mine EMPlan.	✓					
	(g) Conduct a bore census of the area surrounding the licensed place.	✓					
Stormwater							
(F 8-1)	An erosion and sediment control plan must be developed and implemented for the activities on the licensed place which has been certified by a Certified Professional in Sediment and Erosion Control (CPESC), or a professional with appropriate experience and / or qualifications accepted by the Administering Authority and be included in the Plan of Operations.	✓				ESCP Plan included in *Plan of Operation 2011-2014 .* Post Mine Landuse Plan Nov (2016)	
(F8-2)	Erosion protection measures and sediment control measures must be implemented and maintained to minimise erosion and the release of sediment and contamination of storm water.	✓				ESCP Plan included in *Plan of Operation 2011-2014 .* Post Mine Landuse Plan Nov (2016) No areas of accelerating erosion observed on site. Good groundcover observed on rehabilitated landforms on site	

Schedule / Reference	Commitment/requirement	Compliance	Not Compliance	Opportunities for Improvement	Potential Non Compliance	Finding/Evidence	Recommendation/ Discussion
Acid Rock Drainage and Leachate management							
(F9-1)	All reasonable and practicable measures must be implemented to prevent hazardous leachate being directly or indirectly released or likely to be released as a result of the activity to any groundwater or water course.	✓				Ongoing monitoring is occurring and follow up actions as deemed necessary have been implemented, including water treatment	
Water Management Strategy							
(F10-1)	A water management strategy must be prepared for inclusion in the Plan of Operations. The strategy will include: (a) Data collation and identify existing data requirements (b) Design and detail additional works as required (c) Implement / construct additional works	✓				A Water Management Strategy, November 2014 has been prepared and included in the revised *Barrick* Croydon Gold Mine Plan of Operations Nov 2014- Nov 2017 (inclusive of EA amendments).	
(F10-2)	An annual review of the water management strategy must be submitted by November each year.	✓				Water Management Strategy Nov 2014; Barrick Croydon Gold Mine Annual groundwater monitoring report 2016 sited	
(F11-1)	The environmental authority holder must develop and implement a Receiving Environment Monitoring Program (REMP) to monitor, identify and describe any adverse impacts to surface water environmental values, quality and flows due to the authorized mining activity. This must include monitoring the effects of the mine on the receiving environment periodically (under natural flow conditions) and while mine affected water is being discharged from the site. For the purposes of the REMP, the receiving environment is the waters of the Belmore Creek and connected or surrounding waterways within 10 km downstream of the release. The REMP should encompass any sensitive receiving waters or environmental values downstream of the authorized mining activity that will potentially be directly affected by an authorized release of mine affected water.	✓				Review of Receiving Environmental Monitoring Program 2016 (Rev01)	Refer discussions in F1-1, F4-1 and F7-2

Schedule / Reference	Commitment/requirement	Compliance	Not Compliance	Opportunities for Improvement	Potential Non Compliance	Finding/Evidence	Recommendation/ Discussion
(F11-2)	The REMP must: (a) Assess the condition or state of receiving waters, including upstream conditions, spatially within the REMP area, considering background water quality characteristics based on accurate and reliable monitoring data that takes into consideration temporal variation (e.g. seasonality); and (b) Be designed to facilitate assessment against water quality objectives for the relevant environmental values that need to be protected; and (c) Include monitoring from background reference sites (e.g. upstream or background) and downstream sites from the release (as a minimum, the locations specified in Schedule F – Table 3); and (d) Specify the frequency and timing of sampling required in order to reliably assess ambient conditions and to provide sufficient data to derive site specific background reference values in accordance with the *Queensland Water Quality Guidelines* 2006. This should include monitoring during periods of natural flow irrespective of mine or other discharges; and (e) Include monitoring and assessment of all water quality parameters listed in Schedule F – Table 2; and (f) Include, where appropriate, monitoring of metals/metalloids in sediments (in accordance with ANZECC & ARMCANZ 2000, BATLEY and/or the most recent version of AS5667.1 *Guidance on Sampling of Bottom Sediments)*; and (g) Include, where appropriate, monitoring of macroinvertebrates in accordance with the AusRivas methodology; and (h) Apply procedures and/or guidelines from ANZECC & ARMCANZ 2000 and other relevant guideline documents; and (i) Describe sampling and analysis methods and quality assurance and control; and (j) Incorporate stream flow and hydrological information in the interpretations of water quality and biological data.	✓					Refer discussions in F1-1, F4-1 and F7-2
(F11-3)	A report outlining the findings of the REMP, including all monitoring results and interpretations in accordance with conditions F11-1 and F11-2 must be prepared annually and made available on request to the administering authority. This must include an assessment of background reference water quality, the condition of downstream water quality compared against water quality objectives, and the suitability of current discharge limits to protect downstream environmental values.	✓					Refer discussions in F1-1, F4-1 and F7-2
Other observations/Notes :							

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