MALABAR COAL

**MALABAR COAL LIMITED**
ABN 29 151 691 468
Level 26, 259 George Street
Sydney NSW 2000
PO Box R864
Royal Exchange NSW 1225
**Ph:** +61 2 8248 1272
**Fax**: +61 2 8248 1273
**Website**: www.malabarcoal.com.au

10 December 2019

**Lauren Evans**
Team Leader, Energy and Resource Assessments
NSW Department of Planning, Industry and Environment
GPO Box 39
Sydney NSW 2001

**By email:** Lauren.Evans@planning.nsw.gov.au

Dear Lauren,

**RE: RESPONSE TO IESC ADVICE ON THE MAXWELL PROJECT (SSD-9526)**

I refer to the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development's (IESC's) advice to the to the Department of Planning, Industry and Environment (DPIE) regarding the Maxwell Project (SSD-9526), dated 19 November 2019.

The IESC's advice included a response to a series of DPIE questions, as well as a number of recommendations for additional assessment work and undertakings to monitor and mitigate potential impacts should the Maxwell Project be approved.

Enclosure 1 provides Malabar's responses to the IESC recommendations. Where relevant, Malabar's responses consider the detailed feedback provided by the IESC in response to the DPIE's questions.

Malabar commissioned WRM Water and Environment (WRM) to undertake additional analysis in response to the IESC's recommendations. Additional information provided by WRM is included in Enclosure 2 and referenced, where relevant, in Malabar's responses in Enclosure 1.

The *Integrated Assessment of Potential Impacts on Groundwater Dependent Ecosystems* (Appendix V of the Environmental Impact Statement) also includes relevant information in support of the responses to the IESC recommendations and is included in Enclosure 3.

Please do not hesitate to contact the undersigned should you wish to discuss.

Yours sincerely,

Bill Dean
General Manager – Projects
**Malabar Coal Limited**

ENCLOSURE 1

MALABAR'S RESPONSES TO THE IESC RECOMMENDATIONS

| ID | IESC Recommendation | Response |
|---|---|---|
| 1 | ***Pre-Determination Matters*** | |
| 1.1 | Additional evidence is needed to determine whether EPBC Act-listed ecological communities and other terrestrial vegetation (e.g. riparian flora) within the zone of groundwater drawdown are groundwater-dependent. This should include maps of depth to groundwater under existing conditions and after predicted groundwater drawdown that are overlain with vegetation mapping. | The Maxwell Project Environmental Impact Statement (EIS) included an *Integrated Assessment of Potential Impacts on Groundwater Dependent Ecosystems* (GDE Assessment) (Appendix V of the EIS). The GDE Assessment was prepared in accordance with *Assessing Groundwater Dependent Ecosystems: IESC Information Guidelines Explanatory Note [Consultation Draft]* (Doody, Hancock and Pritchard, 2018).<br>It appears as though the GDE Assessment for the Project may not have been reviewed by the IESC as it is not referenced in the list of '*References cited within the IESC's advice'*. The GDE Assessment is included in Enclosure 3.<br>Relevant to the IESC's recommendation, the GDE Assessment includes:<br>• Bureau of Meteorology (BoM) potential GDE mapping on Figure 3.<br>• A map of existing depth to groundwater on Figure 4, which indicates the depth to groundwater within the Maxwell Underground area is typically greater than 20 m.<br>• Additional detail and cross-sections (Figures 5a to 5c) regarding the shallow groundwater (depth of less than 20 m) present in alluvial areas.<br>• Detailed mapping and photographs of potentially groundwater dependent vegetation (Swamp Oak Forest) within the areas of shallower groundwater on Figures 6a to 6d.<br>• Discussion of the potential groundwater dependence of Swamp Oak Forest in Section 4.3.2, which concludes the Swamp Oak are a Type 2 GDE (ecosystems dependent on the surface expression of groundwater) as defined in the *Australian Groundwater-Dependent Ecosystems Toolbox* (Richardson et al.,2011). |
| 1.2 | An ecohydrological conceptual model is required that illustrates potential impact pathways and likely ecological responses to predicted changes in surface and groundwater quantity and quality in the project area and downstream. This conceptual model should be used to guide a comprehensive risk assessment that incorporates likely cumulative impacts under various climatic scenarios. | As described above, based on an extensive review of regional and site-specific information, the GDE Assessment concluded the only GDEs in the vicinity of the Project are the Swamp Oak Forest shown on Figures 6a to 6d of the GDE Assessment and stygofauna present in the alluvium.<br>Potential impact pathways (including water quantity and quality) are discussed in Section 5 of the GDE Assessment. These potential impact pathways have been assessed in the Surface Water Assessment (WRM Water and Environment [WRM], 2019) and Groundwater Assessment (HydroSimulations, 2019). Where relevant, the Surface Water and Groundwater Assessments consider the potential impacts of the Project in consideration of various climatic scenarios (including sensitivity to climate change).<br>With regard to potential impacts on baseflow, HydroSimulations (2019) conclude:<br>*Figure 85 shows the change in predicted net river baseflow for Saddlers Creek, Saltwater Creek and the Hunter River during and post mining. Figure 85 shows that there is no change in baseflow along Saddlers Creek and Saltwater Creek. This corresponds with the predicted area of groundwater drawdown in Layer 1 (Figure 73) that shows groundwater drawdown within the saturated alluvium is localized within the upper reaches of Saddlers Creek. This area of the creek exhibits losing conditions (refer Section 4.4 and Section 4.5), therefore no expected reduction in baseflow contributions.* |

| ID | IESC Recommendation | Response |
| --- | --- | --- |
| 1.3 | An analysis of the impacts of potential spills (e.g. during flood events) of mine-affected water from Access Road Dam and Rail Loop Dam should be provided. | There is a 1% probability (in any one year) that Rail Loop Dam and Access Road Dam could overflow to Ramrod Creek. The predicted overflow volume ranges from 20 to 30 megalitres (ML). However, overflows from these storages would only occur during extreme rainfall events. The water within the dams during these events would be heavily diluted by catchment inflows and any overflows would be further diluted by significant flows in Ramrod Creek (WRM, 2019).<br>WRM has undertaken further quantitative analysis of potential spills from the Rail Loop Dam and Access Road Dam, which concludes (refer Enclosure 2):<br>• The Rail Loop Dam and Access Road Dam are predicted to overflow in only 1 of the 103 years of historical rainfall that was modelled.<br>• During the modelled Rail Loop Dam overflows, a dilution ratio of at least 200:1 within Ramrod Creek is predicted. During the modelled Access Road Dam overflows, a dilution ratio of at least 30:1 within Ramrod Creek is predicted.<br>• Modelled overflows to Ramrod Creek would only represent between 0.5% and 3.3% of the flow in the receiving environment.<br>• The salinity of overflows from Rail Loop Dam or Access Road Dam would likely be similar or better quality than the receiving waters.<br>• The water balance model conservatively represents activities on-site. In practice, should an overflow be imminent, Malabar could rapidly increase the pumping capacity in the Access Road and Rail Loop Dams to reduce the likelihood of an overflow. |
| 1.4 | Quantitative estimates of all surface water losses resulting from subsidence should be provided. This should include analysis of the impacts on the flow regime, including increases in the duration and number of low- and zero-flow days as these changes may affect instream and riparian biota (e.g. Swamp Oaks, Casuarina glauca) along Saddlers Creek and other waterways. Ponding may also adversely affect existing vegetation and recruitment (e.g. through waterlogging). | Loss of catchment flows due to Project subsidence is considered in Section 8.5 of the Surface Water Assessment, including as a result of ponding (Section 8.5.1) and surface fracturing (Section 8.5.2).<br>WRM has undertaken further analysis of the potential impacts on the flow regime, including potential impacts on low flows, with reference to the historical Saddlers Creek flow monitoring data and the outcomes of the Geomorphology Assessment (Fluvial Systems, 2019) (refer Enclosure 2).<br>With regard to potential impacts of the Project on the low flow regime, WRM concludes (Enclosure 2):<br>*Saddlers Creek is highly baseflow driven, with the majority (approximately 90%) of recorded flows being below 1 megalitres per day (ML/d) (11.6 litres per second [L/s]). This indicates that most of the time, flow in Saddlers Creek is driven by groundwater flows (rather than surface flows). As such, any increases in ponding or surface fracturing resulting from subsidence would be unlikely to have an impact on the number of low- and zero-flow days in Saddlers Creek.*<br>Further to the above, potential subsidence impacts on streams overlying the Maxwell Underground area would be monitored and managed in accordance with the adaptive management strategy described in the Geomorphology Assessment (Fluvial Systems, 2019). In the event that monitoring identifies a loss of surface water flows, these would be licensed, as required, in accordance with the *Water Management Act, 2000*. |

| ID | IESC Recommendation | Response |
|---|---|---|
| 1.5 | The large discrepancy in the rate of seepage from spoil to the existing voids reported in the surface water (WRM 2019) and groundwater reports (HydroSimulations 2019) should be explained. | Further clarification on this issue was provided in Section 6.1.2 of the Submissions Report.<br><br>WRM (2019) calibrated the site water balance model over the period January 2017 to December 2018, for which stored water volumes on-site were available and there were no active operations at the Maxwell Infrastructure. It was assumed that there were no changes to site catchments over this period, no transfers of water between the storages or voids, and no water consumption at Maxwell Infrastructure.<br><br>The calibration review used recorded daily site rainfall data and considered the stored volume within the open voids but did not include any allowance for water stored within the in-pit spoil.<br><br>The modelled combined inventory for North Void, East Void and South Void were compared to the recorded combined void inventory, which identified an additional inflow to the voids of approximately 6.1 megalitres per day (ML/day).<br><br>HydroSimulations (2019) determined that the source of the additional inflow is seepage from the in-pit spoil, with a small contribution from external groundwater inflows (WRM, 2019). The calibrated numerical groundwater model was used to quantify the volume of external groundwater inflows to the existing final voids. This was predicted to be 3 megalitres per year (ML/year) on average and less than 11 ML/year maximum (HydroSimulations, 2019). |

| ID | IESC Recommendation | Response |
|---|---|---|
| 1.6 | To quantify confidence in groundwater modelling outputs, the proponent should provide an explanation of the differences between observed and predicted water levels in transient calibration hydrographs and the discrepancies between the current model and Gateway model and discuss how this impacts the plausible range of predicted impacts. | A Preliminary Groundwater Assessment was prepared by HydroSimulations (2018) in support of an application for a Gateway Certificate for the Project.<br>The EIS Groundwater Assessment presents the significant advances since completion of the Preliminary Groundwater Assessment. This includes additional baseline data gathered, hydrogeological conceptualisation details, numerical modelling complexity and uncertainty analyses (HydroSimulations, 2019).<br>The EIS Groundwater Assessment also considered the advice and recommendations from Department of Industry – Water (now DPIE – Water) (dated 20 December 2018), the IESC (dated 9 November 2018) and the report by the NSW Mining and Petroleum Gateway Panel that accompanied the Conditional Gateway Certificate for the Project issued on 20 December 2018. A description of how groundwater-related recommendations of the IESC and the Conditional Gateway Certificate have been addressed is presented in Appendices B and C of the Groundwater Assessment, respectively.<br>The regional groundwater model was calibrated using a range of data sources including:<br>• groundwater levels measured during the Bore Census;<br>• NSW Government groundwater level monitoring records;<br>• standpipe groundwater levels recorded during the Project groundwater monitoring program;<br>• vibrating wire piezometer (VWP) groundwater levels recorded during the Project groundwater monitoring program;<br>• groundwater levels recorded for the former Drayton Mine and Mt Arthur Mine groundwater monitoring programs;<br>• vertical groundwater level differences; and<br>• temporal groundwater level differences.<br>Overall, the calibration of the numerical groundwater model showed generally good agreement to the comprehensive groundwater level/pressure data (HydroSimulations, 2019). Section 5.3.2.1 of the EIS Groundwater Assessment provides a description of the differences between observed and simulated groundwater levels. There was no consistent over- or under-prediction of groundwater levels at the target bore locations. Groundwater levels surrounding the Hunter River and Saddlers Creek generally match well.<br>Dr Frans Kalf in the peer review of the EIS Groundwater Assessment concluded the calibration of the groundwater model is acceptable (Kalf and Associates, 2019).<br>Further to the above, Section 6.2.2 of the Maxwell Project Submissions Report includes a review of long-term underground mining case studies in the Hunter Valley that compares predicted and actual groundwater inflows. Information has been compiled from relevant groundwater assessments, groundwater reports, annual reviews and annual environmental management reports for three underground mines in the Hunter Valley with long-term (>10 years) groundwater inflow records (Ashton, Wambo and Bulga underground mines). The review indicates that measured annual groundwater inflows have typically been approximately equal to or less than those predicted with a numerical groundwater model.<br>It is also noted that the DPIE – Water and NSW Resource Access Regulator (NRAR) submission on the Project did not raise any concerns regarding the groundwater model calibration. |

