Appendix Fs

Codrilla Groundwater Assessment – Addendum Report

Australasian Groundwater & Environmental Consultants Pty Ltd

ADDENDUM REPORT on

REVISED MINE PLAN AND NUMERICAL MODELLING RERUN

CODRILLA COAL PROJECT

prepared for
BOWEN BASIN COAL JOINT VENTURE

Project No. G1471/A
April 2011

ABN:64 080 238 642

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ADDENDUM REPORT ON

REVISED MINE PLAN AND NUMERICAL MODELLING RERUN

CODRILLA COAL PROJECT

1.0 INTRODUCTION

This follow-up report is an Addendum to the report prepared by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) for the Codrilla Coal Project Environmental Impact Assessment titled:

- *"Codrilla Coal Project – Groundwater Impact Assessment"*, Project No. G1471, dated July 2010.

This Addendum addresses the following modification to the proposed mine plan:

- The mine schedule has been reversed to run from east to west as against that previously assessed from west to east over a similar time period and life of mine.

This Addendum should be read in conjunction with the above mentioned report.

2.0 AMENDMENT TO THE CODRILLA PROJECT MINE PLAN

The revised mining plan proposes for mining commencing at the eastern end of the East Pit in 2013, with a generally westerly direction progression to the floor of the Upper Vermont Seam. The project is scheduled for completion after 14 years, in 2026. The revised mine plan and timing used in this addendum assessment provides for mining:

- commencing at the eastern end of East Pit and progressing westwards over a 11-year period between 2013 and 2023; and
- then restarting at the western end of West Pit and progressing eastwards over a five-year period between 2022 and 2026.

3.0 REVISED NUMERICAL GROUNDWATER MODEL

The revised mine plan has required a revision of the numerical model to incorporate the change in mining progression with the aim being to compare the predicted impact on groundwater levels both adjacent to the mine area and regionally as a result of the two mine progression options.

3.1 Modelling Objectives

The overall objective of the numerical modelling was to simulate the impact of the revised Codrilla Mine open cut operations on the hydrogeological regime of the area and in particular to undertake predictive modelling in order to:

- assess the potential groundwater inflow volumes to the open cut pits over the life of the mine;
- predict the zone of influence of dewatering and the level and rate of drawdown at specific locations as a result of the inflows to the mine;
- identify areas of potential risk where groundwater impact mitigation/control measures may be necessary; and
- the rate of groundwater recovery and long term impacts occurring on cessation of mining.

3.2 Model Code Selection

The numerical simulation of groundwater flow in the aquifers was undertaken using the MODFLOW SURFACT code (Hydrogeologic, 1997[1] – hereafter referred to as SURFACT), which is a commercial derivative of the standard MODFLOW code.

3.3 Modelling Strategy

This revised numerical model has utilised the original numerical modelling that was developed by:

- creating the model structure that resembles the regional geological structure incorporating the mine area and surrounds by simulating this geometry as separate model layers and applying appropriate hydraulic (aquifer) parameters and boundary conditions representative of the real environment; and
- calibrating the model to steady state conditions, that is to currently observed groundwater conditions that are known to exist within the project area.

Whilst this revision of the numerical model has been based on the original calibrated steady state model, the predictive transient modelling was undertaken to assess:

- impact of operation of the mine for a period of 14 years from 2013 to 2026 in accordance with the revised mine plan; and
- long-term recovery of the water levels in the final mine voids for the East and West Pit voids.

The extent of the model is shown in Drawing No. 6A.

[1] Hydrogeologic, (1997), MODFLOW SURFACT (Version 3.0), Software Code Documentation, Herndon, Virginia, USA, Hydrogeologic Inc.

3.3.1 Model Geometry and Boundary Conditions

The model geometry remains unchanged with 7 layers and surface elevations as was used previously. The three-dimensional view of the model domain and layers shown in Figure 1 below illustrates the geological layers in the model.

Boundary conditions also remain unchanged with details for each described below.

An active "flow" boundary as:

- a constant head boundary applied across the south-eastern edge of the model.

Three inactive or "no flow" boundaries along the:

- south-western boundary coincident with the concealed fault alignment;
- coal seam sub-crop alignments that mark the northern and eastern boundaries;
- north-west corner of the model that is considered beyond the influence of the proposed Codrilla Mine open pits; and
- the base of Layer 7 in the model.

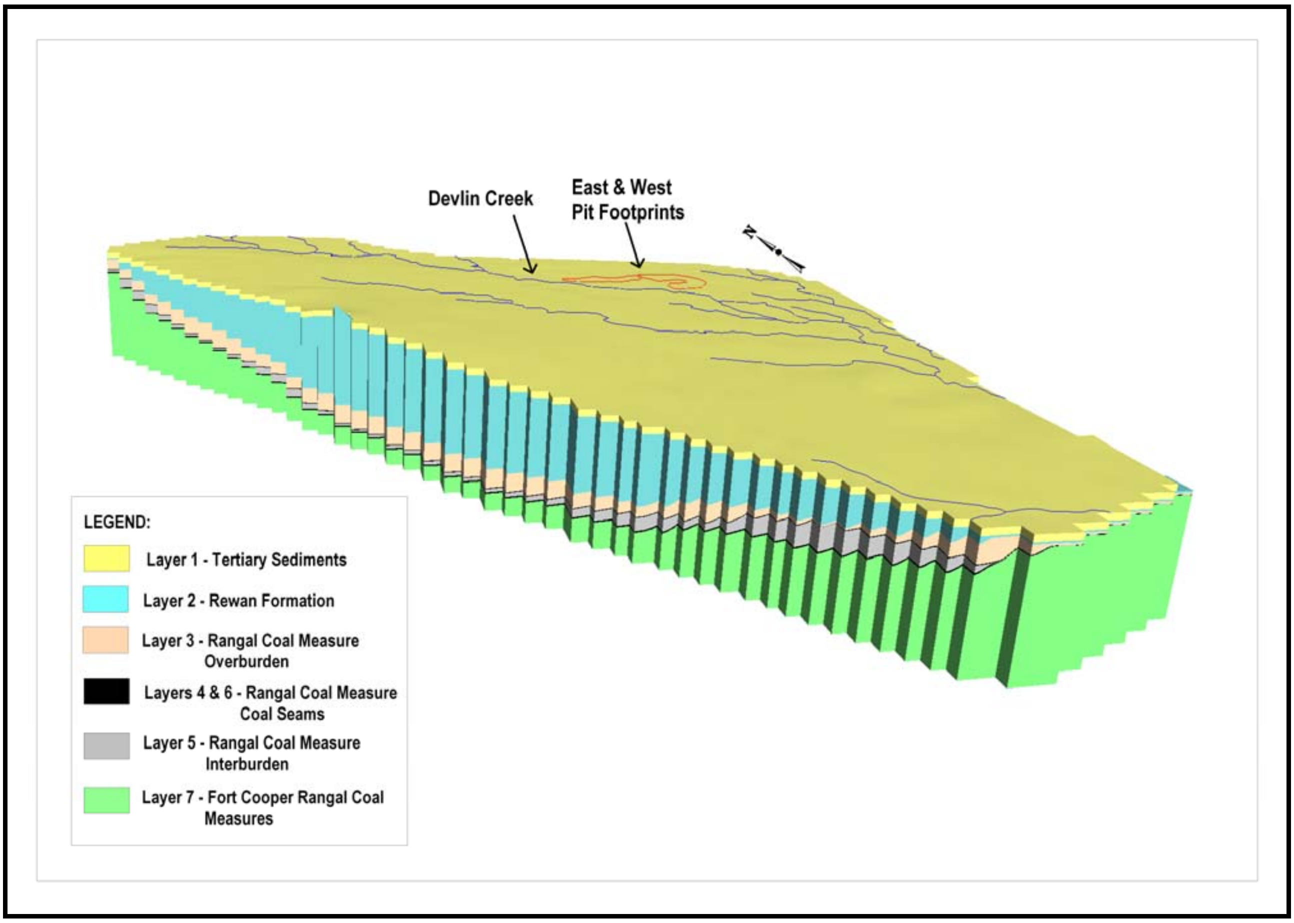


Figure 1: 3D Representation of Model Domain looking from South-west to North-east

3.3.2 Hydraulic Parameters

The values for all hydraulic parameters used in the current model remain unchanged from the original model and are presented below in Table 1.

Table 1: HYDRAULIC PARAMETERS

Layer	Parameter	Value
Layer 1 (Tertiary Sediments)	Horizontal Hydraulic Conductivity [kh]	Tertiary zone 0.05 m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	Tertiary zone 0.05
	Specific Storage [S_s]	soil zone 5×10^{-4}
Layer 2 (Triassic Rewan Formation)	Horizontal Hydraulic Conductivity [kh] based on Transmissivity relationship	Transmissivity 0.5m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	1×10^{-3}
	Specific Storage [S_s]	1×10^{-5}
Layer 3 (Permian Rangal Coal Measures overburden above the upper most coal seam)	Horizontal Hydraulic Conductivity [kh] based on Transmissivity relationship	Transmissivity 0.5m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	1×10^{-3}
	Specific Storage [S_s]	1×10^{-5}
Layer 4 (Lower Leichhardt 2 Coal Seam – upper most coal seam)	Horizontal Hydraulic Conductivity [kh]	0.05m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	5×10^{-3}
	Specific Storage [S_s]	1×10^{-4}
Layer 5 (Permian Rangal Coal Measures interburden between the upper and lower most coal seams	Horizontal Hydraulic Conductivity [kh] based on Transmissivity relationship	Transmissivity 0.2m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	1×10^{-3}
	Specific Storage [S_s]	1×10^{-5}
Layer 6 (Upper Vermont Coal Seam – lower most coal seam)	Horizontal Hydraulic Conductivity [kh]	0.05m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	5×10^{-3}
	Specific Storage [S_s]	1×10^{-4}
Layers 7 (Fort Cooper Coal Measures, base of model)	Horizontal Hydraulic Conductivity [kh]	0.001m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	1×10^{-4}
	Specific Storage [S_s]	1×10^{-6}

3.3.3 Recharge and Discharge

Rainfall sourced recharge was applied to the topographic surface of the uppermost layer (Layer 1) in the model. The recharge was applied at a constant rate, with no adjustment for seasonality. Bureau of Meteorology data collected at the Moranbah Water Treatment Plant over the 37-year period 1972 to 2009 shows:

- an average annual rainfall of 587.9mm/yr, or 1.61mm/day; and
- a mean daily evaporation of 6.4mm/day (0.0064m/day).

Discharge was modelled using the SURFACT Drain (DRN) package by assigning drain cells in Layer 1 only coincident with the creek alignments, and in Layers 1 to 6 to represent water abstraction from the East and West Pits during mining.

3.4 Steady State Calibration

Steady state calibration of the groundwater flow model to observed steady state water levels was undertaken in the previous model for Codrilla with the two parameters required for calibration being were hydraulic conductivity and recharge. A model wide recharge rate of 2.011×10^{-7} m/day (equivalent to 0.0125% of the average annual rainfall) was used to represent the pattern of groundwater contours and direction of groundwater flow under steady state conditions that generally matched those measured in the monitoring bores. This recharge rate was only applied to Layer 1. The steady state simulated pre-mining groundwater levels are shown in Drawing No. 7A.

4.0 PREDICTIVE SIMULATIONS

4.1 Transient Modelling – Mining Phase

The revised mining plan proposes for mining commencing at the eastern end of the East Pit in 2013, with a generally westerly direction progression to the floor of the Upper Vermont Seam. The project is scheduled for completion after 14 years, in 2026. The mine plan and timing used in the impact assessment is presented on Drawing No. 8A.

Conversion of the calibrated steady state model to transient flow conditions for the predictive mining scenario required the transient model to be set up with 56 stress periods, each of 91.3 days duration representing quarterly development of the mine over the 14 years life of mine period. The simulated steady state heads from model calibration were used as initial conditions representing groundwater levels at the start of the transient predictive simulation.

Dewatering of the open cut mining areas to represent the transient simulation of mine progression was undertaken using SURFACT drain cells set to the floor of the seam being mined. The simulation of the mining operations required the following simplified assumptions for each pit:

- Drain cells (DRN package) located coincident with the base of the East and West Pit footprints were placed to the floor of the Upper Vermont Seam (Layer 6) to allow for water to be removed from the model domain, thereby representing mine dewatering.

- The amount of water removed was determined by the drain conductance which was specified nominally high at 10,000m^2/day to ensure groundwater levels were reduced to the floor of the pit.
- In the pit spoil area disposal was not represented during the transient analysis thereby making the dewatering assumptions conservative – that is the amount of water being removed from the pit being greater than will be the case in reality.

To account for the progressive development of mining starting with East Pit and then moving westwards to the West Pit, the modelling strategy included a stop-start approach which incorporated the mining of each pit as two separate stages. This provided for simulation of the resultant mine dewatering of each pit as two separate stages as per the revised mine plan.

- the first stage being the simulation of mining at East Pit carried out over 44 stress periods (and representing 11 years between 2013 and 2023); and
- the second stage being mining at West Pit over 12 stress periods (representing 3 years between 2023 and 2026).

The simulation was stopped at end of the 44th stress period and spoil placed within the East Pit footprint with the exception of the final void to represent in-pit backfilling of the pit using spoil material. The transient model was then re-started to simulate mining of West Pit. The aquifer conditions at the end of Stage 1 were used to start the Stage 2 simulation. During the Stage 2 simulation, dewatering of the West Pit was undertaken while water levels within East Pit were allowed to begin recovering.

The following parameters were used to represent the spoil material and water body within the final void in both the East and West Pits:

- The hydraulic conductivity value in the mined pit area was adjusted to 0.1m/day for the spoil material and 10,000m/day in the final void.
- The specific yield of the mined pit area was adjusted to 0.01 for the spoil material and 1 in the final void.
- The storage coefficient of the mined pit area was adjusted to 0.0001 for the spoil material and 1 in the final void.
- Recharge to the mined pit area was adjusted to 10% of annual rainfall over the spoil material and 100% of annual rainfall over the final void.
- The evapo-transpiration package was made active in the mining area with an evaporation rate of 0.0064m/day over the spoil material and 0.0048m/day for the final void (i.e., adjusted evaporation rate using a pan factor of 0.25 for the water body within the pit).

4.2 Piezometric Surface/Water Table Levels

Model simulated water levels at the end of mining in 2026 in Layers 1 and 6, which represent the Tertiary sediment aquifer and Vermont Coal Seam respectively, are presented in Drawing No. 9A. The zone of depressurisation around the East and West Pits is clearly evident as observed by the steeply declining contours around the mined area.

The drawdown within the Tertiary sediment aquifer and Vermont Coal Seam attributable to the proposed mine development is presented in Drawing No. 10A. This shows a generally steep drawdown curve within each layer, with the resultant cone of depression proximal to the East and West Pits mined areas. The extent of drawdown in Layer 1 as depicted by the 1m contour is generally contained to within a 2.5km radius of the northern, southern, eastern and western extents of the mined area. A similar drawdown response as depicted by the 1m contour is observed in Layer 6 extending up to around 4km north, south, east and west from the mine area. It is evident that commencement of mining from East Pit does not result in the greater overall drawdown extent observed with the previous mine plan. That is the aquifer drawdown extent does not extend as far the regional aquifer boundaries west and south-west of the mine area (as simulated by the model boundaries).

Simulated water levels at locations representing the centre of each pit and the final voids are shown in Figure 2. As for the previous mine plan, the modelling indicates a relatively steep drawdown response within the highwall sequences whilst mining progresses through that section of the open pit. This will likely give rise to saturated conditions resulting in seepage fronts along highwall batters during mining. Once mining ceases in the East Pit, the modelling predicts water levels rising within spoil material placed within the pit, whilst water levels within the final void recover more slowly, remaining near the base of the void. The modelling then shows a more pronounced drawdown response to water levels within the West Pit to that initially observed in the East Pit but with no obvious recovery observed before the end of mining in 2026. It should be noted that the simulation does not consider progressive placement of spoil within the West Pit, which potentially over-estimates the overall impact from the mine dewatering. However given the uncertainties and assumptions made with respect to the model parameters and setup, the predicted drawdown responses are considered acceptable.

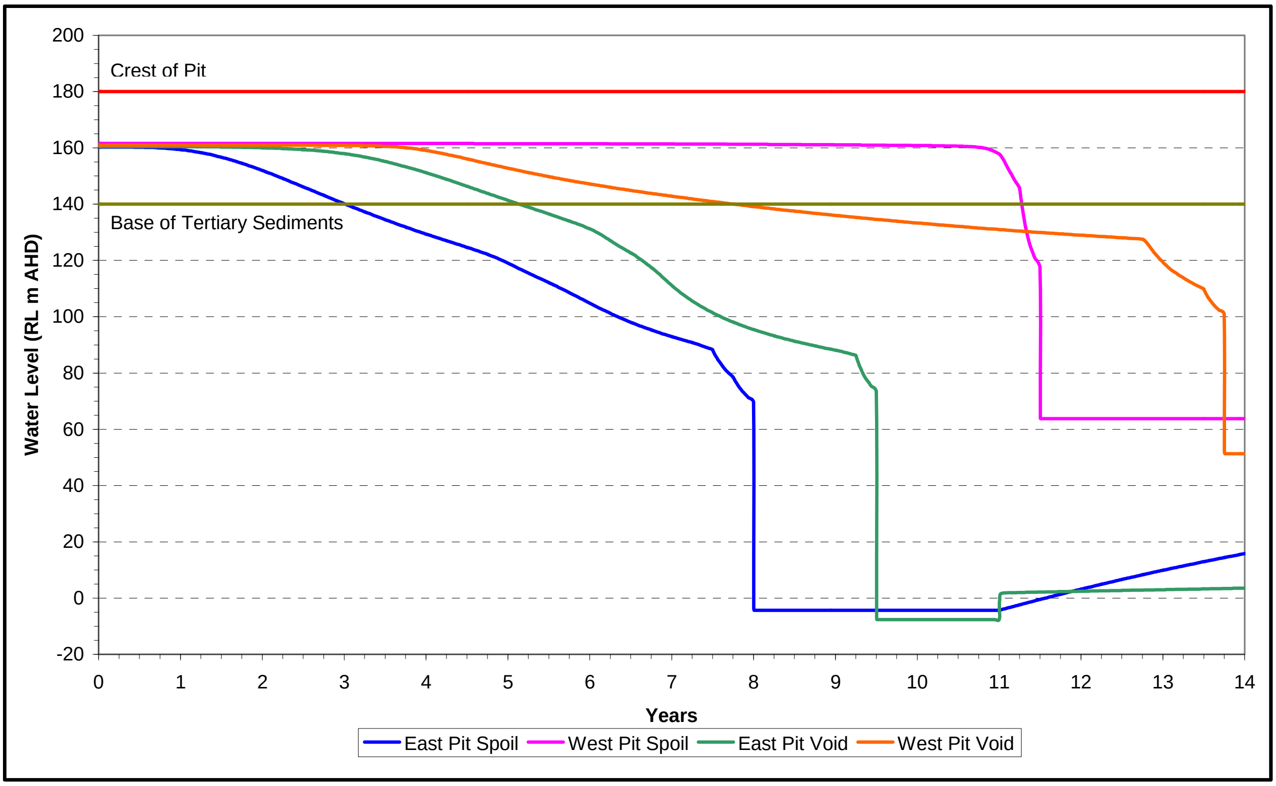


Figure 2: Simulated Drawdown within East and West Pits during Mining

4.3 Impact on Groundwater Users

As discussed in Section 4.2 the depressurised zone in the Tertiary sediments and underlying bedrock sequences extends up to 4km north, east and south of the mine. The only bore intersected by this drawdown is registered monitoring bore RN13040287 located about 3.5km north of the mine. The drawdown does not intersect any other of the 13 registered bores or the single unregistered bore identified as part of this study.