<table>
<tr><th>ID</th><th>IESC Recommendation</th><th>Response</th></tr>
<tr><td>2</td><td colspan="2">Post-Determination Matters</td></tr>
<tr><td>2.1</td><td>There are substantial uncertainties in subsidence prediction associated with multi-seam mining.<br><br>• Subsidence monitoring should be designed and implemented to verify predictions, particularly along and across drainage lines. In addition to the proposed monitoring, the proponent should undertake shallow borehole monitoring of saturated alluvium underlying Saddlers Creek near its confluence with the Hunter River, as recommended by the groundwater model peer reviewer. These data could be integrated with riparian zone assessments and revegetation strategies.<br><br>• The next update to the numerical groundwater model should include quantitative uncertainty analysis that takes into account the potential influence of subsidence on finer-scale variability in hydraulic properties.<br><br>• Revegetation of riparian areas above the underground workings (ahead of mining) is needed. This should improve the resilience of stream ecosystems to subsidence impacts and help compensate for ecological impacts.</td><td>In relation to the subsidence prediction methodology, the peer reviewer, Professor Bruce Hebblewhite, noted:<br><br>It is noted that much of the Study Area is agricultural land with relatively few sensitive features that could be adversely impacted by the subsidence effects discussed. To this extent, the application of the MSEC IPM prediction methodology is considered to provide reasonable levels of confidence for subsidence prediction and impact assessment, given that “worst-case” scenarios have been adopted in the cases where greatest uncertainty exists.<br><br>Prior to causing any subsidence, Malabar would be required to prepare and submit an Extraction Plan for the Project for approval by the DPIE. This is an approval required by standard conditions of development consents for underground coal mines in NSW.<br><br>Extraction Plans are prepared for a series of panels that are a subset of the approved mine layout. There is a process to review the adequacy and effectiveness of an Extraction Plan during the preparation of a new Extraction Plan for subsequent panels.<br><br>The Extraction Plans would include performance measures for natural and built features. Malabar would implement an adaptive management approach to achieve the performance measures for the Project. Adaptive management would involve the monitoring and periodic evaluation of the environmental consequences against the performance measures, and adjustment (if necessary) of the management and control measures to achieve the adopted performance measures.<br><br>After the first three years of mining, and every five years thereafter, the validity of the groundwater model predictions would be assessed and if the data indicates significant deviation from the model predictions, an updated groundwater simulation model would be developed. Updated groundwater simulation models would be subject to comprehensive uncertainty analysis, consistent with the analysis undertaken for the Project groundwater model (HydroSimulations, 2019).<br><br>Potential subsidence impacts on streams overlying the Maxwell Underground area would be monitored and managed in accordance with the adaptive management strategy described in the Geomorphology Assessment (Fluvial Systems, 2019), which states:<br><br>If a significant increase is observed in the rate of knickpoint development or migration, these should be professionally assessed in order to determine the most appropriate control measure. The most commonly used, and reliable, approach to knickpoint control is rock grade control structures. Large wood structures are a potential alternative approach. The most appropriate method for knickpoint control would need to be assessed for each knickpoint, with access to the site likely to be a significant determinant.<br><br>Consistent with the recommendation made by Dr Frans Kalf (Attachment 6 of the EIS), Malabar would establish additional alluvial monitoring bores in the Saddlers Creek alluvium.</td></tr>
</table>

| ID | IESC Recommendation | Response |
| --- | --- | --- |
| 2.2 | The proponent should undertake an analysis to determine whether the normal fault located at Saddlers Creek materially affects groundwater flow and, if so, incorporate these findings into the updated groundwater model. Use of environmental water tracers (e.g. major ions, stable water isotopes) to identify possible inflows to the creek in the vicinity of the fault could be considered. | The Project intersects Permian aged coal measures that are folded along the Muswellbrook Anticline and Calool Syncline. Detailed site geological investigations (MBGS, 2018) identified fewer faults are present in the area than previously mapped (HydroSimulations, 2019).<br><br>Faults in the area have also been categorised more as barriers to flow rather than conduits to groundwater flow (AGE, 2013). This correlates to findings by MBGS (2018) that identified that local north-east to south-west trending faults at the Maxwell Underground are largely associated with dyke intrusions around 2 m wide (HydroSimulations, 2019).<br><br>The faults/dykes are localised within the Maxwell Underground area, therefore their presence may influence the timing of groundwater inflows from the Permian coal measures, but are unlikely to influence regional groundwater trends and Project impacts. Therefore, the dykes have not been included within the 'base case' numerical groundwater model, but have been explored within the sensitivity analysis. The sensitivity analysis indicated that inclusion of the dykes resulted in reductions in the predicted extent of depressurisation, alluvial drawdown and baseflow take, indicating the base case model design is conservative (HydroSimulations, 2019).<br><br>Notwithstanding, Malabar would undertake further hydraulic testing of the fault located at Saddlers Creek (e.g. through use of environmental water tracers) during the first three years of mining. If hydraulic testing indicates the fault could materially affect groundwater flow, these findings would be incorporated into the updated groundwater model that would be undertaken after the first three years of mining. |
| 2.3 | Given uncertainties about the volumes of surface water lost through subsidence, the proponent should monitor to verify these losses. Depending on the volumes, the proponent may require additional water licences. | Further discussion regarding the potential impacts on streams overlying the Maxwell Underground area is provided in the response to IESC Recommendation 1.4 and Enclosure 2.<br><br>Potential subsidence impacts on streams overlying the Maxwell Underground area would be monitored and managed in accordance with the adaptive management strategy described in the Geomorphology Assessment (Fluvial Systems, 2019). In the event that monitoring identifies a loss of surface water flows, these would be licensed, as required, in accordance with the *Water Management Act, 2000*. |

| ID | IESC Recommendation | Response |
|---|---|---|
| 2.4 | An existing 3.5-m knickpoint on stream b2(1) should be stabilised in advance of mining to prevent it migrating upstream following subsidence, as recommended in the excellent report by Gippel (2019). | Malabar would manage the existing knickpoint on stream b2(1) in accordance with the recommendations made in the Geomorphology Assessment prepared for the Project by Dr Christopher Gippel (Fluvial Systems, 2019), which states:<br>*The most likely scenario would be upwards migration of the existing 3.5 m high knickpoint on stream b2(1), following the flood drainage path to join with stream b2(2). Efforts to mitigate this risk should be focused on stabilising this major knickpoint.*<br>*…*<br>*If a significant increase is observed in the rate of knickpoint development or migration, these should be professionally assessed in order to determine the most appropriate control measure. The most commonly used, and reliable, approach to knickpoint control is rock grade control structures. Large wood structures are a potential alternative approach. The most appropriate method for knickpoint control would need to be assessed for each knickpoint, with access to the site likely to be a significant determinant.*<br>*It is noted that knickpoints are a ubiquitous feature of the existing environment of the Mining Study Area. Control of these existing knickpoints would involve changes to past agricultural and land management practices, such as reducing stock numbers, fencing waterways, and replanting riparian zones.*<br>*Changes to stream alignment do not necessarily need to be arrested. Forcing streams to follow their original alignment when a more hydraulically efficient path is present can be expensive and ultimately futile. In this situation, work to maintain the existing course should be undertaken only where not doing so threatens significant assets. Channel instabilities can be managed through construction of bunds to maintain runoff paths towards the original drainage line locations, or hardlining the banks and possibly beds of sections of channels that are under threat of change.*<br>Further detail regarding the management of the existing knickpoint on stream b2(1) would be included in the relevant Extraction Plan, which would need to be prepared and approved by the DPIE prior to secondary extraction occurring beneath the knickpoint on stream b2(1). |
| 2.5 | The surface water quality monitoring program should be expanded to include metals, at least including molybdenum, selenium, antimony and arsenic as recommended in the geochemistry assessment (GEM 2019). | Malabar would update the surface water quality monitoring program to include metals, including molybdenum, selenium (Se), antimony (Sb) and arsenic (As) as recommended in the geochemistry assessment (Geo-Environmental Management Pty Ltd [GEM], 2019).<br>The updated surface water quality monitoring program would be described in the Water Management Plan for the Project. |

| ID | IESC Recommendation | Response |
|---|---|---|
| 2.6 | Additional targeted ecological surveys should be undertaken to inform adaptive management as part of a risk-based approach guided by an appropriate ecohydrological conceptual model showing potential impact pathways and predicted ecological responses. | As discussed in the response to IESC Recommendation 1.2, potential impact pathways (including water quantity and quality) are discussed in Section 5 of the GDE Assessment.<br>The GDE Assessment describes that the Swamp Oak within the Saddlers Creek and Saltwater Creek are likely to be primarily accessing the stream baseflow and seepage in the soil profile rather than the deeper groundwater (Hunter Eco, 2019).<br>HydroSimulations (2019) found that stream baseflow (and surface water flow) would not be affected by the predicted Project groundwater drawdown in the alluvium. Consequently, it is unlikely that the predicted Project groundwater drawdown would adversely impact the Swamp Oak along either Saddlers Creek or Saltwater Creek.<br>Notwithstanding, Malabar would implement a monitoring program for the riparian vegetation along Saddlers Creek, which would include:<br>• monitoring of the shallow, alluvial bores in the Saddlers Creek alluvium (MW1, MW2, MB2-Alluvial and MB3-Alluvial); and<br>• annual Swamp Oak health inspections on Saddlers Creek and Saltwater Creek.<br>Malabar has an existing data-sharing agreement with BHP for the Mt Arthur Mine, and would periodically request monitoring data collected from the shallow, alluvial bores in Saddlers Creek (GW45 and GW47).<br>The outcomes of the riparian vegetation monitoring program would be reported in the Annual Review. The Annual Review would also identify if any additional monitoring sites are required, or if optimisation of the existing monitoring sites should be undertaken. |
| 2.7 | Management plans should incorporate and justify triggers to define the circumstances in which geomorphic and erosional impacts would be (actively) remediated. Proposed groundwater mitigation measures need to be detailed in a trigger-action-response plan. | Water level and water quality triggers would be developed as part of the Water Management Plan for the Project. In the event monitoring identifies an exceedance of an established trigger, Malabar would implement a response plan in accordance with the Water Management Plan for the Project. |
| 2.8 | The final landform design should address the recommendations listed in the geochemical assessment (GEM 2019, pp. 27–28). | Consistent with the recommendations made by GEM (2019), Malabar would implement the following management measures for the emplacement of coarse and fine rejects (collectively referred to as 'Rejects'):<br>• Ongoing geochemical characterisation of Rejects throughout the life of the Project (including kinetic net acid generation testing) to confirm the geochemical lag period of the material.<br>• Surface alkali treatment to extend the geochemical lag period of the Rejects or over-dumping with Rejects within the geochemical lag period so that acid conditions do not develop during active dumping.<br>• The Rejects emplacement in the East Void would be designed to prevent the reactive rejects from oxidising and the salts from migrating to the revegetation layer.<br>• Water quality monitoring program for the East Void to include; pH, EC, alkalinity/acidity, sulphate ($SO_4$), As, Sb and Se.<br>• As areas within the East Void reach the final landform surface, they would be progressively capped and rehabilitated where practical. |

| ID | IESC Recommendation | Response |
| --- | --- | --- |
| 2.9 | Assuming that the final void(s) of the existing mine will be used for the proposed project, the design and management should include:<br>• a sensitivity analysis that tests assumptions in final-void modelling and tests whether there is a chance that final voids could overtop;<br>• an assessment of the likely water quality in final void(s) and how it changes over time;<br>• an analysis of the potential for high-density saline void water to cause density-driven flow to the wider groundwater system; and<br>• if void(s) might overtop, a strategy to monitor and mitigate any adverse effects. | Pit lake equilibrium levels in the final voids were determined by WRM (2019) based on direct rainfall to the void surface and catchment runoff, less evaporation losses. The recovery groundwater modelling predicts that net groundwater inflows to the voids at the predicted equilibrium level would be negligible (HydroSimulations, 2019).<br>The historical rainfall and evaporation sequences (129 years) were repeated five times to create a long-term climate record. No overflows from any of the three voids were simulated, with the maximum modelled water level reaching (WRM, 2019):<br>• 44 m below the North Void overflow level;<br>• 9 m below the East Void overflow level; and<br>• 11 m below the South Void overflow level.<br>WRM has undertaken further analysis regarding the potential impact of climate change on the risk of overflows from the voids and conclude:<br>*Under the 'worst case' climate changes scenario using the RCP4.5 emissions scenario, the water balance modelling results show that the final void water levels are less than 0.5 m above the baseline climate conditions. This indicates that the predicted increase in annual rainfall (4.4%) is mostly offset by the predicted increase in evapotranspiration (5.5%).*<br>*Consistent with the baseline climate conditions presented in the Surface Water Assessment, the voids are predicted to remain below the target maximum water level (175 metres Australian Height Datum [mAHD]) as long-term groundwater sinks.*<br>HydroSimulations (2019) evaluated the potential impacts of the Project on groundwater resources using a numerical regional groundwater model. Groundwater modelling included predictive modelling over the life of the Project as well as recovery modelling for a 1,000-year period post-mining.<br>Pit lake levels derived by WRM (2019) were implemented in the recovery groundwater model using a series of constant heads over time. HydroSimulations (2019) simulated the long-term behaviour of the final voids and determined that they would remain as permanent and localised groundwater sinks.<br>As there is no mechanism to lose salt within the closed void system, the voids continually accumulate salt over time and become hypersaline or approach hypersaline conditions over the 400-year simulation (WRM, 2019). The salinity in each of the voids over the 400-year simulation is shown on Chart 7 of the Maxwell Project Submissions Report.<br>The Geochemistry Assessment characterised Rejects that would be generated by the four coal seams in the Jerrys Plains Subgroup being targeted for the Project. The Geochemistry Assessment determined that the Rejects are expected to be enriched with As, Sb and Se in varying degrees and the contained Se is likely to be readily soluble (GEM, 2019).<br>Metals concentrations were tested in the East Void on 31 January 2019, 28 February 2019 and 15 July 2019. On all sampling events, concentrations of As, Sb and Se were below the reporting limits of 0.001 milligrams per litre (mg/L) (As and Sb) and 0.01 mg/L (Se).<br>After the first three years of mining, and every five years thereafter, the validity of the groundwater model predictions would be assessed and if the data indicates significant deviation from the model predictions, an updated groundwater simulation model would be developed. Updated groundwater simulation models would include final void modelling, as required. |

[1] Antimony (Sb) was not tested on 15 July 2019.