The closest registered and unregistered water supply bores to the proposed mine development are:

- RN85164 which is located approximately 10km north of the mine beyond the model boundary and hence within geology not hydraulically connected to that within the model area;
- RN111879 which is located approximately 11km south-east of the mine and within the model boundary; and
- The Devlin Creek property bore (DC Bore) located approximately 11km north-west of the proposed mining lease boundary.

As stated above, all bores are located beyond the extent of impact simulated in the transient analysis and hence would not be influenced by the mine development and resultant impact from aquifer dewatering.

4.4 Inflow to Mined Void

The model predicted heads and cell by cell flows were extracted for each stress period to assess the rate of groundwater inflow to the mine pits for the revised mine plan. The model simulated inflow rates to the proposed East and West Pits are shown in Figure 3 below. Detail of predicted inflows to each pit is discussed below.

<u>East Pit</u>

The predicted flows into East Pit range from 3.1ML/day at the end of the first stress period (representing the first quarter of the first year of mining) to maximum values between 5.5ML/day and 5.6 ML/day from mid 2015 to the end of 2016 (Year 4) when the outside northern and southern sections of East Pit are mined.

From 2016 the predicted inflows decrease steadily down to around 2.6ML/day over the next five years to mid 2022 (Year 10) as mining progresses through the inner sections of East Pit. This is due to these sections of the mine being mostly dewatered as a result of earlier mining of the outer northern and southern sections.

The increase in the predicted inflows from 2.6ML/day mid 2022 to 5.3ML/day at the end of 2023 (Year 11 and the end of mining in East Pit) are a response to the commencement of mining in West Pit at the start of the second quarter in 2022.

Overall, higher inflows are predicted for this revised mine plan (up to 5.6ML/day) compared to that previously simulated (up to 4.7ML/day) which is to be expected considering the increased size of the revised East Pit mine plan.

West Pit

As mentioned above, simulation of mining in West Pit starts with the second quarter in 2022 and continues until the end of 2026 (Year 14). The sharp decline in predicted inflows from 5.3ML/day to 1.2ML/day at the end of 2023 (Year11), represent cessation of active dewatering and placement of spoil backfill within East Pit (excluding the final void area). Progression of mining is thereafter limited to West Pit only, with inflows increasing from 1.2ML/day to a maximum of 3.3ML/day at the end of 2025 (Year 13). The final year of mining in 2026 (Year 14) indicates predicted inflows declining marginally to around 2.5ML/day.

The initially higher inflows predicted after the mining commences in the West Pit at the end of 2023 (5.3ML/day) are a combination of inflows to both the East Pit and West Pit. Hence it is possible the actual inflows to the West Pit would be similar to those predicted previously since the mine plan for West Pit is not significantly different from that previously simulated.

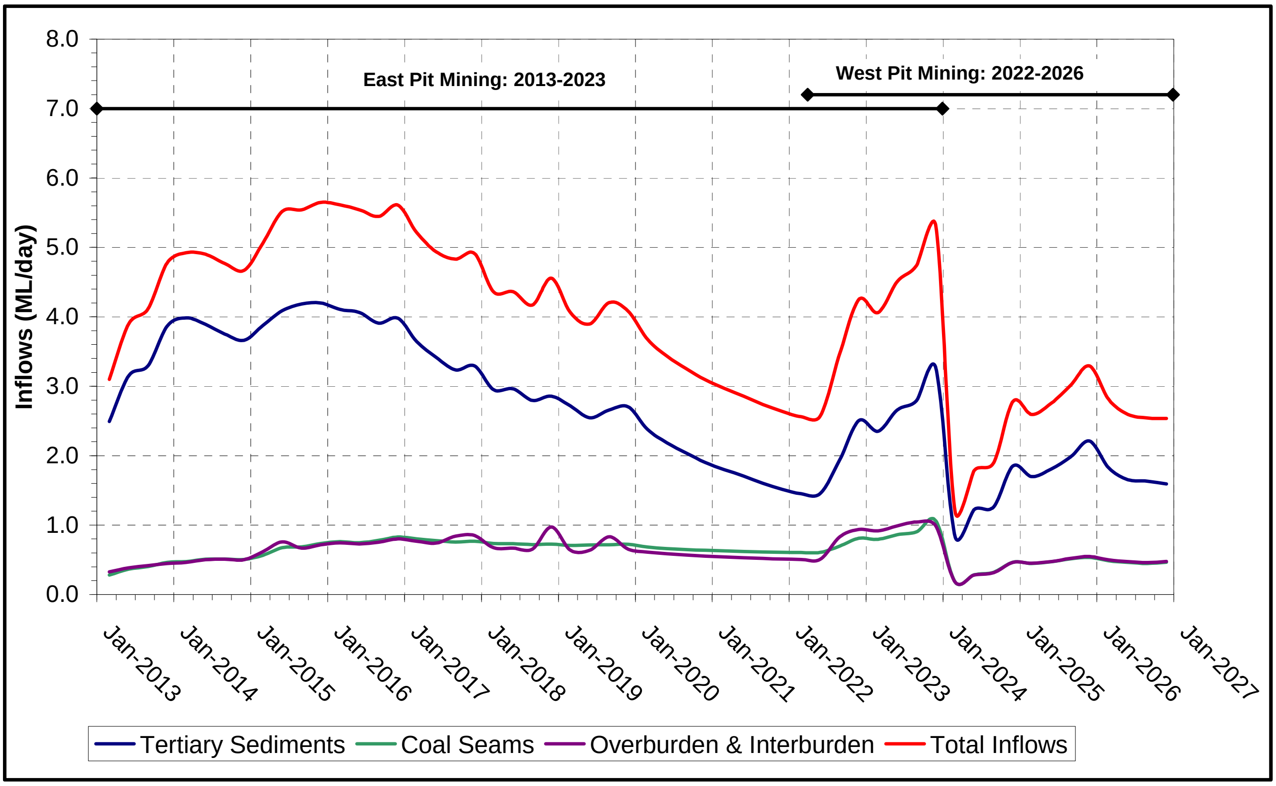


Figure 3: Simulated Seepage within East and West Open Pits

As for the previous simulation of predicted inflows to the East and West Pits, it is important to note that whilst a large proportion of the groundwater inflow will be lost from the aquifer, not all of this water report to dewatering pumps in the mine. This is because the model does not account for loss of water through evaporation from the coal face and water that is removed with the coal as moisture.

No details on the mined volumes of overburden/interburden and coal have been provided for this revised mine plan. However, based on the previously adopted assumptions for mining the coal seams, the potential groundwater loss via evaporation and moisture in the coal and waste rock could account for as much 40% of the total inflows predicted into East and West Pits.

Therefore when the loss from evaporation and coal moisture is considered, the actual volumes reporting to the in pit sumps are expected to be low.

It should also be noted that the simulated inflows are potentially a conservative overestimate for the following reasons:

- The model does not include the minor faults in the area and simulates a continuous aquifer system – assuming these faults act as barriers to groundwater flow, inflows to the model will be lower than predicted by the laterally continuous aquifers in the model; and
- The model assumes the entire pits remain dewatered when the pits are active.

4.5 Transient Model Budget Summary

The model water balance for the East Pit and West Pit transient analyses are presented in Table 2 and Table 3. These show the percent discrepancy was 0.85% in East Pit and 0.03% in West Pit, which indicate good accuracy for the numerical simulations and overall stability of the two models.

Table 2: TRANSIENT MODEL WATER BALANCE (EAST PIT – 2013 TO 2023)

Component	Cumulative Volume (ML)
IN	
CONSTANT HEAD =	0
DRAINS =	0
RECHARGE =	426.7
TOTAL IN =	27,085.5
OUT	
CONSTANT HEAD =	207.3
DRAINS =	26,879.6
RECHARGE =	0
TOTAL OUT =	27,315.6
IN - OUT =	230.1
PERCENT DISCREPANCY =	0.85

Table 3: TRANSIENT MODEL WATER BALANCE (WEST PIT – 2022 to 2026)

Component	Cumulative Volume (ML)
IN	
CONSTANT HEAD =	0
DRAINS =	0
RECHARGE =	1,099.9
TOTAL IN =	17,084.5
OUT	
CONSTANT HEAD =	56.5
DRAINS =	3,987.1
RECHARGE =	0
TOTAL OUT =	17,089.9
IN - OUT =	5.4
PERCENT DISCREPANCY =	0.03

Cumulative recharge increased from 426.7ML for East Pit to 1,099.9ML for West Pit with overall cumulative water losses as outflow from drain cells decreasing from 26,879.6ML (East Pit) to 3,987.1ML (West Pit). The losses from drain cells include dewatering from East and West Pits as well as discharge into the creeks within the model domain.

4.6 Leakage from Alluvial Aquifers

As discussed in the previous predictive modelling, the open pits are in close proximity to alluvium associated with Devlin Creek, in which a shallow groundwater aquifer exists as a perched aquifer. Groundwater levels in the shallow alluvial aquifer (where present) occur well above any groundwater associated with the underlying Tertiary sediments, indicating these aquifers are not hydraulically interconnected. This being the case and providing mining does not intersect the Devlin Creek alluvium, it is unlikely that mine dewatering and resultant depressurisation of the underlying Tertiary and Permian aquifers will impact on groundwater associated with the alluvium (alluvial aquifer).

4.7 Transient Modelling – Groundwater Recovery

Once mining operations cease within the East Pit at the end of 2023, dewatering of the East Pit open void also ceases and a slow recovery in groundwater levels in the area commences. As discussed in Section 4.1, recovery within the East Pit commenced after 2023 (Year 11) when mining ceased in that pit. Although the mine plan over the 14-year period shows progressive backfilling of each open pit with spoil from the section being mined, the model applies this spoil backfill in two stages, at the end of East Pit mining (in 2023), and on completion of mining in the West Pit at the end of 2026. Hence, at the end of mining in 2026 the configurations of the two final voids are as follows:

- The void at the western end of the East Pit footprint with an area of approximately 71ha. The lowest point in the final void will be RL-5m, a depth of about 180m below the spill level of the void (approximately RL174m).
- The void at the eastern end of the West Pit footprint with an area of approximately 57ha. The lowest point in this final void will be RL29m, a depth of about 151m below the spill level of the void (approximately RL180m).