ENCLOSURE 2

WRM WATER AND ENVIRONMENT LETTER
MAXWELL PROJECT SURFACE WATER ASSESSMENT – RESPONSE TO IESC COMMENTS

# Maxwell Project Surface Water Assessment

## Response to IESC comments

Malabar Coal Limited

1383-03-B4, 10 December 2019

For and on behalf of WRM Water & Environment Pty Ltd
Level 9, 135 Wickham Tce, Spring Hill
PO Box 10703 Brisbane Adelaide St Qld 4000
Tel 07 3225 0200

Matthew Briody
**Principal Engineer**

# Contents



# List of Figures



# List of Tables



# List of Plates

# 1 Introduction

In early 2019, WRM prepared a Surface Water Assessment for the Maxwell Project (the Project) on behalf of Malabar Coal Limited (Malabar), as part of the overall Environmental Impact Statement (EIS) submission.

As part of the EIS assessment process, the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) has prepared advice to the Department of Environment and Energy (DoEE) and the NSW Department of Planning, Industry and Environment (DPIE) regarding the Project.

This IESC advice included several comments and suggestions for additional work relating to the Surface Water Assessment. Malabar has requested WRM review these comments and prepare a response.

Our response to these surface water related IESC comments are provided in the following sections.

# 2 Impact of Predicted Dam Overflows

## 2.1 IESC QUERY

On Page 2 of the IESC advice, the IESC recommended the following additional work is undertaken:

- An analysis of the impacts of potential spills (e.g. during flood events) of mine-affected water from Access Road Dam and Rail Loop Dam should be provided.

## 2.2 WRM RESPONSE

Section 6.3.3 of the Surface Water Assessment for the Project states the following:

- There were no modelled overflows from Mine Entry Area (MEA) Dam, Treated Water Dam and Savoy Dam during any of the model realisations over the life of the Project.
- There is a 1% probability (in any one year) that Rail Loop Dam and Access Road Dam could overflow to Ramrod Creek. The predicted overflow volume ranges from 20 to 30 megalitres (ML). However, overflows from these storages would only occur during extreme rainfall events. The water within the dams during these events would be heavily diluted by catchment inflows and any overflows would be further diluted by significant flows in Ramrod Creek.

On the basis of the above, the Surface Water Assessment concluded that the Project would not adversely affect surface water quality in downstream receiving waters.

Notwithstanding, we have undertaken additional quantitative analysis of the predicted Rail Loop Dam and Access Road Dam overflows to confirm the assessment of potential impacts on the receiving environment (Ramrod Creek) during overflow events.

### 2.2.1 Flow Volumes

The site water balance model for the Project provides a statistical analysis of the water management system's performance encompassing 103 separate simulations representing a full range of historical climatic sequences. The simulations are based on measured rainfall data dating as far back as 1889, with the first run based on rainfall data from 1889 to 1915, the second using data from 1890 to 1916 and so on.

The Rail Loop Dam and Access Road Dam are predicted to overflow in only 1 of the 103 historical climate sequences rainfall that were modelled.

The current catchment area of Ramrod Creek to the Hunter River confluence is approximately 3,500 hectares (ha). The Project OPSIM water balance model has been used to estimate the flow in Ramrod Creek during the periods of predicted overflows from the Rail Loop Dam and Access Road Dam and calculate the available dilution ratio. The outcomes are as follows:

- During the modelled Rail Loop Dam overflows, a dilution ratio of at least 200:1 within Ramrod Creek is predicted.
- During the modelled Access Road Dam overflows, a dilution ratio of at least 30:1 within Ramrod Creek is predicted.

This indicates that the modelled overflows to Ramrod Creek would only represent between 0.5% and 3.3% of the flow in the receiving environment (at the Hunter River confluence). That is, the predicted overflows would have a negligible volumetric impact on Ramrod Creek.

### 2.2.2 Water Quality

Table 3.8 of the Surface Water Assessment shows the historical water quality within Ramrod Creek at the BHP gauges, as follows:

- At the upstream monitoring site (SW09), the median electrical conductivity (EC) is 6,260 microSiemens per centimetre (µs/cm), with 80% of the 33 samples being above 4,138 µs/cm.
- At the downstream monitoring site (SW12), the median EC is 5,120 µs/cm, with 80% of the 137 samples being above 4,504 µs/cm.
- This water quality data indicates that that Ramrod Creek is typically saline, with the vast majority of samples have an EC of greater than 4,000 µs/cm.

The predicted salinity of modelled overflows from Rail Loop Dam and Access Road Dam is between 1,750 and 4,500 µs/cm. This indicates that the salinity of overflows from Rail Loop Dam or Access Road Dam would likely be similar or better quality than the receiving waters.

In addition, given the expected dilution ratios within the receiving waters during overflows, any overflows from these dams would have a negligible impact on the water quality in Ramrod Creek.

Further, it is noted that the water balance model is run on a daily time step, which may overpredict the likelihood of overflows. Should an overflow be imminent, Malabar could rapidly increase the pumping capacity in Access Road and Rail Loop Dams to reduce the likelihood of an overflow.

# 3 Impact of Subsidence on Saddlers Creek Flow Regime

## 3.1 IESC QUERY

On Page 2 of the IESC advice, the IESC has identified the following additional work as being required:

- Quantitative estimates of all surface water losses resulting from subsidence should be provided. This should include analysis of the impacts on the flow regime, including increases in the duration and number of low- and zero-flow days as these changes may affect instream and riparian biota (e.g. Swamp Oaks, *Casuarina glauca*) along Saddlers Creek and other waterways. Ponding may also adversely affect existing vegetation and recruitment (e.g. through waterlogging).

## 3.2 WRM RESPONSE

The Subsidence Assessment (Mine Subsidence and Engineering Consultants [MSEC], 2019) concluded that:

- The drainage lines within the Maxwell Underground area are ephemeral and, therefore, surface water flows only occur during and for short periods after rainfall events.
- In times of heavy rainfall, the majority of the runoff would flow over the natural surface soil beds and would not be diverted into the dilated strata below.
- In times of low flow, however, surface water flows could be diverted into the dilated strata below the beds where the bedrock is shallow or exposed.

As part of the Geomorphology Assessment for the Project, Fluvial Systems (2019) undertook a review of potential increases in depressions based on the subsidence predictions in the Subsidence Assessment. This review indicates that increased depressions (and any associated ponding) would only occur at a small number of locations.

Section 8.5 of the Surface Water Assessment addresses the loss of catchment flows due to mine subsidence through the following mechanisms:

- Increase ponding (Section 8.5.1); and
- Surface fracturing (Section 8.5.2).

The impact assessment provided in the Surface Water Assessment found that:

- the total volume of water retained in the local waterways by the additional surface depressions, assuming no infilling, would be 32 ML; and
- potential diversion of flows into the underlying strata during low flow events would be negligible.

Review of the historical flow data for Saddlers Creek at Bowfield between 1956 and 1981 (see Figure 3.6 from the Surface Water Assessment, reproduced below) shows that the Saddlers Creek is highly baseflow driven, with the majority (approximately 90%) of recorded flows being below 1 megalitres per day (ML/d) (11.6 litres per second [L/s]). This indicates that most of the time, flow in Saddlers Creek is driven by groundwater flows (rather than surface flows). As such, any increases in ponding or surface fracturing resulting from subsidence would be unlikely to have an impact on the number of low- and zero-flow days in Saddlers Creek. In addition, the Groundwater Assessment (HydroSimulations, 2019) concluded that the Project would have zero impact on baseflow in Saddlers Creek.

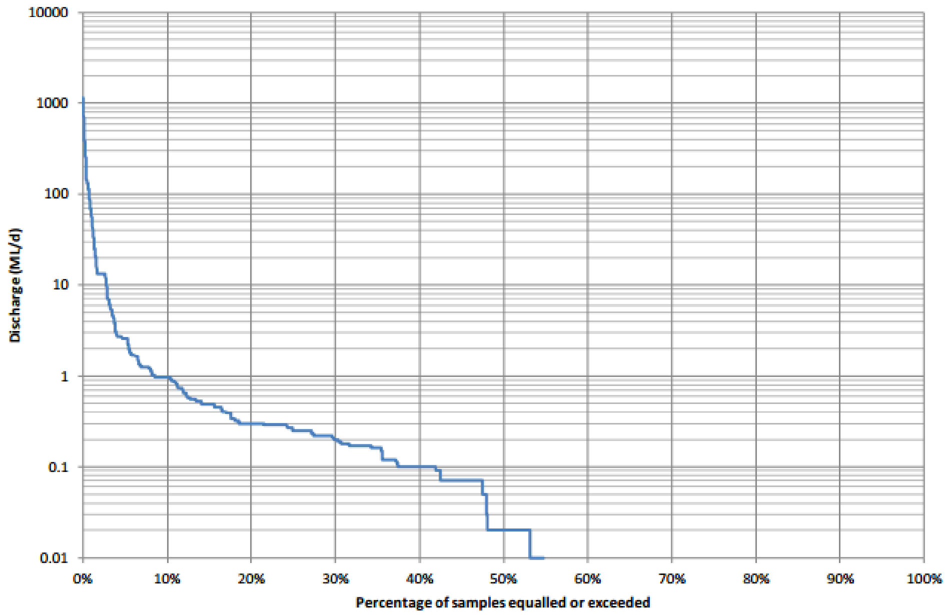



**Figure 3.6 - Derived flow-duration relationship for Saddlers Creek at Bowfield (1956-1981)**

The gullies that drain into Saddlers Creek and Saltwater Creek across the Maxwell Underground area are generally devoid of vegetation and the catchments have previously been modified (through contour banks) as part of historic agricultural activities (refer Plates 1 and 2). The predicted increases in ponding due to subsidence are unlikely to adversely affect the limited existing vegetation. In addition, the Geomorphology Assessment (Fluvial Systems, 2019) concluded that in-channel subsided areas would naturally fill with sediment over time.

**Plate 1 -Ephemeral Stream in the Maxwell Underground Area**

**Plate 2– Contour Drain in the Maxwell Underground Area**

Notwithstanding the above, we understand that Malabar would implement the periodic subsidence monitoring programme recommended in the Geomorphology Assessment, which states (Fluvial Systems, 2019):

> *This report provides data for the baseline geomorphic condition of streams in the Mining Study Area. The methodology used in this report to survey geomorphic characteristics is repeatable, and as such, the geomorphological survey undertaken for this report should be repeated after mining to identify potential impacts associated with subsidence.*
>
> …
>
> *… Objective comparison of LiDAR-derived DEMs over the entire impacted area would be the primary basis on which mining impact on stream morphology would be measured. Approaches requiring a level of subjective interpretation, including comparison of photographs or field inspections, would provide supplementary information.*
>
> …
>
> *The geomorphic response to subsidence is likely to be slow, so a frequency of five years for catchment-wide resurvey (including LiDAR survey) and reporting of stream geomorphological condition is suggested in addition to annual visual inspection. The headwater streams identified in this report would not need to be included in the monitoring program, as the risk to geomorphic character is expected to be insignificant. However, it is suggested that a sample of 10 headwater sites (i.e. randomly distributed points on headwater streams) be included in the field survey to confirm this assumption. It is noted that all streams would be monitored by the repeated LiDAR survey, so any areas of concern for headwater streams can be identified through this methodology.*

The Geomorphology Assessment also recommends a process of adaptive management to address potential subsidence impacts, which may involve allowing in-channel subsided areas to naturally fill with sediment over time. In cases where a geomorphologist determines that a subsidence impact should not be remediated (to allow it to self-heal), Malabar would engage an appropriately qualified hydrologist to confirm any water take is appropriately licensed (as required).

# 4 Probable Maximum Flood (PMF) Estimate

## 4.1 IESC QUERY (COMMENT 14)

On Page 7 of the IESC advice, Comment 14 states the following:

- The Probable Maximum Flood (PMF) was estimated using a storage-routing model with parameters that the IESC assumes have been derived from regional (and not site-specific) information. Although the overall approach adopted is reasonable, there are two issues with the estimates.
  - The catchment was assumed to be rather drier than conditions recommended in the national guidelines (Nathan and Weinmann 2019, Section 6.4), where the adopted initial and continuing losses were 15 mm and 3 mm/h, compared to the recommended values of 0 mm and 1 mm/h. (No discussion was provided on the selection of temporal patterns, storm duration or pre-burst rainfalls, which are all factors that can significantly influence the estimates).
  - There is considerable uncertainty associated with the adopted parameterisation and selected inputs, and it might be expected that simpler regional estimates of peak flow (as discussed in Nathan and Weinmann 2019, Section 6.2.4.1) could be equally relied upon.
- Overall, it is considered that the PMF estimates are about half the expected magnitude, which implies a frequency of occurrence that is about 10 to 100 times greater than that typically associated with such extreme events. That said, the annual exceedance probability of the derived estimate is likely to be rarer than 1 in 5000, and thus represent flood conditions that are very much more extreme than any in the historic record. As such, the IESC does not consider the impact of the proposed mining works on current flood risks to be of material concern.

## 4.2 WRM RESPONSE

The Saddlers Creek PMF design discharges were based on PMF design rainfalls obtained from the 2006 Commonwealth Bureau of Meteorology (BOM) published "*Guidebook to the Estimation of Probable Maximum Precipitation: Generalised South East Australia Method*". The rainfall-based approach is considered best practice for the approximation of the PMF flood discharges and far better than the regional 'quick' estimates devised in AR&R. These 'quick' estimates are used as a first pass assessment only.

Based on the IESC comment above, we have re-run the XP-RAFTS hydrologic model with the following losses for the PMF design event:

- Initial rainfall loss: 0 millimetre (mm).
- Continuing rainfall loss: 1 millimetre per hour (mm/h).

This results in a downstream peak discharge of approximately 1,030 cubic metres per second ($m^3/s$), which is only 4% greater than the modelled peak discharge of 990 $m^3/s$. This small increase in peak flow would not have a material impact on the PMF flood level or extent.

# 5 Climate Change Modelling for Final Voids

## 5.1 IESC QUERY (COMMENT 16D)

On Page 8 of the IESC advice, Comment 16d states the following:

- use of SILO data implicitly assumes that future average climatic conditions will be identical to the past and is inconsistent with the use of NARCLiM climate projections utilised in the groundwater assessment. The majority of global climate models project warmer and drier conditions for this region (e.g. CSIRO, 2012). It is prudent to assess the performance of the site water management system under these projected changes, where factors required to adjust historic climate series by simple scaling can be obtained from the NSW Climate Data Portal (NSW Government 2019a) or the Australian Climate Futures tool (CSIRO and BOM 2019).

## 5.2 WRM RESPONSE

### 5.2.1 Methodology and Sensitivity Parameters

The potential changes to climate beyond the life of the Project were assessed using the projections and methodologies given in the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Commonwealth Bureau of Meteorology (BoM) report entitled “Climate Change in Australia Technical Report” (CSIRO, 2015). This report provides guidance on the possible projections of future climate for the Australian East Coast based on a current understanding of the climate system, historical trends and model simulations of the climate response to changing greenhouse gas and decreasing aerosol emissions.

Projections are given for a number of climatic variables including (but not limited to) temperature, rainfall, wind speed and potential evapotranspiration. CSIRO (2015) presents a number of possible approaches to quantify risks associated with climate change impacts.

For this assessment, the Representative Concentration Pathway 4.5 (RCP4.5) emissions scenario has been adopted. The year 2090 was selected as the representative year, being approximately 50 years post-mine life. Potential changes in climate have been obtained using the projection builder tool provided in the Climate Change Australia website. Climate variable inputs for the ‘best case’, and ‘worst case’ RCP4.5 climate change scenarios are provided in Table 5.1.

Table 5.1 – Projections of changes to climate – Year 2090

| Scenario | Climate model | Rainfall Annual change | Evapotranspiration Annual change |
|---|---|---|---|
| Best case | GFDL-ESM2M | -19.8% | 6.9% |
| Worst case | NorESM1-M | 4.4% | 5.5% |

### 5.2.2 Potential Climate Change Impacts

#### 5.2.2.1 Overview

Potential climate change impacts to the final void water balance was assessed by simulating the 'worst' case climate scenario for the Year 2090 climate change projection, as it represents the scenario which is critical from a containment perspective (highest increase in rainfall with lowest increase in evapotranspiration). The water balance model climate inputs (rainfall and evaporation) were factored by the values given in Table 5.1.

#### 5.2.2.2 Potential Impact on Final Void Water Levels

The impact of the potential changes in rainfall and evapotranspiration for the proposed final voids are presented in Figure 5.1, Figure 5.2 and Figure 5.3. The results show the following (with the baseline results shown for reference):

- North Void: The equilibrium and peak water level are less than 0.5 m higher than under baseline climate conditions.
- East Void: The equilibrium and peak water level are less than 0.5 m higher than under baseline climate conditions.
- South Void: The equilibrium and peak water level are less than 0.5 m higher than under baseline climate conditions.

Under the 'worst case' climate changes scenario using the RCP4.5 emissions scenario, the water balance modelling results show that the final void water levels are less than 0.5 m above the baseline climate conditions. This indicates that the predicted increase in annual rainfall (4.4%) is mostly offset by the predicted increase in evapotranspiration (5.5%).

Consistent with the baseline climate conditions presented in the Surface Water Assessment, the voids are predicted to remain below the target maximum water level (175 metres Australian Height Datum [mAHD]) as long-term groundwater sinks.

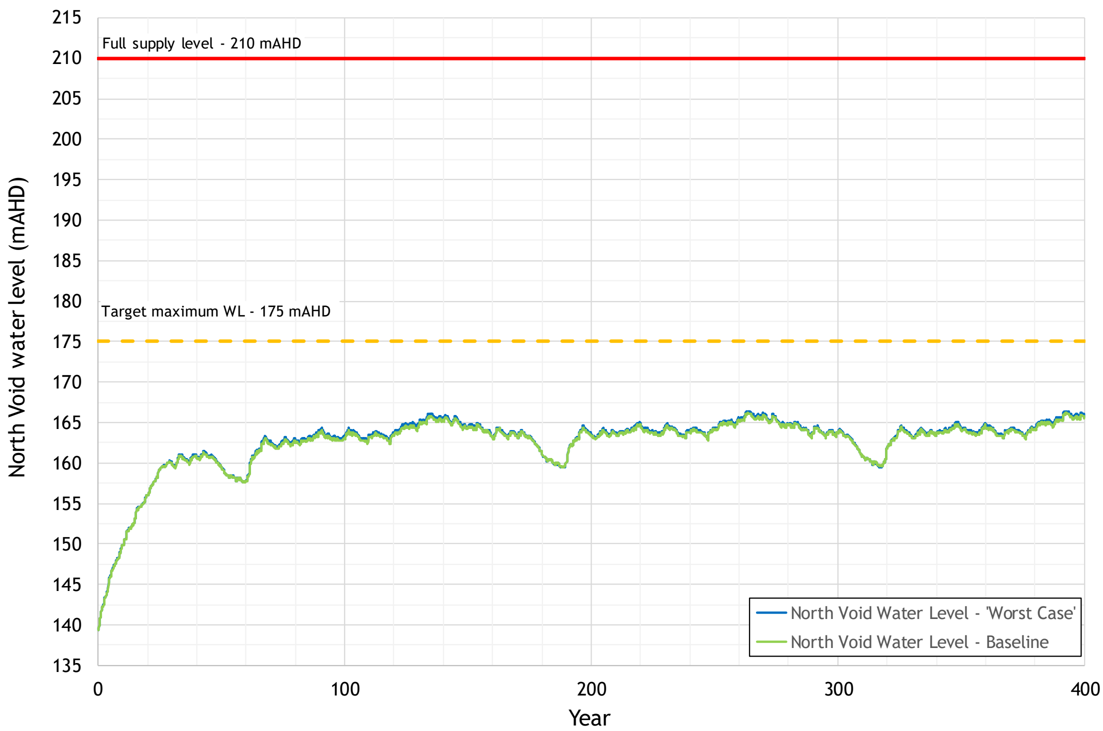



**Figure 5.1 - North Void water level - climate change assessment**

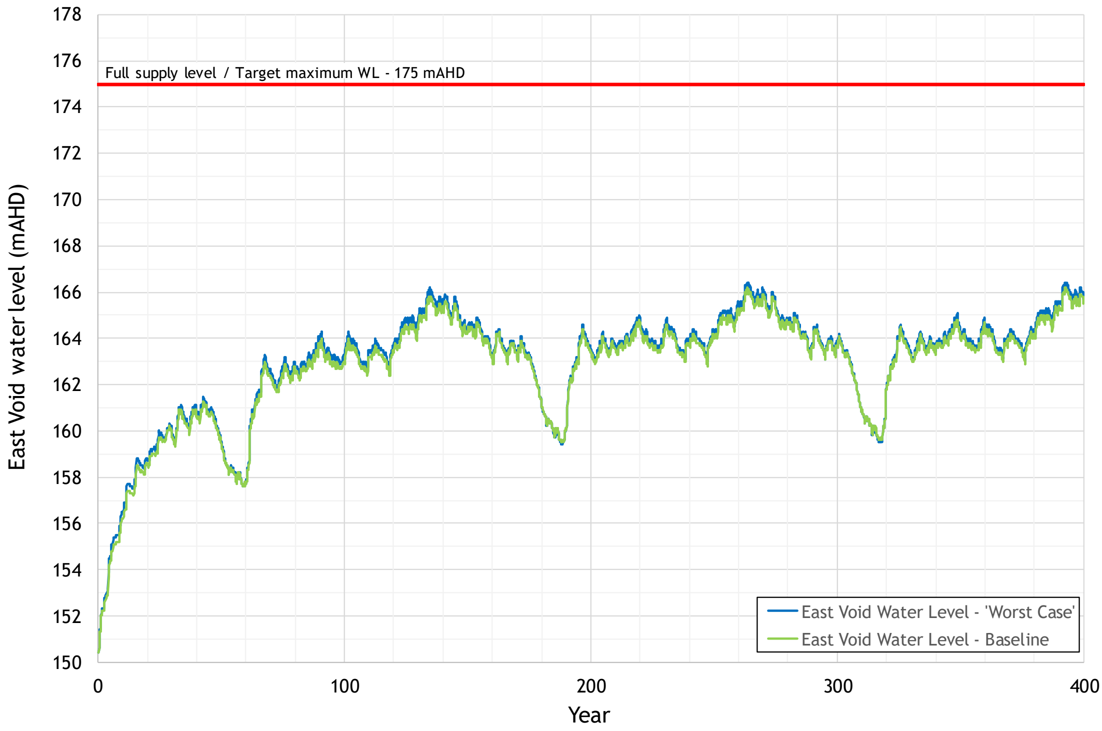



**Figure 5.2 - East Void water level - climate change assessment**

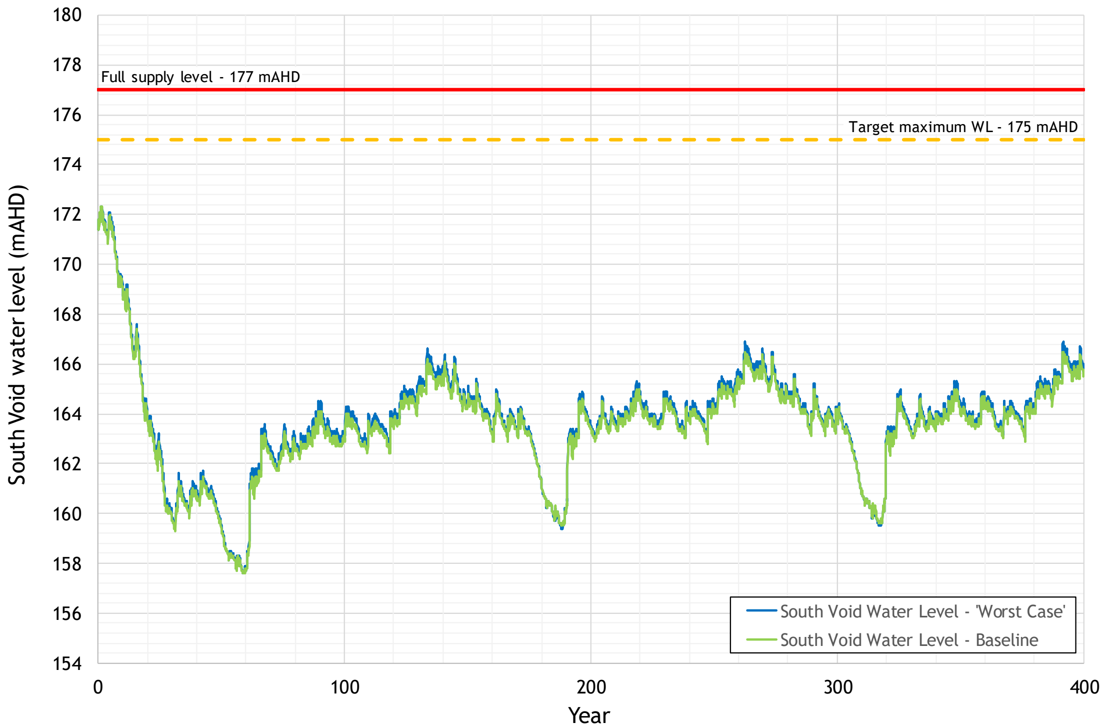



**Figure 5.3 - South Void water level - climate change assessment**

# 6 References


| | |
|---|---|
| BOM, 2006 | *Guidebook to the Estimation of Probable Maximum Precipitation: Generalised South East Australia Method*, Hydrometeorological Advisory Service, October 2006. |
| CSIRO, 2015 | *Climate Change in Australia Technical Report*. |
| Fluvial Systems, 2019 | *Maxwell Project, Environmental Impact Statement, Technical Study Report, Geomorphology Assessment,* prepared for Malabar Coal Limited by Fluvial Systems, June 2019. |
| HydroSimulations, 2019 | *Maxwell Project Groundwater Assessment,* Report No. HS2018/44, prepared for Malabar Coal Limited by HydroSimulations, July 2019 |
| MSEC, 2019 | *Subsidence Predictions and Impact Assessment for the Maxwell Project,* Report No. MSEC986, prepared for Malabar Coal Limited by MSEC, 9 July 2019. |
| WRM, 2019 | *Surface Water Assessment – Maxwell Project*, Report No. 1383-02-J5, prepared for Malabar Coal Limited by WRM Water and Environment Pty Ltd, 9 July 2019. |

ENCLOSURE 3

INTEGRATED ASSESSMENT OF POTENTIAL IMPACTS ON GROUNDWATER DEPENDENT ECOSYSTEMS
APPENDIX V OF THE ENVIRONMENTAL IMPACT STATEMENT

MALABAR COAL

MAXWELL PROJECT

# APPENDIX V

## Integrated Assessment of Potential Impacts on Groundwater Dependent Ecosystems

**MAXWELL PROJECT**

**INTEGRATED ASSESSMENT OF POTENTIAL IMPACTS ON GROUNDWATER DEPENDENT ECOSYSTEMS**

MALABAR COAL

JULY 2019
Project No. SHM-18-03
Document No. 00990868

## TABLE OF CONTENTS

## LIST OF TABLES



## LIST OF FIGURES

# 1 INTRODUCTION

Maxwell Ventures (Management) Pty Ltd, a wholly owned subsidiary of Malabar Coal Limited (Malabar), is seeking consent to develop an underground coal mining operation, referred to as the Maxwell Project (the Project).