The locations and extents of the final voids are shown below in Figure 4.

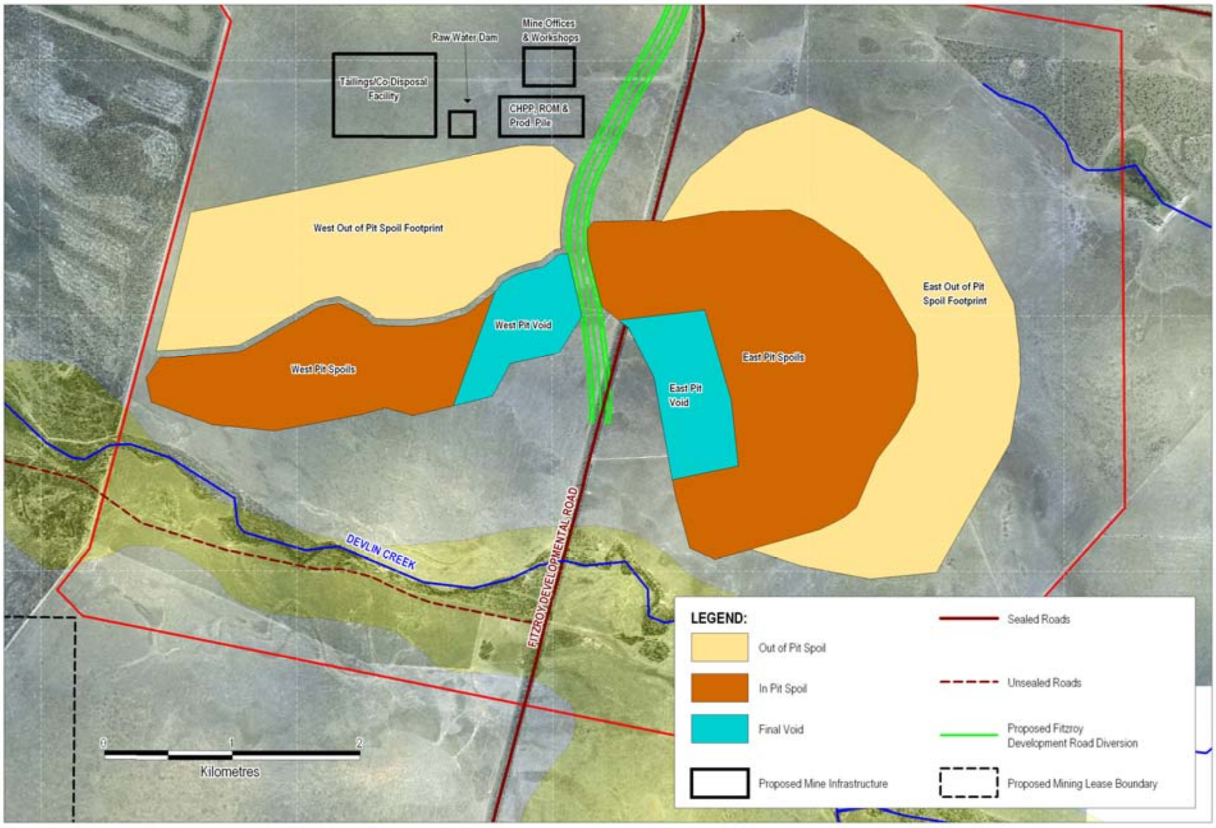


Figure 4: Locations and Extents of Final Voids and Spoil

At the cessation of mining, there will be a relatively high groundwater gradient between the open voids and the coal seam aquifers which will result in relatively rapid inflows; however, as the lakes begin to form in the voids, the gradient is reduced and the rate of groundwater inflow will decrease. Direct rainfall at the site will also add to the void and eventually a state of 'quasi' equilibrium will occur which will be influenced by the balance of inflows from groundwater and rainfall, and losses from evaporation.

The rate of recovery of groundwater levels in the aquifers will be dependent on rainfall, with below average rainfall years likely to extend the recovery period and wet years to reduce the time for stabilisation. Groundwater levels will likely recover below pre-mining levels as average daily evaporation is around four times the average daily rainfall in the area.

The closest monitoring bore to the proposed final void in the western pit is MB8B, located about 650m to the north-east which recorded a pre-mining groundwater level of RL159.2m. The closest registered bore to this void is RN13040287, located about 3500m to the north-northeast which recorded a pre-mining groundwater level of RL157.7m.

The water level in the final voids was estimated by running the transient groundwater recovery model with modifications incorporated for model parameters for areas of spoil backfill and final voids.

The hydraulic properties adopted for both the East and West Pits spoil backfilled areas and final voids are summarised in Table 4.

Table 4: SPOIL AND VOID HYDRAULIC PARAMETERS		
Layer	**Parameter**	**Value**
East and West Pits Spoil	Horizontal Hydraulic Conductivity [kh]	0.1 m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	0.01
	Specific Storage [S_s]	1 x 10^{-4}
	Recharge	1.609 x 10^{-4}m/day (10% of annual rainfall)
	Evapo-Transpiration	0.0064m/day
East and West Pits Voids	Horizontal Hydraulic Conductivity [kh]	10,000m/day
	Vertical Hydraulic Conductivity [kv]	10,000m/day
	Specific Yield [S_y]	1
	Specific Storage [S_s]	1
	Recharge	1.609 x 10^{-3}m/day (100% of annual rainfall)
	Evaporation	0.0048m/day

For both the East and West Pits spoil areas the evapo-transpiration rate was set with a constant extinction depth of 2m applied, whereas for the East and West Pits final void areas a cell-by-cell extinction depth was determined by calculating the total depth from the original ground surface to the bottom of the mined coal seam. The maximum evaporation rate in the final voids was set at the average evaporation rate multiplied by a pan factor of 0.75 to represent evaporation from an open water body.

The estimated recovery in water levels in the final voids and spoils is shown in Figure 5.

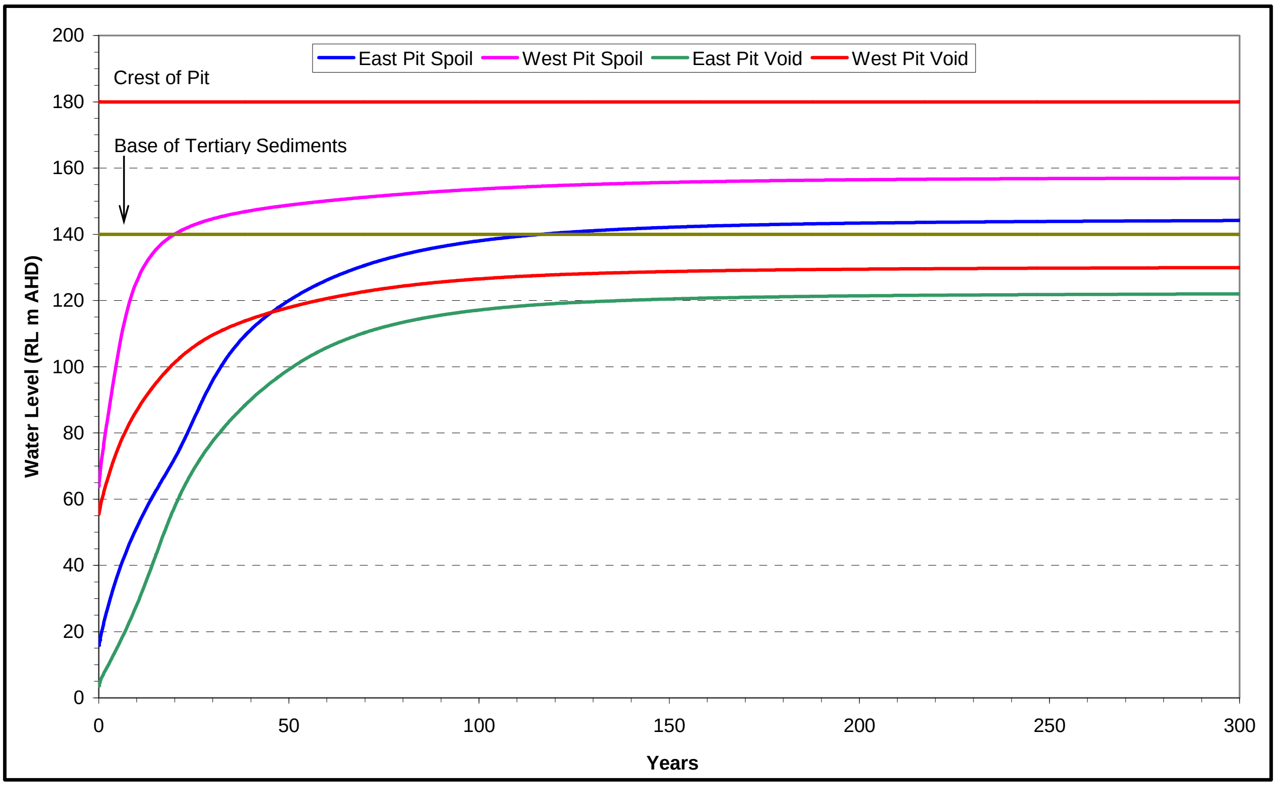


Figure 5: Simulated Water Level in East and West Pits Final Voids and Spoil

The assessment indicates groundwater levels in both the East and West Pit voids show a slow recovery rate with water levels rising to a pseudo-equilibrium level around RL120m in East Pit and RL128m in West Pit after 120 years post mining. Thereafter the water levels still continue to recover but at a very slow rate only reaching RL122m and RL130m in East and West Pit voids respectively after 300 years post mining. Similarly the water levels within the spoil in each pit initially recover relatively quickly to a pseudo-equilibrium level of around RL120m in East Pit spoil and RL149m in West Pit spoil after 50 years post mining. Thereafter the water levels in East Pit spoil rise very slowly to around RL157m and in West Pit to RL144m after 300 years post mining, generally levelling out after around 100 years.

The evaporative pumping effect in conjunction with the slow rainfall recharge potential for this area will result in the final equilibrium recovered void water levels being somewhere between that predicted for West Pit void and spoil water levels, which will probably be close to the base of the Tertiary Sediments. Hence the voids will most likely act as a local sink for groundwater and result in a gradual increase in the salinity of the void water over time. The quality of the water will be controlled by the groundwater seepage quality, leaching of salts from the spoil piles and evaporative concentration of rainfall inputs. The salinity of the water would be expected to be brackish, becoming saline over time. The void will act as a sink for the local groundwater and therefore attract water from the surrounding coal measures, with the hydraulic gradients preventing any migration of pit water back into the coal measures.

4.8 Model Uncertainty and Limitations

This model has been constructed based on limited available data and the use of the model predictions should be treated as such. The uncertainty in the model results can be reduced through the collection of inflow data after mining commences. If significant divergence is observed between the measured and model predicted inflows, revisiting the model and specifically re-calibration of the model parameters against the measured inflow data will reduce uncertainty and provide better predictions for the future. Similarly, a better understanding of the recharge potential from rainfall into the aquifer hosted in the Tertiary sediments would provide for a more accurate correlation between the predicted water levels for the steady state analysis with those measured.

Development, calibration and the results of predictive simulations from any groundwater model are based on available data characterizing the groundwater system under investigation. It is not possible to collect all the data characterizing the whole aquifer system in detail and therefore various assumptions have to be made during development of a groundwater model. A number of assumptions were made during development of the groundwater model described in this report and these assumptions together with their impact on the simulation results are discussed below.

- The model assumed that the hydraulic properties of the Tertiary and coal seam aquifers were uniform across the entire model domain. In reality the permeability of these aquifers would be variable which would result in a less uniform zone of depressurization than that predicted by the numerical model.
- In contrast the model has used variable hydraulic properties for the Rewan and Permian overburden and interburden sequences determined from a constant transmissivity value divided by the overall depth of these sequences within the model. This means the shallower sequences nearer the mine site have a higher permeability value than those located further to the south-west where these sediments are deeper and hence thicker. In reality such variability in hydraulic properties is more likely to be a function of depth below ground level where the extent and number of secondary permeability features such as faults and joints decline with depth as the rock becomes more competent.
- The lack of historical groundwater level and baseflow records for the water courses in the area meant only a steady state calibration could be undertaken.

5.0 POTENTIAL IMPACT OF PROJECT ON GROUNDWATER REGIME AND MITIGATION OPTIONS

Based on this revised mine plan, the project development will only intersect groundwater within the Codrilla A MLA, and not along the haul road alignment Options 1 to 3 within the Codrilla B MLA. This being the case, the haul road alignment is not considered to have any impact on groundwater and hence discussion hereafter on potential impacts on the groundwater regime from the project is limited to that within the Codrilla A MLA.

5.1 Groundwater Inflow to Mine and Control Strategies

The numerical modelling indicates inflows to the East Pit will initially be around 35L/s (3.1ML/day) and will increase up to about 65L/s (5.6ML/day). Similarly, predicted inflows to the West Pit will initially be around 14L/s (1.2ML/day) and will increase up to about 38L/s (3.3ML/day). However, the actual volumes of water pumped from each section of the mine will likely be less than these volumes predicted as some water will be removed as moisture with the coal and some will be lost by evaporation from the open working face. These losses may represent up to about 40%. This being the case, inflows would only be expected to become an issue once they exceed those potential losses (through evaporation and overburden, interburden and coal moisture content) after the second year of mining for each pit.

Groundwater inflow to the open working highwall sections of the mine should be controlled by strategically located sumps and pumped to surface storages. The water will be of poor quality as discussed, but consideration could be given to using it in the CHPP and for dust suppression.

5.2 Groundwater Levels and Regional Impact

The mine development and operation will depressurise the Tertiary, deeper Triassic/ Permian and coal seam aquifers by groundwater inflows into the East and West Pits which will lower the elevation of the piezometric surface of these aquifers and create a cone of depression around the mine. The model simulated extent of the cone of depression in the overburden at the end of mining is shown on Drawing No. 9A. The drawdown due to mining is shown in Drawing No. 10A.

The drawings indicate that the zone of significant drawdown at the end of mining (i.e., greater than 5m) is limited to the area immediately surrounding the East and West Pits. That is, a generally steep drawdown curve develops a cone of depression up to approximately 4km radius of the northern, southern, eastern and western extents of the mined area. Based on these simulated drawdown levels, the extent of impact on groundwater levels is more prevalent on a local scale immediately adjacent to the mine site, but less so on a regional scale. As there are no other mines within the regional extents of the study area, there will be no cumulative drawdown impacts on the regional aquifer.

It is possible the extent of the simulated drawdown could be less than that predicted, as the numerical model does not include faulting on a local scale which could act as additional hydraulic barriers and limit the effects of aquifer drawdown.

5.3 Impact on Existing Farm Bores

As discussed in Section 4.3, there are no operational domestic or stock bores within or adjacent to the proposed mining lease area. Therefore no water supply bores will be affected by the lowering of water levels predicted.

5.4 Impact on Environmental Values

The Groundwater Impact Assessment for this project has identified that there are no groundwater dependent ecosystems that are likely to be impacted by the Codrilla Coal Project. Any vegetation that extracts groundwater is likely to intersect the alluvial aquifer associated with Devlin Creek. The groundwater level in the alluvial aquifer is around 15m higher (more elevated) than the deeper Tertiary, Triassic/Permian and coal seam aquifers and there is no direct hydraulic interconnection between these aquifers. On the basis that the alluvial aquifer is perched and shows no signs of hydraulic interconnection with the underlying saline aquifers, and will not be intersected by the mine operation open pits, it is unlikely that the alluvial aquifer will be affected by the mining operation.

The only environmental value for the groundwater that could be suitable for the proposed Codrilla Coal Project operation would be that for industrial use. Impact on the saline aquifers will not affect this environmental value as there are no other nearby users of this saline groundwater. The Groundwater Impact Assessment for this project has identified that no other obvious environmental values for groundwater were identified in the project area, due to the poor water quality and low bore yields.

5.5 Groundwater Contamination

The potential for groundwater contamination may occur from the following sources:

- rejects disposal, workshops, waste disposal – Tertiary, Triassic/Permian and coal seam aquifers;
- mining – coal seam aquifer.

There is potential for spills and contamination by metals and hydrocarbons from mine workshop, waste disposal and fuel storage areas; however adequate bunding and immediate clean-up of spills which is standard practice or a legislated requirement at mine sites, should prevent contamination of shallow groundwater system. Any spills from these areas are typically very localised and not regionally significant.

In assessing the potential impact, reference is made to the geochemical assessment report prepared by GSS Environmental (2010). GSS Environmental has geochemically characterised overburden, interburden and potential coal reject material from the proposed mine project and concluded that:

5.4.1 Overburden

> *The results from the Acid Base testing indicates* that *the overburden material will initially generate neutral to slightly alkaline runoff and seepage due to the current pH of the material. All overburden samples had very low sulphur content and are considered inert. The acid neutralising capacity generally exceeded the maximum potential acidity for overburden samples indicating that the material has sufficient buffering capacity to neutralise the small amount of acidity that may be generated from sulphide oxidation. All overburden samples were classified as non acid forming.*
>
> *The salinity levels of the runoff and seepage water is expected to be moderate. This may cause some vegetation species to be slower growing once the roots penetrate the moderately saline overburden material. Over time it is expected that salinity levels near the surface layers of overburden will lower due to leaching further into the dump profile. Water management structures such as dams should be monitored for salinity levels and appropriate management and release actions should be followed.*
>
> *The presence of extremely sodic material throughout the overburden profiles gives rise to the need for implementing appropriate erosion and sediment controls on site prior to and during the development of the overburden emplacements. This sodic material is prone to severe surface crusting, gully erosion and tunnelling.*

5.4.2 Reject Material

CHPP reject is to be stored in the main in a co-disposal facility, that is, the coarse and fine reject streams will be combined at the CHPP and pumped as slurry to the disposal area. The excess water that drains from the matrix of reject solids will be recovered and returned to the process water circuit. There may be localized low pH seepage but based on the NAPP results the return water is not expected to be generally acidic.

In the context of rehabilitation, the CHPP reject appears to be not particularly saline but poor fertility and combustion risk (from the included coal) dictate that an inert cover will be necessary.

Considering the conclusion reached by GSS Environmental (2010), it is considered unlikely that leachate generated from these materials will adversely impact groundwater quality. As discussed the groundwater quality in the overburden and coal seam aquifers is poor (saline) and would only be suitable for limited industrial use. Based on the results of this geochemical characterisation, interaction between in pit disposal of overburden, interburden and potential coal rejects material with recovering (rising) groundwater levels and surface water (rainfall) runoff is not considered likely to result in poorer quality water in the Tertiary and Permian sediment aquifer systems following cessation of mining.

5.6 Fitzroy Water Resource Plan and Regulations

The project area falls in the Water Resource (Fitzroy Basin) Plan 1999, which applies to waters in watercourses and lakes, water in springs and overland flow water and does not apply to groundwater resources. However, the project is located in the Highlands Sub-artesian Area which is a declared sub-artesian area where any development works:

- that take or interfere with sub-artesian water, other than for domestic purposes or for stock watering, require a water entitlement, water permit or seasonal water assignment notice;
- are assessable development under the Sustainable Planning Act 2009 for taking sub-artesian water other than domestic purposes or for stock watering.

Similarly, the Queensland Government Water Regulation 2000 Moratorium Notice which regulates the Isaac River and Connors River Catchment in relation to the Highland Declared Area states that new applications to take sub-artesian water will not be accepted, except for applications to take sub-artesian water for mine dewatering purposes, or for a significant project as declared under Section 26 of the State Development and Public Works Organization Act 1979.

This being the case, the project will require both a water licence and a development permit to take or interfere with groundwater associated with the Tertiary and Permian sediments.

AUSTRALASIAN GROUNDWATER AND ENVIRONMENTAL CONSULTANTS PTY LTD

Reviewed by:

DUNCAN W. IRVINE
Senior Hydrogeologist

ANDREW M. DURICK
Principal Modeller/Senior Hydrologist

LIMITATIONS OF REPORT

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has prepared this report for the use of Bowen Basin Coal Joint Venture in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 8 March 2011.