The Project is in the Upper Hunter Valley of New South Wales (NSW), east-southeast of Denman and south-southwest of Muswellbrook (Figure 1).

Malabar owns and manages the existing infrastructure within Coal Lease (CL) 229, Mining Lease (ML) 1531 and CL 395 (known as the 'Maxwell Infrastructure') (Figure 2). The Maxwell Infrastructure includes an existing coal handling and preparation plant (CHPP), rail facilities and other infrastructure and services (including water management infrastructure, administration buildings, workshops and services). The Project would include the use of the substantial existing Maxwell Infrastructure, along with the development of some new infrastructure (Figure 2).

This Integrated Assessment of Potential Impacts on Groundwater Dependent Ecosystems (GDE Assessment) forms part of an Environmental Impact Statement (EIS), which has been prepared to accompany a Development Application for the Project in accordance with Part 4 of the NSW *Environmental Planning and Assessment Act, 1979*.

## 1.1 PURPOSE

This GDE Assessment has been prepared to satisfy the assessment requirements pertaining to Groundwater Dependent Ecosystems (GDEs) in the Secretary's Environmental Assessment Requirements (SEARs), regulatory input to the SEARs and relevant GDE guidelines.

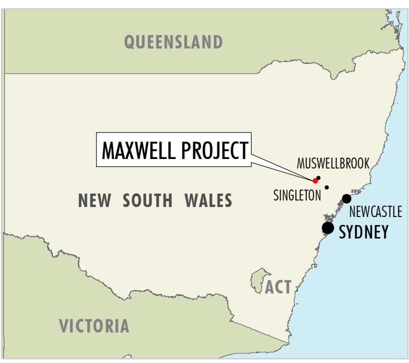
## 1.2 METHODOLOGY

This GDE Assessment draws on information and assessments in the following technical reports prepared for the Maxwell Project:

- Biodiversity Development Assessment Report (Hunter Eco, 2019);
- Groundwater Assessment (HydroSimulations, 2019);
- Surface Water Assessment (WRM Water & Environment Pty Ltd [WRM], 2019);
- Aquatic Ecology and Stygofauna Assessment (Eco Logical Australia [Eco Logical], 2019);
- Subsidence Assessment (Mine Subsidence Engineering Consultants Pty Ltd [MSEC], 2019); and
- Geomorphology Assessment (Fluvial Systems Pty Ltd [Fluvial Systems], 2019).

The remainder of this report is structured as follows:

- Section 2: provides an overview of the Project.
- Section 3: outlines the regulatory requirements relevant to this GDE Assessment.
- Section 4: identifies potential GDEs, including their level of groundwater dependence and baseline condition.
- Section 5: assesses the likelihood, frequency and magnitude of potential impacts to each GDE.
- Section 6: outlines proposed measures to avoid or mitigate impacts to GDEs and establishes a monitoring program to assess the effectiveness of mitigation or identify unexpected impacts.


LEGEND
- Mining Operation
- Proposed Mining Operation
- Railway
- Local Government Boundary
- State Forest
- National Parks and Wildlife Service Estate
- Maxwell Project Exploration Licence Boundary
- Maxwell Project Mining and Coal Lease Boundary
- Indicative Extent of Underground Development

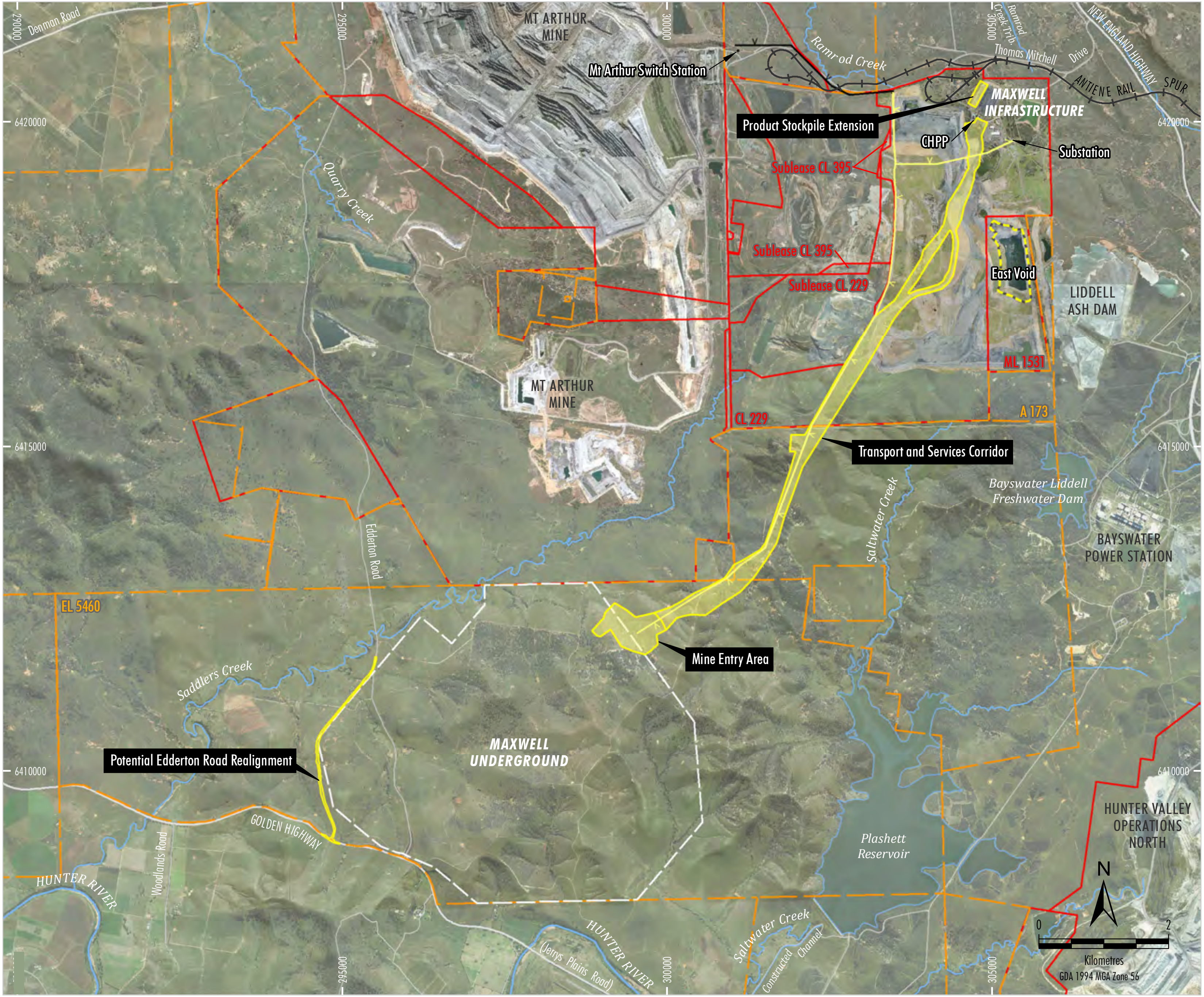
*Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services and Innovation (2019); Office of Environment and Heritage NSW (2019)*

MALABAR COAL

MAXWELL PROJECT

**Regional Location**

**Figure 1**




LEGEND

- Railway
- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Extent of Underground Development
- Indicative Surface Development Area
- CHPP Reject Emplacement Area
- Proposed 66 kV Power Supply
- Proposed Ausgrid 66 kV Power Supply Extension #

# Subject to separate assessment and approval.

*Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019) Orthophoto Mosaic: 2018, 2016, 2011*

MALABAR COAL

MAXWELL PROJECT

**Project General Arrangement**

**Figure 2**

SHM-18-03 Maxwell_EIS_App GDE_202A

## 2 PROJECT OVERVIEW

The Project would involve an underground mining operation that would produce high quality coals over a period of approximately 26 years.

At least 75% of coal produced by the Project would be capable of being used in the making of steel (coking coals). The balance would comprise export thermal coals suitable for the new-generation High Efficiency, Low Emissions power generators.

The Project would involve extraction of run-of-mine (ROM) coal from four seams within the Wittingham Coal Measures using the following underground mining methods:

- underground bord and pillar mining with partial pillar extraction in the Whynot Seam; and
- underground longwall extraction in the Woodlands Hill Seam, Arrowfield Seam and Bowfield Seam.

The substantial existing Maxwell Infrastructure would be used for handling, processing and transportation of coal for the life of the Project. The Maxwell Infrastructure includes an existing CHPP, train load-out facilities, and other infrastructure and services (including water management infrastructure, administration buildings, workshops and services).

A mine entry area would be developed for the Project in a natural valley in the north of EL 5460 to support underground mining and coal handling activities and provide for personnel and materials access.

ROM coal brought to the surface at the mine entry area would be transported to the Maxwell Infrastructure area. Early ROM coal would be transported via internal roads during the construction and commissioning of an overland conveyor system. Subsequently, ROM coal would be transported to the Maxwell Infrastructure area via the overland conveyor system.

The Project would support continued rehabilitation of previously mined areas and overburden emplacements areas within CL 229, ML 1531 and CL 395. The volume of the East Void would be reduced through the emplacement of reject material generated by Project coal processing activities and would be capped and rehabilitated at the completion of mining.

An indicative Project general arrangement showing the underground mining area and key infrastructure is provided on Figure 2. A detailed description of the Project is provided in the main document of the EIS.

# 3 REGULATORY REQUIREMENTS

## 3.1 SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

The SEARs for the Project were issued by the NSW Department of Planning and Environment (DP&E) on 3 September 2018. Supplementary SEARs were issued on 20 November 2018 and revised SEARs were issued on 17 January 2019. Relevant government agencies provided input into the SEARs, including the Department of Industry – Water (DI – Water) and NSW Office of Environment and Heritage (OEH).

The SEARs state that the EIS must present an assessment of the likely impacts of the Project on GDEs. Relevant requirements from the DI – Water and OEH input to the SEARs include:

- A map showing the location of GDEs (Section 4).
- An assessment of potential impacts on GDEs (Section 5).

## 3.2 GATEWAY CERTIFICATE AND REPORT

Malabar lodged an application for a Gateway Certificate (Gateway Application) for the Project in August 2018.

A Conditional Gateway Certificate for the Maxwell Coal Project (Gateway Certificate) was issued by the NSW Mining and Petroleum Gateway Panel (Gateway Panel) on 20 December 2018. The Gateway Certificate recommended that Malabar complete studies on GDEs for the EIS.

The Gateway Certificate was accompanied by a report prepared by the Gateway Panel (Gateway Panel Report). The Gateway Panel Report was informed by advice provided by the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) (IESC, 2018a). A summary of the IESC recommendations pertaining to GDEs is provided in Table 1.

## 3.3 KEY GUIDELINES

The following guidelines have been considered in the preparation of this GDE Assessment:

- *Information Guidelines for the Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals* (IESC, 2018b).
- *Assessing Groundwater Dependent Ecosystems: IESC Information Guidelines Explanatory Note [Consultation Draft]* (Doody, Hancock and Pritchard, 2018).
- *NSW State Groundwater Dependent Ecosystems Policy* (NSW Department of Land and Water Conservation, 2002).
- *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (NSW Office of Water, 2012).