The methodology adopted and sources of information used by AGE are outlined in this report. AGE has made no independent verification of this information beyond the agreed scope of works and AGE assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to AGE was false.

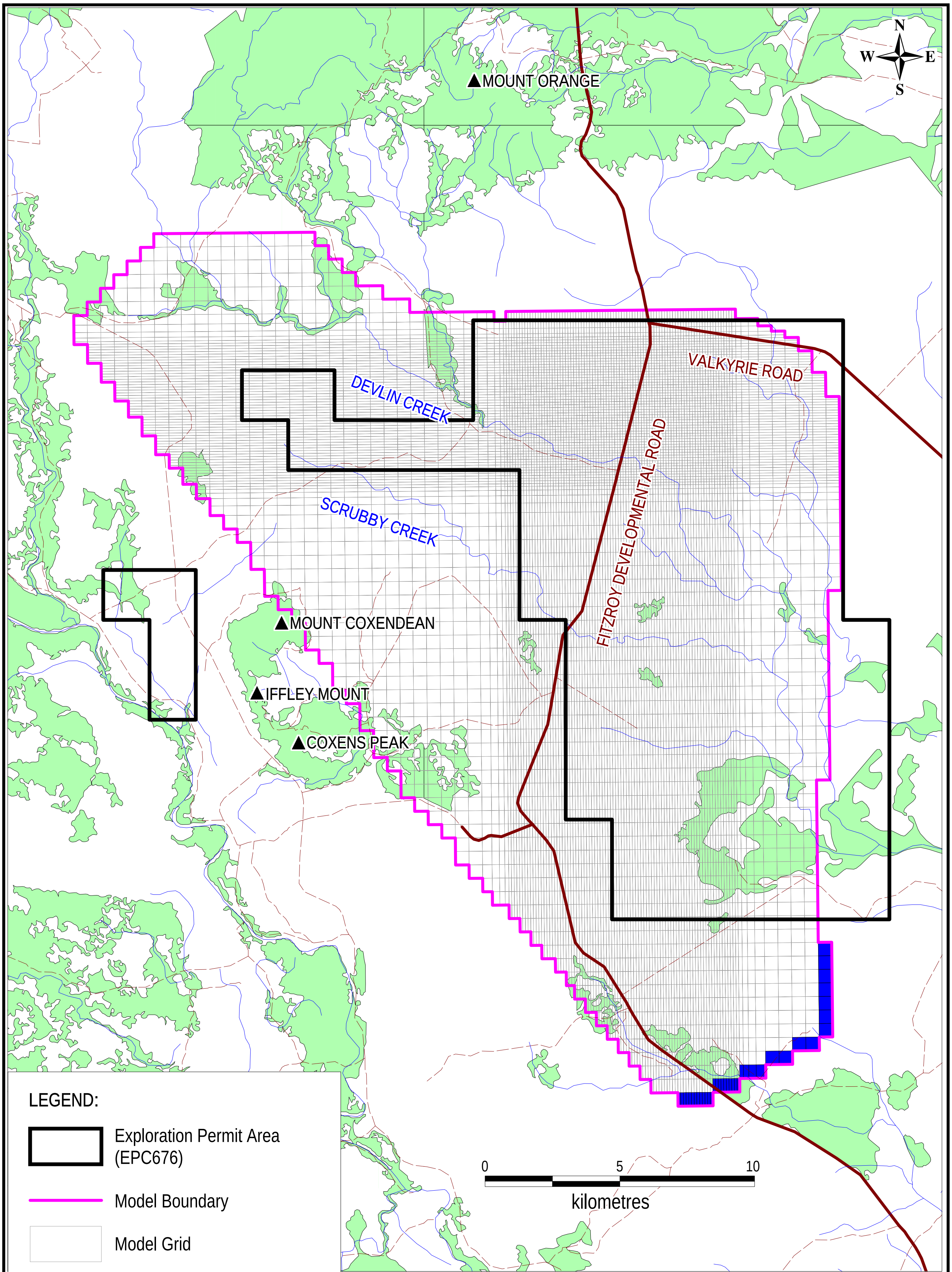
This study was undertaken between 11 February 2011 and 29 April 2011 and is based on the conditions encountered and the information available at the time of preparation of the report. AGE disclaims responsibility for any changes that may occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. It may not contain sufficient information for the purposes of other parties or other users. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing and other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. Where borehole logs are provided they indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of the site, as constrained by the project budget limitations. The behaviour of groundwater is complex. Our conclusions are based upon the analytical data presented in this report and our experience.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, AGE must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge, information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.



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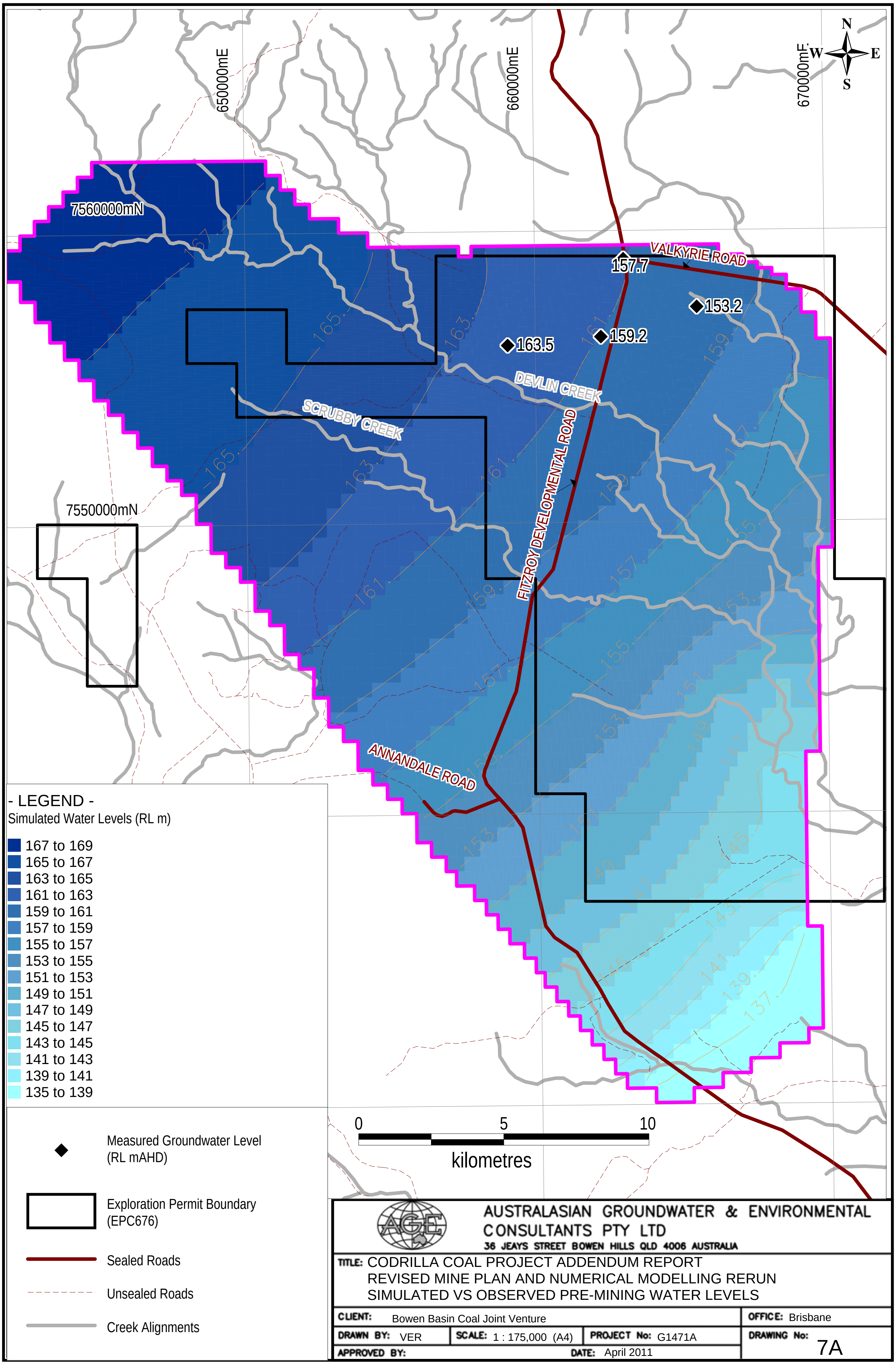
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: CODRILLA COAL PROJECT ADDENDUM REPORT REVISED MINE PLAN AND NUMERICAL MODELLING RERUN MODFLOW MODEL GRID			
CLIENT: Bowen Basin Coal Joint Venture			OFFICE: Brisbane
DRAWN BY: VER	SCALE: 1 : 200,000 (A4)	PROJECT No: G1471A	DRAWING No: 6A
APPROVED BY:	DATE: April 2011		