**Table 1**
**IESC Recommendations to Gateway Panel**

| Recommendation | Report Section |
|---|---|
| *30. A detailed, independent and peer reviewed assessment of the potential surface to seam fracturing with an integrated hazard map (c.f. Herron et. al. 2018) overlaying the GDEs, BSAL areas, geological structures and drainage lines close to the Hunter River alluvium is needed.* | Sections 4 and 5 |
| *39. An assessment of the extent and condition of GDEs and water-dependent flora and fauna is needed, followed by an appropriate risk assessment (e.g. Serov et al. 2012). These studies should consider the ecological water requirements for any water-dependent species and their habitat. The locations of any shallow groundwater discharge points and other GDEs should be included, especially in areas where drawdown is predicted. A systematic approach to the assessment of GDEs is recommended in which:* | Section 4.3.2 |
| *a. the methods from, for example, the Australian GDE Toolbox (Richardson et al. 2011) and Eamus et al. (2015) are used to assess groundwater use by vegetation (especially during dry periods).* | Section 4.3.2 |
| *b. the hydrogeological conceptualisation is used to identify areas of shallow groundwater (less than 20 m below ground level) and potential areas of groundwater discharge.* | Section 4.2 |
| *c. vegetation, seasonal depths to groundwater and shallow groundwater drawdown maps are overlaid to identify areas of potential GDEs. These maps should be supported by monitoring data gathered near the regions occupied by potential GDEs, with the shallow groundwater monitoring locations also plotted on the maps.* | Sections 4.2 and 5; Figures 3, 4, 5 and 7 |
| *d. ecohydrological conceptualisations are used that integrate results from hydrogeological, hydrological, geomorphological and ecological investigations at a spatial and temporal scale that is suitable for predicting potential impacts to GDEs and pathways of likely effects of the proposed development. The identified potential impact pathways should then be used to develop proposed mitigation strategies and to monitoring of these strategies' effectiveness.* | Sections 5 and 6 |

# 4 IDENTIFICATION OF GROUNDWATER DEPENDENT ECOSYSTEMS

GDEs are ecosystems that rely upon groundwater for their continued existence. GDEs may be completely dependent on groundwater, such as aquifer GDEs, or may access groundwater intermittently to supplement their water requirements, such as riparian tree species in arid and semi-arid areas (IESC, 2018a).

There are two main types of GDEs (Hunter Eco, 2019):

- ecosystems that are dependent in whole or in part on water reserves held in the ground; and
- ecosystems that are dependent on the surface expression of groundwater.

Water reserves held in the ground form the saturated part of the aquifer soil matrix that sits below the 'water table' or 'phreatic surface', and are differentiated from water bound in the soil matrix in the unsaturated zone above the water table (Hunter Eco, 2019). Water in the soil aquifers originates from all or any of (Hunter Eco, 2019):

- rainfall directly on the aquifer surface;
- runoff from areas immediately adjacent to the aquifer; or
- sub-surface inflow.

The structure of these water reserves or aquifers is significant for plant use of the available water. For root access to water, the aquifer needs to be unconstrained by any impenetrable rock layers. Unconstrained aquifers consist of a lower saturated zone above which lies an unsaturated zone, referred to as the capillary fringe or vadose zone. The surface of the saturated zone where water pressure equals atmospheric pressure is the phreatic zone (Hunter Eco, 2019).

Vegetation making up a GDE, termed 'phreatophytic' and consisting of 'phreatophytes', can have varying degrees of dependency on the groundwater. Obligate GDEs are made up of species that depend entirely on the groundwater and are capable of living with their roots continually wet, or at least for seasonal periods of inundation. Facultative GDEs contain species that access the groundwater via the capillary fringe and also take up water from within the soil matrix above this area (Hatton and Evans, 1998). These plants cannot cope with having their roots inundated with water (Hunter Eco, 2019).

Depth to water is an important consideration for identifying potential GDE and in this context plant rooting depth is relevant. While some plants are capable of sending roots tens of metres into the soil, generally the plants in dry sclerophyll woodland, including trees, would have maximum root depth of approximately 5 metres (m) (Canadell *et al.*, 1996).

The time scale of availability of water to GDEs also needs to be considered and this has been shown to vary from annual seasonal to as infrequently as 6 months in 10 – 20 years (Eamus *et al.*, 2006).

A GDE can also be in a perched system where the soil matrix holds water and prevents this water from penetrating the deeper soil layers. In these perched systems, the vegetation will consist of species that are dependent on a generally permanently wet environment. There can be a link between perched GDEs and an underlying aquifer where the replenishing of the water in the perched system occurs when, as a result of sufficient rainfall, the groundwater overflows into the perched system (Hunter Eco, 2019).

## 4.1 DESKTOP REVIEW OF GROUNDWATER DEPENDENT ECOSYSTEMS

The *Groundwater Dependent Ecosystem Atlas* (GDE Atlas) was developed by the Commonwealth Bureau of Meteorology (BoM) as a national dataset of Australian GDEs to inform groundwater planning and management (BoM, 2018). The Atlas contains information about three types of ecosystems:

- Aquatic ecosystems that rely on the surface expression of groundwater, including surface water ecosystems which may have a groundwater component, such as rivers, wetlands and springs.
- Terrestrial ecosystems that rely on the subsurface presence of groundwater.
- Subterranean ecosystems, including cave and aquifer ecosystems.

GDEs derived in the GDE Atlas are mapped according to the following classifications:

- High potential for groundwater interaction.
- Moderate potential for groundwater interaction.
- Low potential for groundwater interaction.

The GDE Atlas identifies the following potential aquatic and terrestrial[1] GDEs in the vicinity of the Project (Figure 3):

- Aquatic habitat within the Hunter River is mapped as having high potential for groundwater interaction.
- Aquatic habitat within Saddlers Creek is mapped as having moderate to high potential for groundwater interaction.
- Terrestrial vegetation along the Hunter River and Saddlers Creek is mapped as having low potential for groundwater interaction.
- The majority of the remaining terrestrial vegetation in the vicinity of the Project is mapped as having low potential for groundwater interaction.

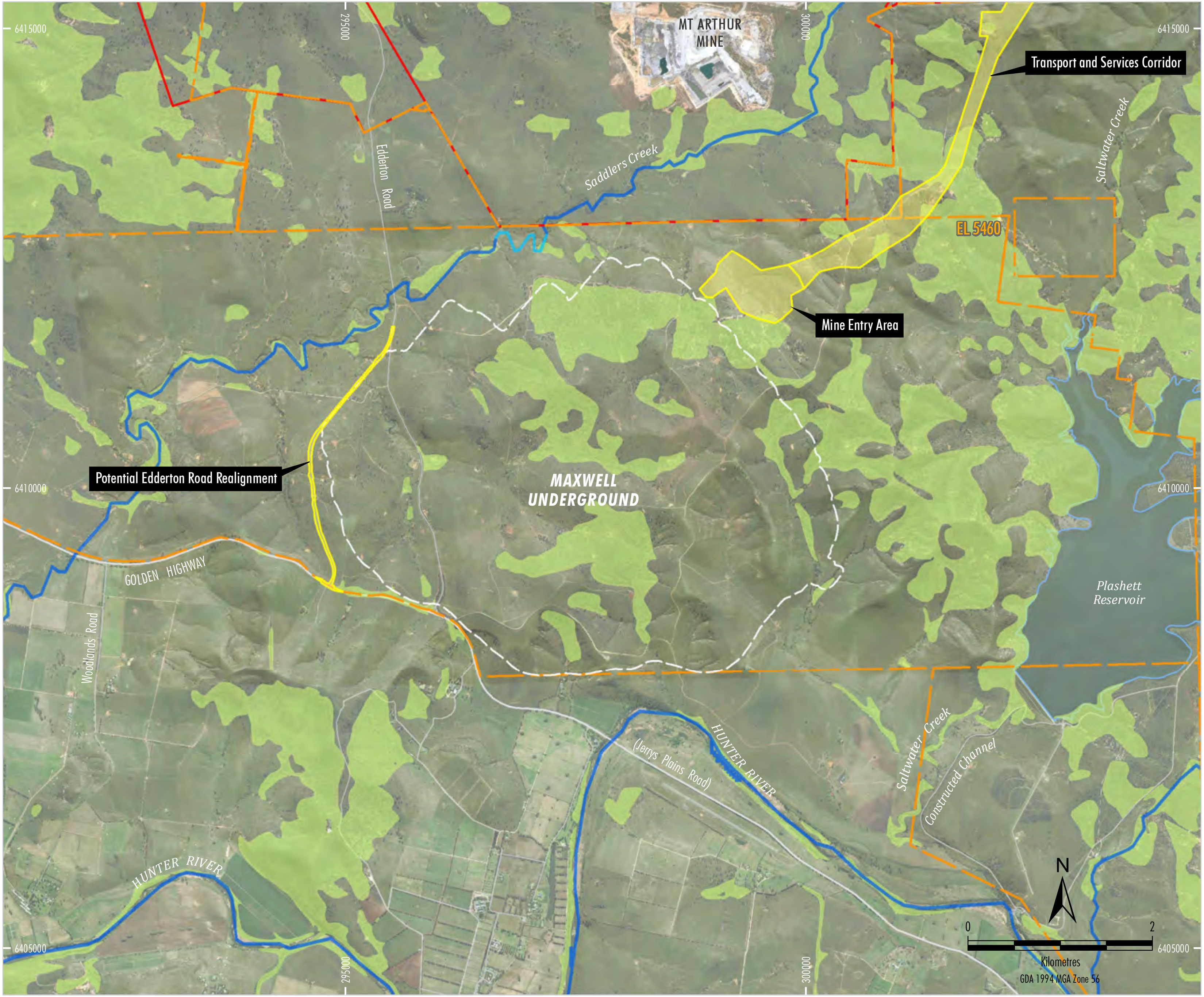
## 4.2 GROUNDWATER SYSTEMS

A conceptual hydrogeological model of the existing groundwater regime was developed by HydroSimulations (2019), based on the review of the available baseline groundwater data and relevant water sharing plans (Appendix B). The three main groundwater systems identified by HydroSimulations (2019) are:

- alluvium associated with the Hunter River;
- alluvium associated with Saddlers Creek; and
- Permian strata that host the coal measures.

The Project coal resource is located within the Jerrys Plains Subgroup, forming part of the upper and middle units of the Wittingham Coal Measures. The Jerrys Plains Subgroup is within the porous rock (i.e. sedimentary rock) groundwater systems of the Sydney Basin and lies within the boundary defined in the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016.*

[1] The GDE Atlas has not analysed the presence of subterranean ecosystems in NSW.




LEGEND

- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Extent of Conventional Subsidence (20 mm subsidence contour)

Potential Terrestrial Groundwater Dependent Ecosystems

- Low Potential GDE

Potential Aquatic Groundwater Dependent Ecosystems

- High Potential GDE
- Moderate Potential GDE

*Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); MSEC (2019); BOM Atlas (2019) Orthophoto Mosaic: 2018, 2016, 2011*

MALABAR COAL

MAXWELL PROJECT

**Groundwater Dependent Ecosystems - Atlas Mapping**

**Figure 3**

SHM-18-03 Maxwell_EIS_App GDE_203B

Alluvial sediments associated with Saddlers Creek, the Hunter River and Saltwater Creek exist to the north-west, south and east of the proposed Maxwell Underground.

The Hunter River alluvium is the most productive aquifer in the region and comprises surficial silts and clays overlying basal sands and gravels up to 20 m depth. The basal sands and gravels are thickest along the alignment of the Hunter River, thinning out toward the edges of the extent of mapped alluvium (HydroSimulations, 2019).

The thick sequences of permeable sands and gravels in the Hunter River alluvium are considered 'highly productive' in accordance with the Aquifer Interference Policy (AIP) (NSW Government, 2012). The edge of the Hunter River alluvium primarily consists of silts and clays that are largely unsaturated and considered 'less productive' (HydroSimulations, 2019).

The stratigraphy of the alluvium along Saddlers Creek varies along the reach due to changes in the depositional environment. HydroSimulations (2019) summarises the stratigraphy of the Saddlers Creek alluvium as follows:

- Basal sands and gravels associated with a higher energy fluvial system occur at the lower reaches of the creek, at the confluence with the Hunter River.
- Further upslope, away from the Hunter River, the stratigraphy comprises surficial clays/silt overlying a heterogeneous distribution of sands and gravels.
- Within the upper reaches of the creek, the stratigraphy largely comprises clays and sandy clays.

The yield of the Saddlers Creek alluvium near the confluence with the Hunter River is expected to be similar to that of the Hunter River alluvium, while the yield further upslope is expected to be lower due to the dominant silts and clays.

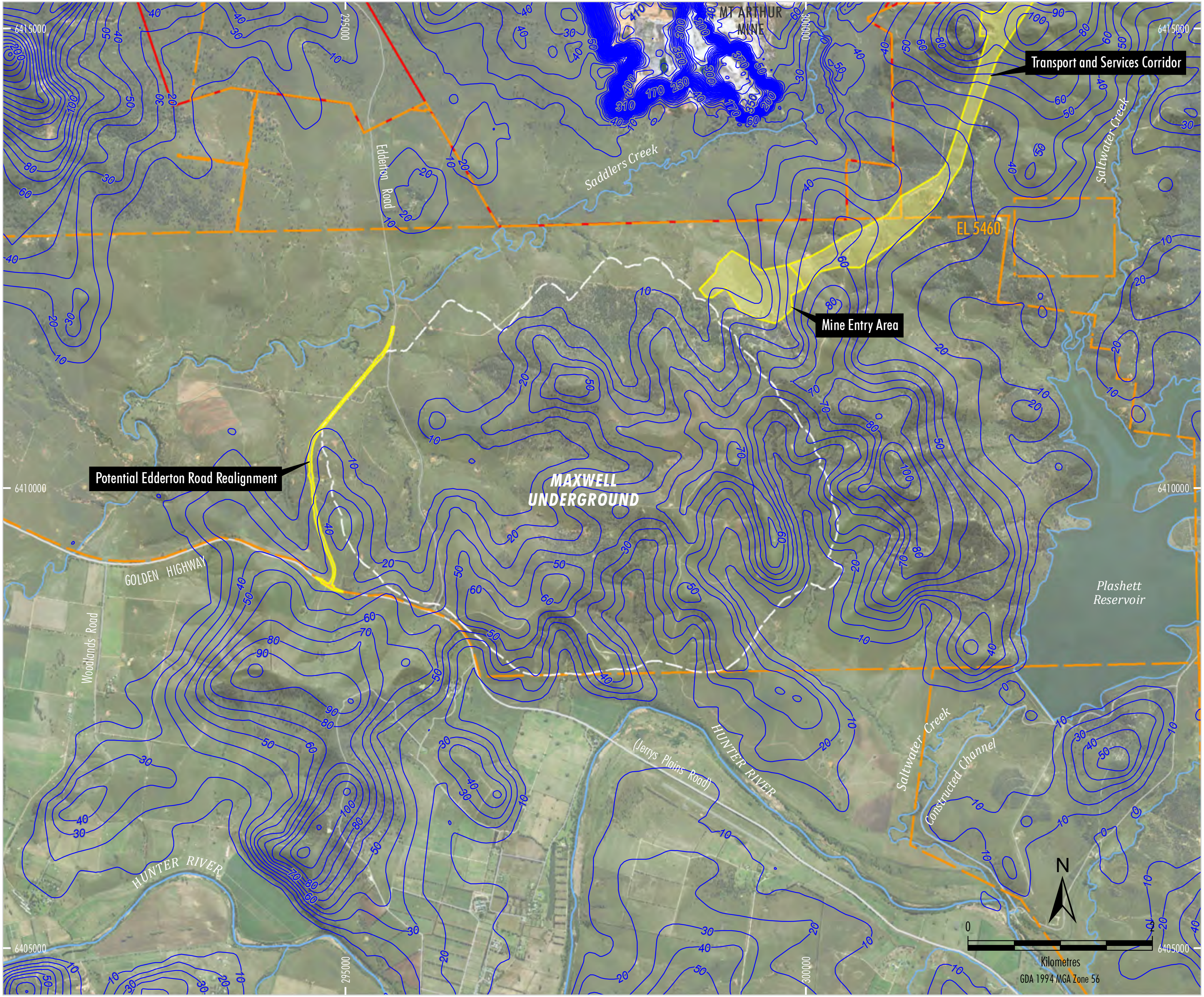
A Project-specific groundwater investigation program has been undertaken to ascertain the extent of the Saddlers Creek alluvium and Hunter River alluvium in the vicinity of the Project, including:

- *Maxwell Project Geomorphology Assessment* (Fluvial Systems, 2019);
- *Alluvial Drilling Report – Maxwell Project* (ENRS, 2018); and
- *AgTEM Survey Investigating Groundwater on Maxwell Underground Coal Mine prospect* (Groundwater Imaging, 2018).

The depth to the groundwater table in the vicinity of the Project is shown on Figure 4. The depth to groundwater within the Maxwell Underground area is typically greater than 20 m.

Shallower groundwater (less than 20 m below the surface of the ground) is present within the alluvium adjacent to the Maxwell Underground area. The interpreted extent of the alluvium in the vicinity of the Project is shown on Figures 5a to 5c.

The tributaries of Saddlers and Saltwater Creek within the Maxwell Underground area comprise narrow and shallow clayey units and were dry at the time of the geomorphology field survey. The tributaries are likely to intermittently store water only during, and for a limited period after, significant rainfall events. Thus, they are unlikely to contain a significant exploitable groundwater resource (Fluvial Systems, 2019).




LEGEND
- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Depth to Water (m)

*Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); MSEC (2019); HydroSimulations (2019) Orthophoto Mosaic: 2018, 2016, 2011*

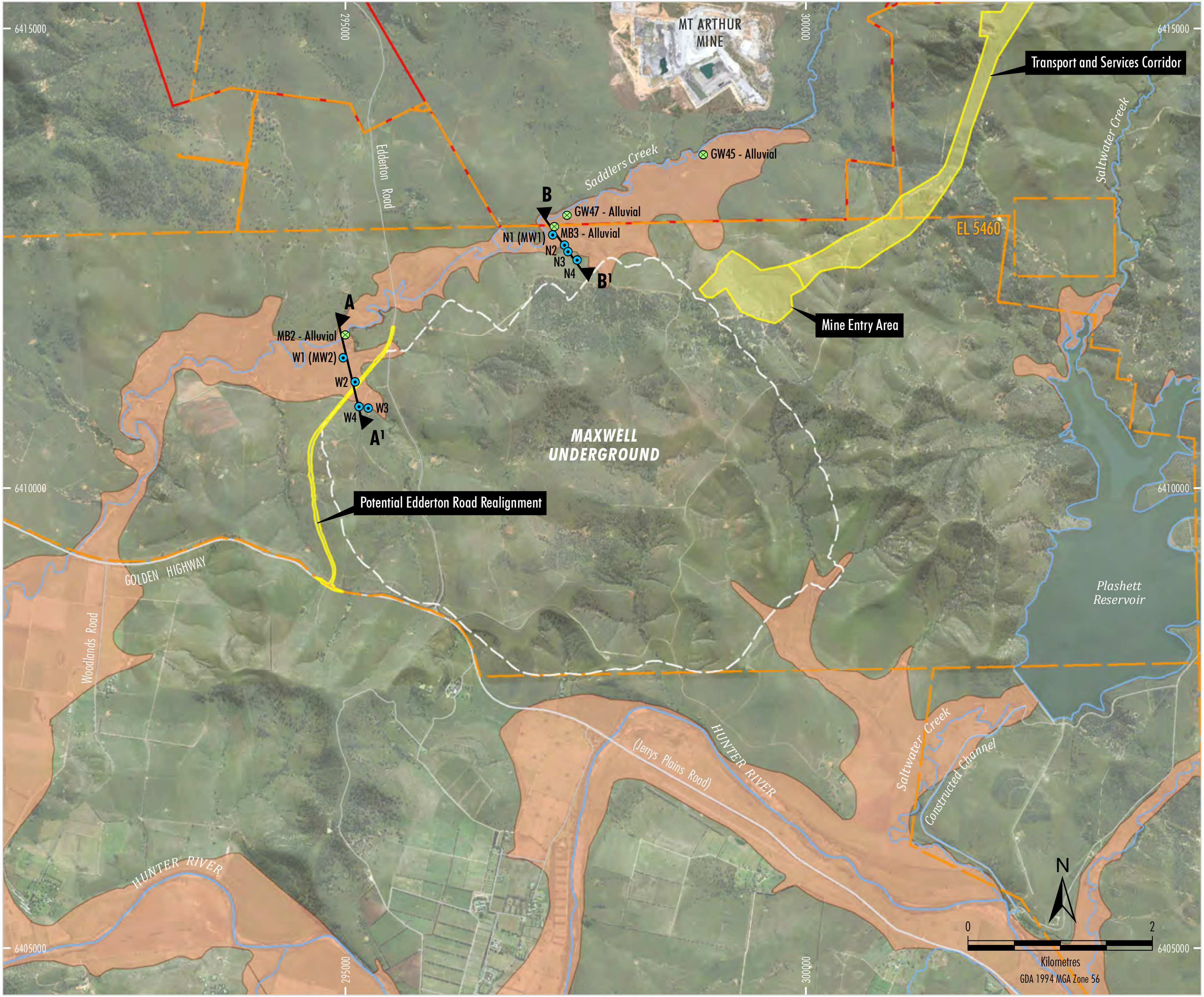
MALABAR COAL

M A X W E L L   P R O J E C T

**Regional Water Table**

**Figure 4**

SHM-18-03 Maxwell_EIS_App GDE_204A




LEGEND

- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Interpreted Alluvial Boundary
- Alluvial Investigation Drillhole
- Existing Alluvial Monitoring Bore

Refer Figures 5b and 5c for cross-sections.

*Source: © NSW Department of Planning and Environment (2018); NSW Department of Finance, Services & Innovation (2018); HydroSimulations (2019); MSEC (2019)*
*Orthophoto Mosaic: 2018, 2016, 2011*

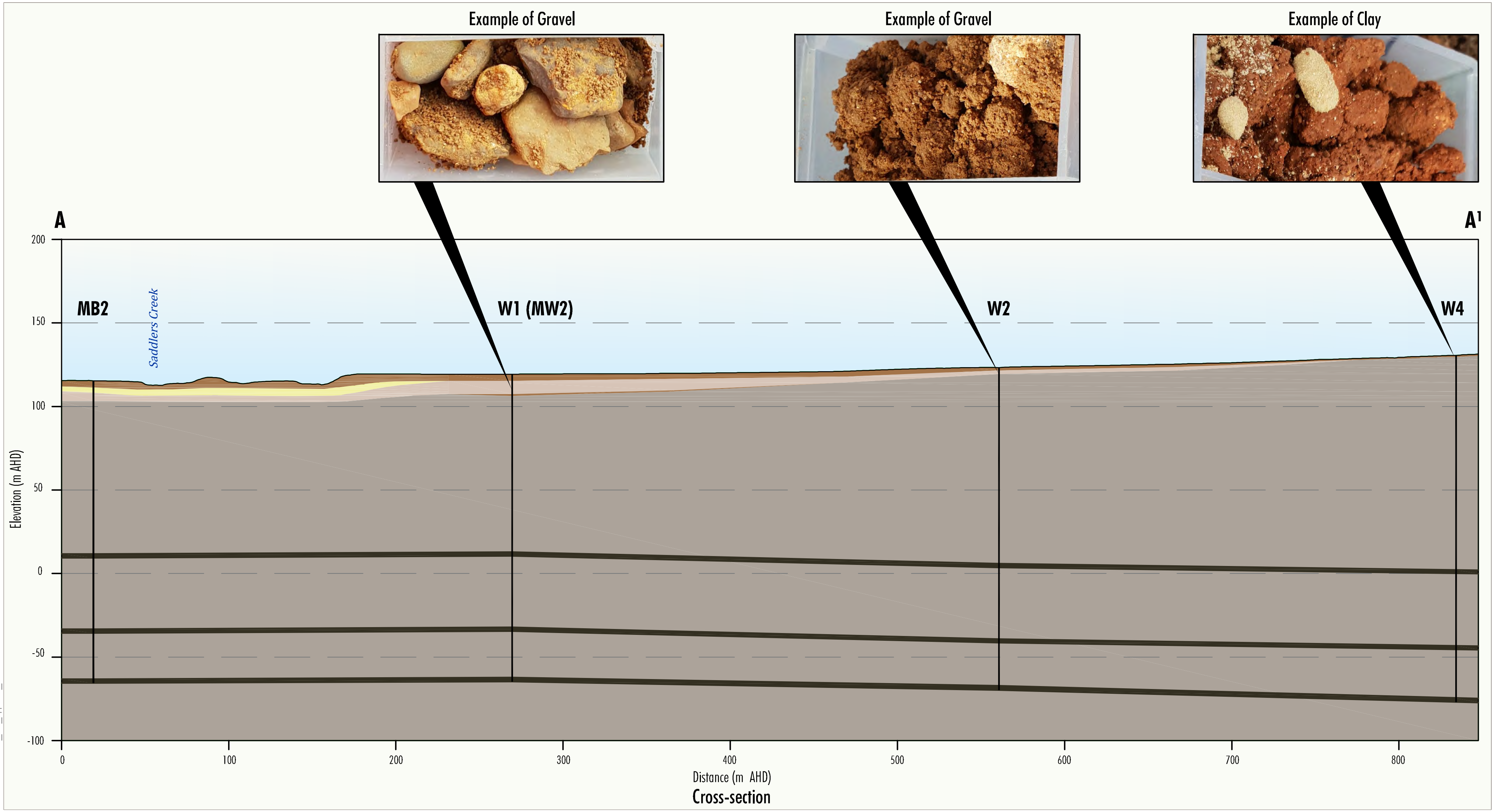
MALABAR COAL

MAXWELL PROJECT

**Interpreted Extent of Alluvium**

**Figure 5a**

SHM-18-03 Maxwell_EIS_App GDE_211A




SHM-18-03 Maxwell_EIS_App GDE_102A

LEGEND
- Clay
- Sand
- Gravel
- Denman Formation/Jerrys Plains Subgroup
- Target Coal Seam