650000mE
660000mE
670000mE
N
W
E
S
7560000mN
7550000mN
VALKYRIE ROAD
DEVLIN CREEK
SCRUBBY CREEK
FITZROY DEVELOPMENTAL ROAD
ANNANDALE ROAD
157.7
153.2
163.5
159.2
- LEGEND -
Simulated Water Levels (RL m)
167 to 169
165 to 167
163 to 165
161 to 163
159 to 161
157 to 159
155 to 157
153 to 155
151 to 153
149 to 151
147 to 149
145 to 147
143 to 145
141 to 143
139 to 141
135 to 139
Measured Groundwater Level (RL mAHD)
Exploration Permit Boundary (EPC676)
Sealed Roads
Unsealed Roads
Creek Alignments
0
5
10
kilometres
AGE
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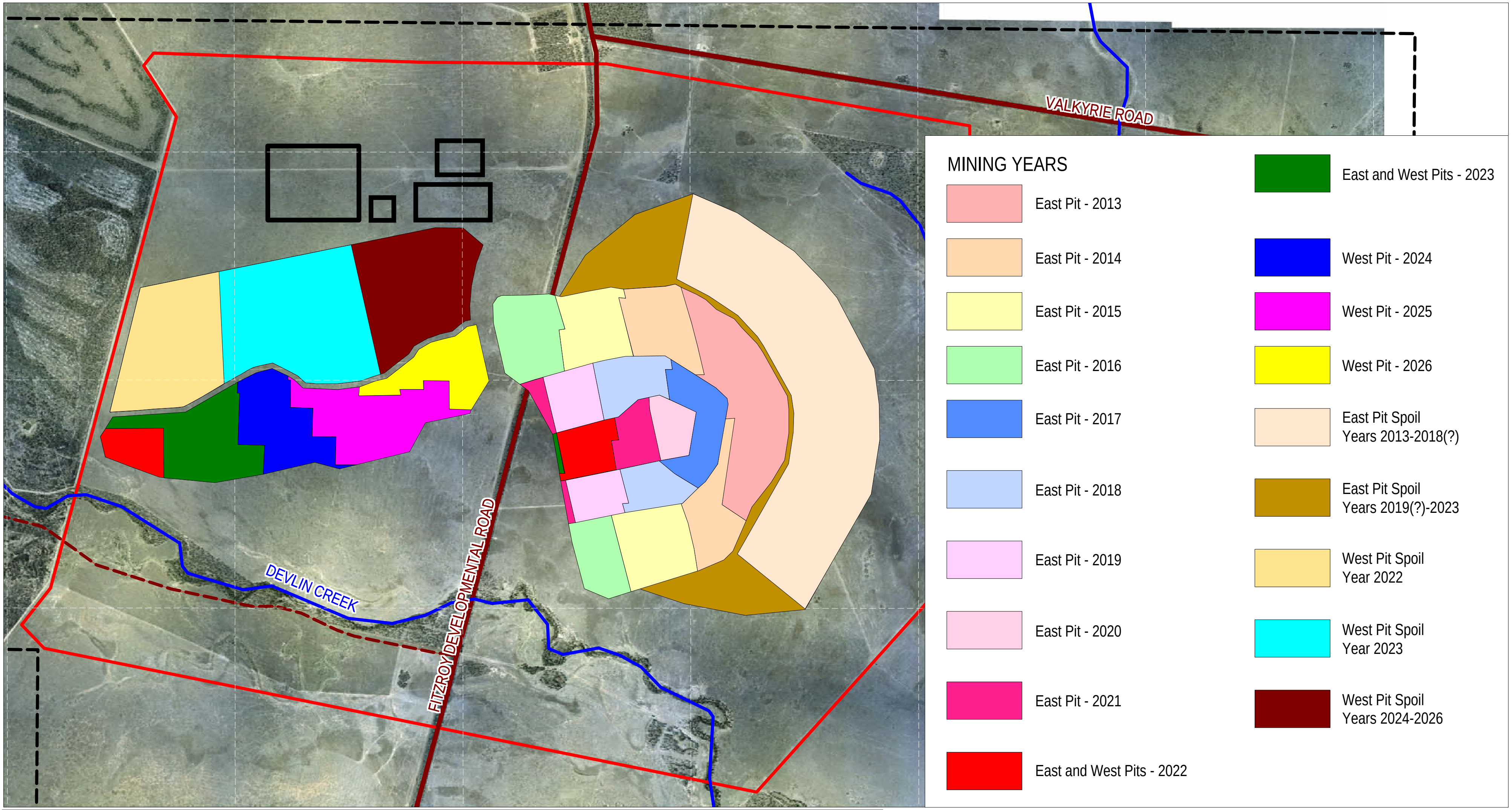
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA
TITLE: CODRILLA COAL PROJECT ADDENDUM REPORT
REVISED MINE PLAN AND NUMERICAL MODELLING RERUN
SIMULATED VS OBSERVED PRE-MINING WATER LEVELS
CLIENT: Bowen Basin Coal Joint Venture
OFFICE: Brisbane
DRAWN BY: VER
SCALE: 1 : 175,000 (A4)
PROJECT No: G1471A
DRAWING No: 7A
APPROVED BY:
DATE: April 2011



LEGEND:

Yellow fill	Quaternary Alluvium
Black dashed box	Exploration Permit Boundary (EPC676)
Black box	Mine Infrastructure
Red box	Proposed Mining Lease Area
Dark red line	Sealed Roads
Dark red dashed line	Unsealed Roads/Tracks
Green line	Fitzroy Development Road Realignment

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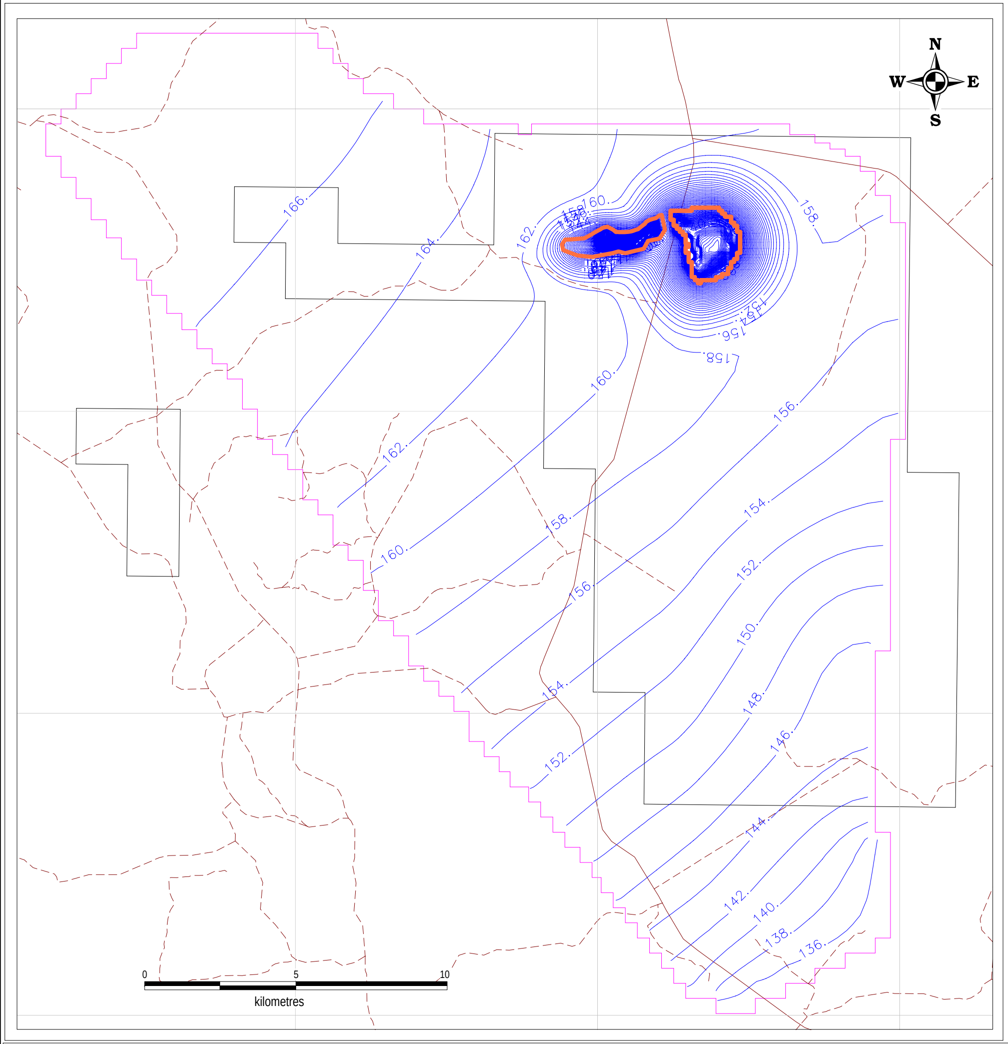
TITLE: CODRILLA COAL PROJECT ADDENDUM REPORT
REVISED MINE PLAN AND NUMERICAL MODELLING RERUN
MINE DEVELOPMENT PLAN

CLIENT: Bowen Basin Coal Joint Venture | **OFFICE:** Brisbane

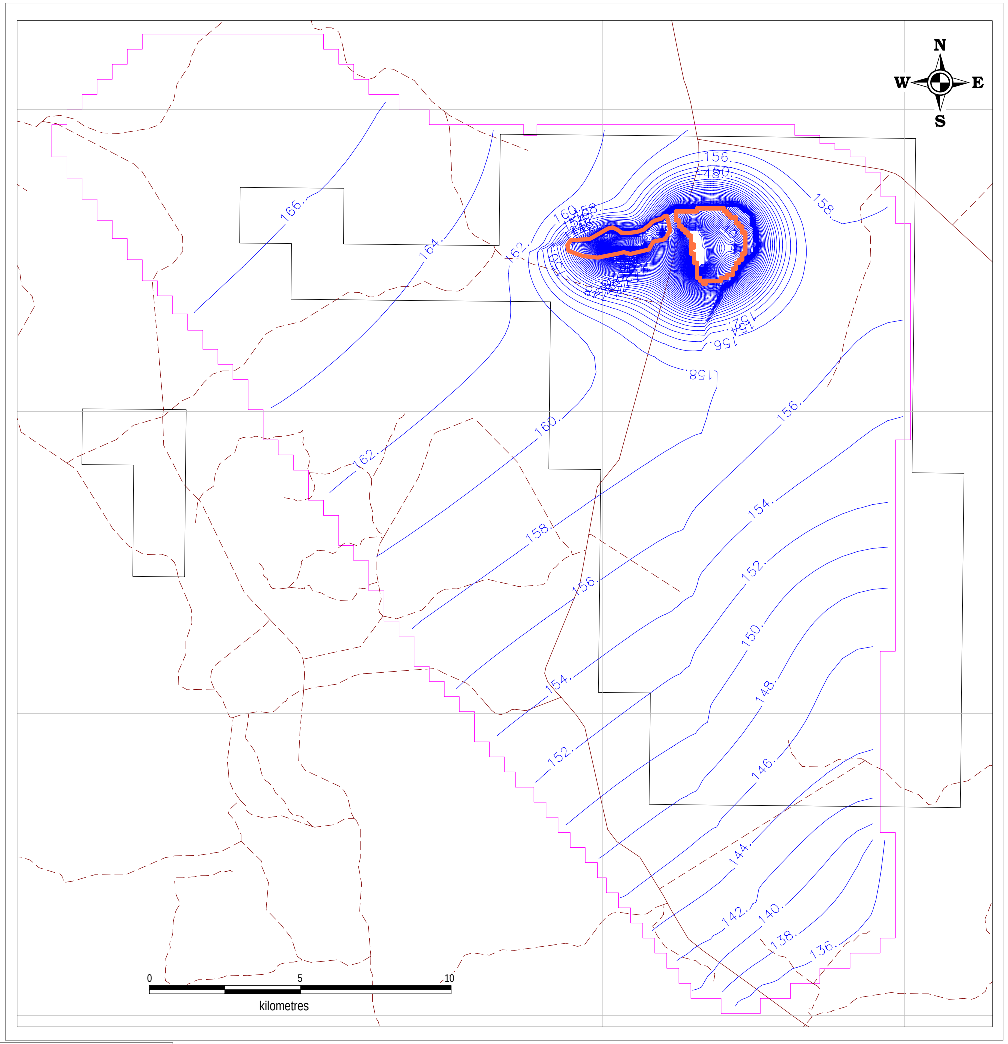
DRAWN BY: DWI | **SCALE:** 1:50,000 (A4) | **PROJECT No:** G1471A | **DRAWING No:** 8A

APPROVED BY: | **DATE:** April 2011

GROUNDWATER CONTOURS AT THE END OF MINING YEAR 2026 - TERTIARY SEDIMENTS



GROUNDWATER CONTOURS AT THE END OF MINING YEAR 2026 - VERMONT COAL SEAM



- LEGEND -

Exploration Permit Boundary (EPC676)

Model Boundary

Groundwater Contours

Sealed Roads

Unsealed Roads

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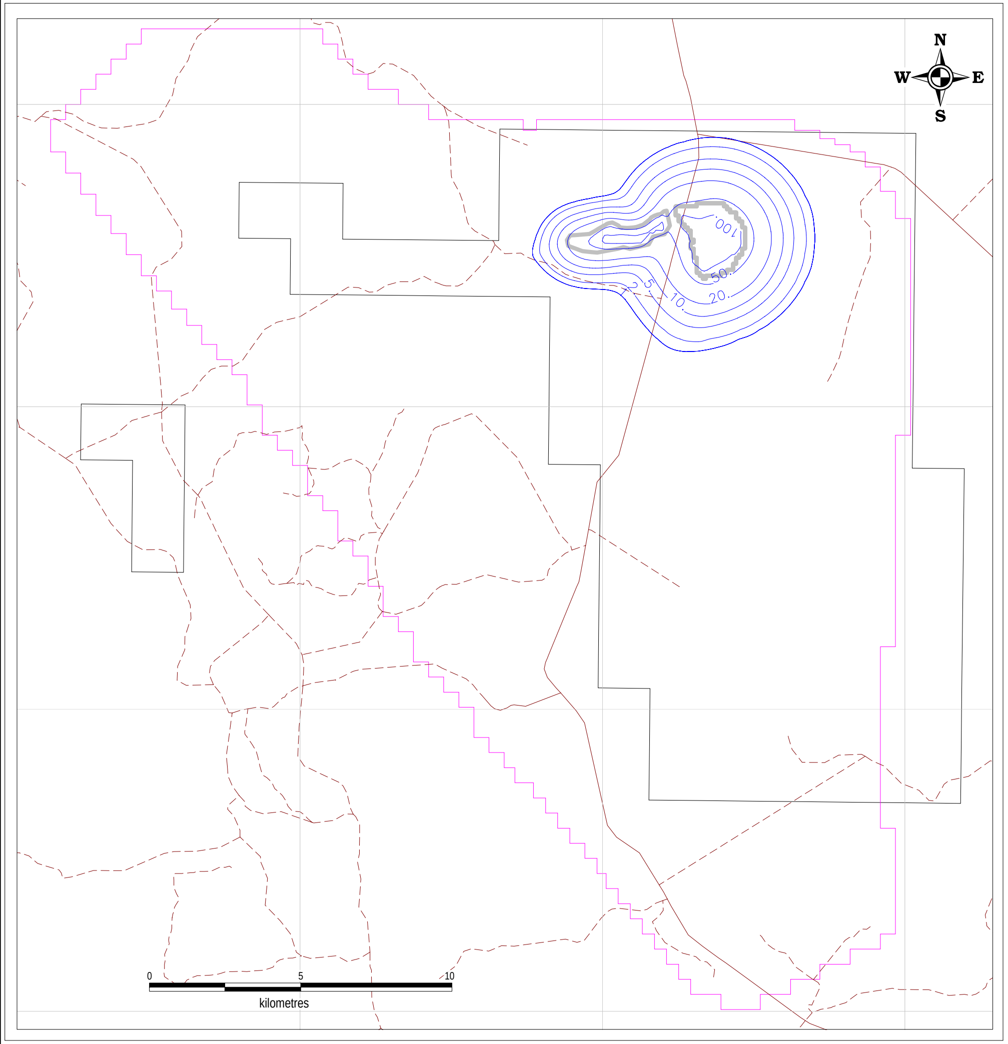
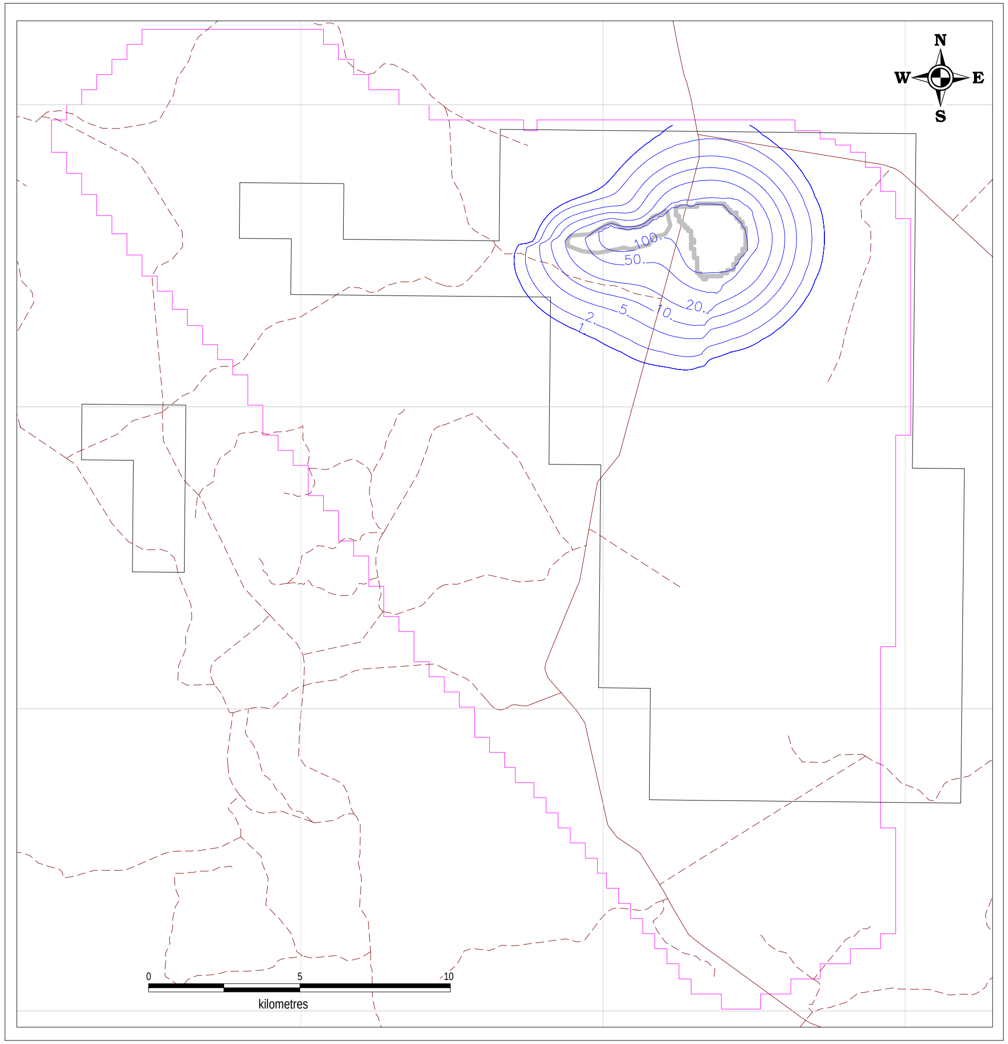
TITLE: CODRILLA COAL PROJECT ADDENDUM REPORT REVISED MINE PLAN AND NUMERICAL MODELLING RERUN GROUNDWATER LEVEL CONTOURS - 2026 END OF MINING			
CLIENT: Bowen Basin Coal Joint Venture			**OFFICE:** Brisbane
DRAWN BY: VER	**SCALE:** 1 : 250,000 (A4)	**PROJECT No:** G1471A	**DRAWING No:** 9A
APPROVED BY:	**DATE:** April 2011		

PREDICTED DRAWDOWN AT THE END OF MINING YEAR 2026 - TERTIARY SEDIMENTS



PREDICTED DRAWDOWN AT THE END OF MINING YEAR 2026 - VERMONT COAL SEAM



- LEGEND -

Exploration Permit Area (EPC676)

Model Boundary

Drawdown Contours

Sealed Roads

Unsealed Roads

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TITLE: CODRILLA COAL PROJECT ADDENDUM REPORT
REVISED MINE PLAN AND NUMERICAL MODELLING RERUN
PREDICTED DRAWDOWN - 2026 END OF MINING

CLIENT: Bowen Basin Coal Joint Venture			**OFFICE:** Brisbane
DRAWN BY: VER	**SCALE:** 1 : 250,000 (A4)	**PROJECT No:** G1471A	**DRAWING No:** 10A
APPROVED BY:		**DATE:** April 2011	