0 100
Metres
Scale 1 Horizontal :1 Vertical

*Source: After Hydrosimulations (2019) and ENRS (2019)*

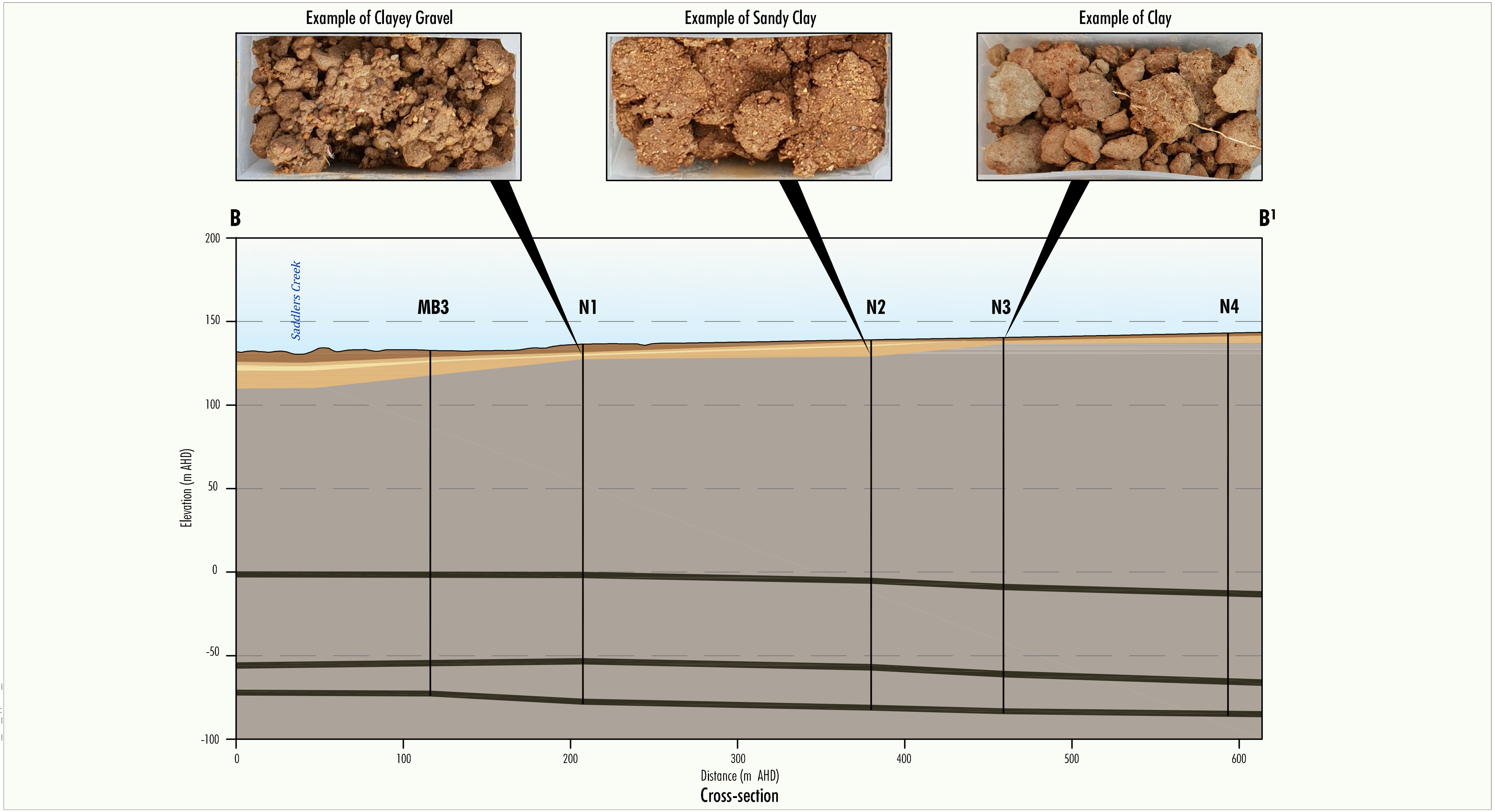
Refer Figure 5a for cross-section location.

MALABAR COAL

M A X W E L L P R O J E C T

**Saddlers Creek Alluvium**
**Cross-section A - A1**

**Figure 5b**




LEGEND
- Clay
- Sandy Clay
- Clayey Gravel
- Denman Formation/Jerrys Plains Subgroup
- Target Coal Seam

0 100
Metres
Scale 1 Horizontal :1 Vertical

MALABAR COAL

M A X W E L L P R O J E C T

Saddlers Creek Alluvium
Cross-section B - B1

*Source: After Hydrosimulations (2019) and ENRS (2019)*

Refer Figure 5a for cross-section location.

**Figure 5c**

Groundwater levels in the Hunter River alluvium range between 6.6 m and 12.0 m below surface, and have remained relatively stable over time, despite periods of below average rainfall (HydroSimulations, 2019).

The depth to groundwater within the upper reaches of Saddlers Creek ranges between 3.7 m and 10.9 m below surface. The depth to groundwater within the lower reaches ranges between and 3.3 m and 6.4 m below surface (HydroSimulations, 2019).

Salinity is a key constraint to groundwater use and can be described by total dissolved solids (TDS) concentrations. Baseline groundwater salinity is analysed in the Groundwater Assessment (HydroSimulations, 2019). In summary:

- The Hunter River alluvium is generally fresh but can range between fresh to moderately saline. Measured TDS averages 791 milligrams per litre (mg/L) and ranges between 354 mg/L and 5,070 mg/L.
- Alluvium within the upper reaches of Saddlers Creek is generally moderately saline, with an average TDS of approximately 3,400 mg/L.
- Where water is present within the regolith material, it is generally moderately saline with an average TDS of approximately 5,400 mg/L.

## 4.3 SITE-SPECIFIC REVIEW OF GROUNDWATER DEPENDENT ECOSYSTEMS

The IESC stated the following regarding types of GDEs potentially impacted by the Project (IESC, 2018a):

> *At least two types of GDEs are potentially impacted:*
>
> *a. Type 1 – Aquifer and cave ecosystems. Stygofauna are known from the alluvial aquifers and hyporheic zones of the Hunter River and its tributaries (Hancock 2006; Hancock and Boulton 2009) and may be affected by altered groundwater regimes. Surveys (Eco Logical 2015 and 2018 cited in Attachment C, pp. 32 – 33) for stygofauna in the Hunter River alluvium and Saddlers Creek alluvium near the proposed project found one known stygofaunal taxon (Syncarida, Notobathynella sp.) from the Hunter River alluvium and two likely stygofaunal taxa (Cyclopoida and Ostracoda) in the Hunter River and Saddlers Creek alluvium.*
>
> *b. Type 3 – Ecosystems dependent on subsurface presence of groundwater. Groundwater-dependent vegetation is likely to occur, especially along riparian zones and on floodplains of Saddlers Creek, Saltwater Creek, the Hunter River and other relevant tributaries in the predicted areas of groundwater drawdown. Further assessment is needed to determine which vegetation in these areas is dependent on groundwater (see response to Question 4, paragraph 39), and how it may be affected by the proposed mining and associated drawdown. In particular, assessments are needed on the possible impacts to EPBC Act listed critically endangered ecological communities (e.g. White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland, Central Hunter Valley eucalypt forest and woodland) which may contain species that are opportunistically dependent on groundwater.*

Further information regarding the presence of these GDEs in the vicinity of the Project is provided in the following sub-sections.

### 4.3.1 Aquifer Ecosystems

Stygofauna are animals that occur in subsurface waters (NSW Department of Primary Industries, 2012).

An Aquatic Ecology and Stygofauna Assessment has been prepared for the Project by Eco Logical (2019) and is presented in Appendix F of the EIS.

Invertebrates were collected from six of the 13 bores sampled. During the surveys one known and two likely stygofauna taxa were collected from the Hunter River alluvium (Syncaarida: *Notobathynella* sp., Cyclopoida: *Diacyclops* sp. and Ostracoda crustacean). One likely stygofauna taxon (*Diacyclops* sp.) was collected from the Saddlers Creek alluvium (Eco Logical, 2019).

All of the above taxa have been previously collected from the Hunter River alluvium from Singleton upstream to Aberdeen (Hancock and Boulton, 2008, 2009; Eco Logical, 2015). None of the stygofauna taxa collected in 2018 are endemic to the Project area and surrounds, as all are widespread along aquifers of the Hunter River and associated tributaries (Eco Logical, 2019).

### 4.3.2 Ecosystems Dependent on Presence of Groundwater

Vegetation mapping was conducted for the Project by Hunter Eco (2019) (Figures 6a to 6d).

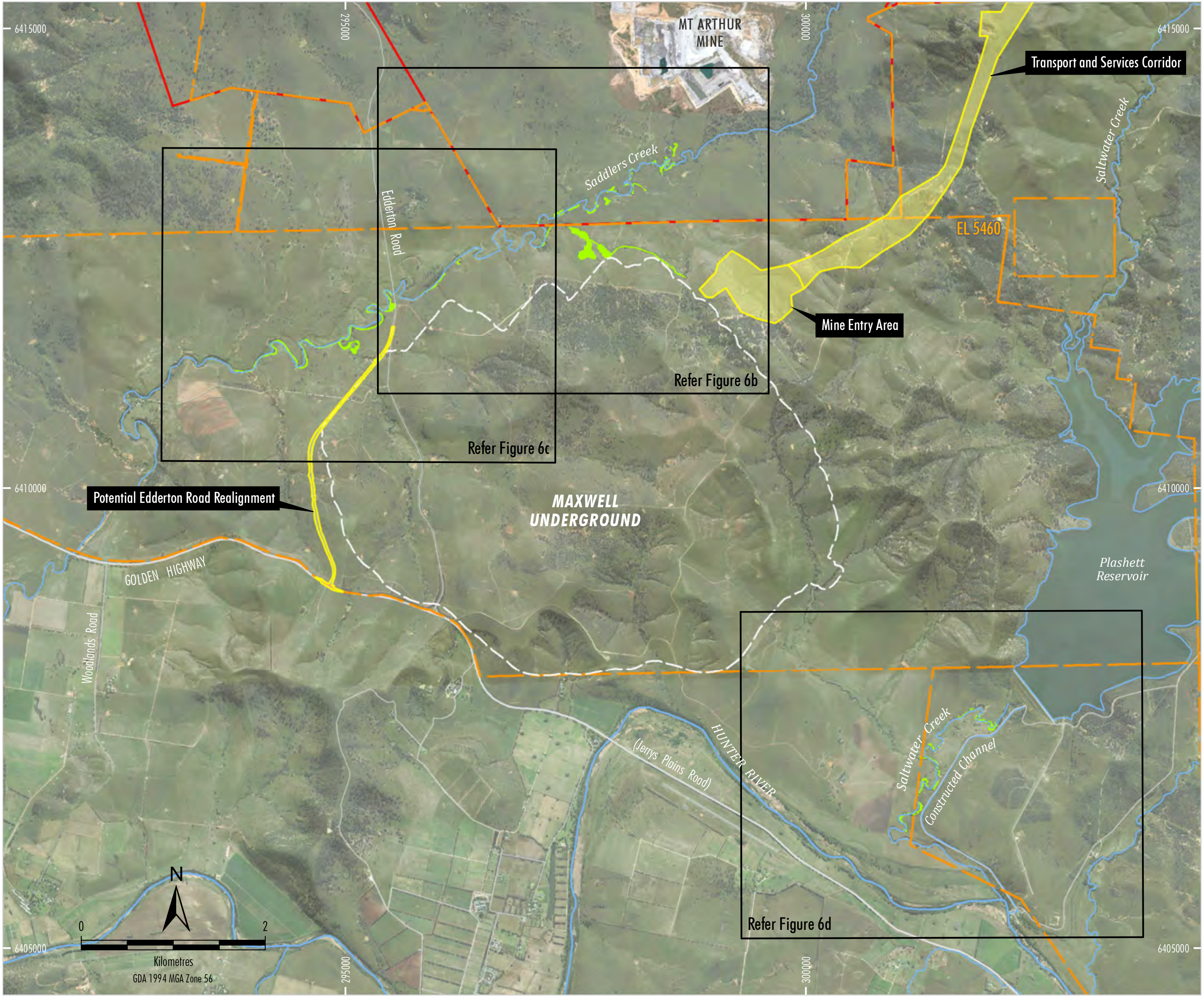
The mapping showed the majority of the Maxwell Underground area was covered with native perennial grassland due to historical land clearing. Remnant and regrowth forest and woodland occur in isolated areas, generally localised along riparian corridors (Hunter Eco, 2019).

Across the rest of the Maxwell Underground area, the identified vegetation was dry sclerophyll woodland/forest, which is not groundwater dependent. This is consistent with the conceptual hydrogeology of the area, which indicates the depth to groundwater within the Maxwell Underground area is typically greater than 20 m (Figure 4).

Hunter Eco (2019) found that the riparian vegetation associated with Saddlers and Saltwater Creeks consists of Swamp Oak (*Casuarina glauca*) that is restricted to the stream edge and immediate high bank to a width of between 10 m and 30 m. Swamp Oak is a clonal suckering species and forms dense thickets that expand at the edges with suckering new growth. Plant height varies from less than a metre to approximately 10 m to 15 m tall (Hunter Eco, 2019).

*BioNet Atlas* (OEH, 2019) showed a single River Red Gum (*Eucalyptus camaldulensis*) paddock tree on the Saddlers Creek floodplain west of the Study Area. This tree was inspected by Hunter Eco (2019) on 3 July 2019 and found to be a Yellow Box, positively identified by the colour of the foliage, and the shape of buds and fruit. In particular the fruit was of a Box type (cup-shaped with recessed disc and enclosed valves) rather than Red Gum type (globose/ovoid with disc raised and exserted valves). There were no River Red Gum in the vicinity of Saddlers Creek or Saltwater Creek.

Swamp Oak essentially forms a monoculture along Saddlers Creek which is likely a result of the very high recorded salinity values (Section 4.2) that Swamp Oak can tolerate (Cramer *et al.*, 1999), but Eucalypts cannot (Hunter Eco, 2019).




LEGEND
- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Swamp Oak Forest (PCT 1731)

*Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Hunter Eco (2019); MSEC (2019)*
*Orthophoto Mosaic: 2018, 2016, 2011*

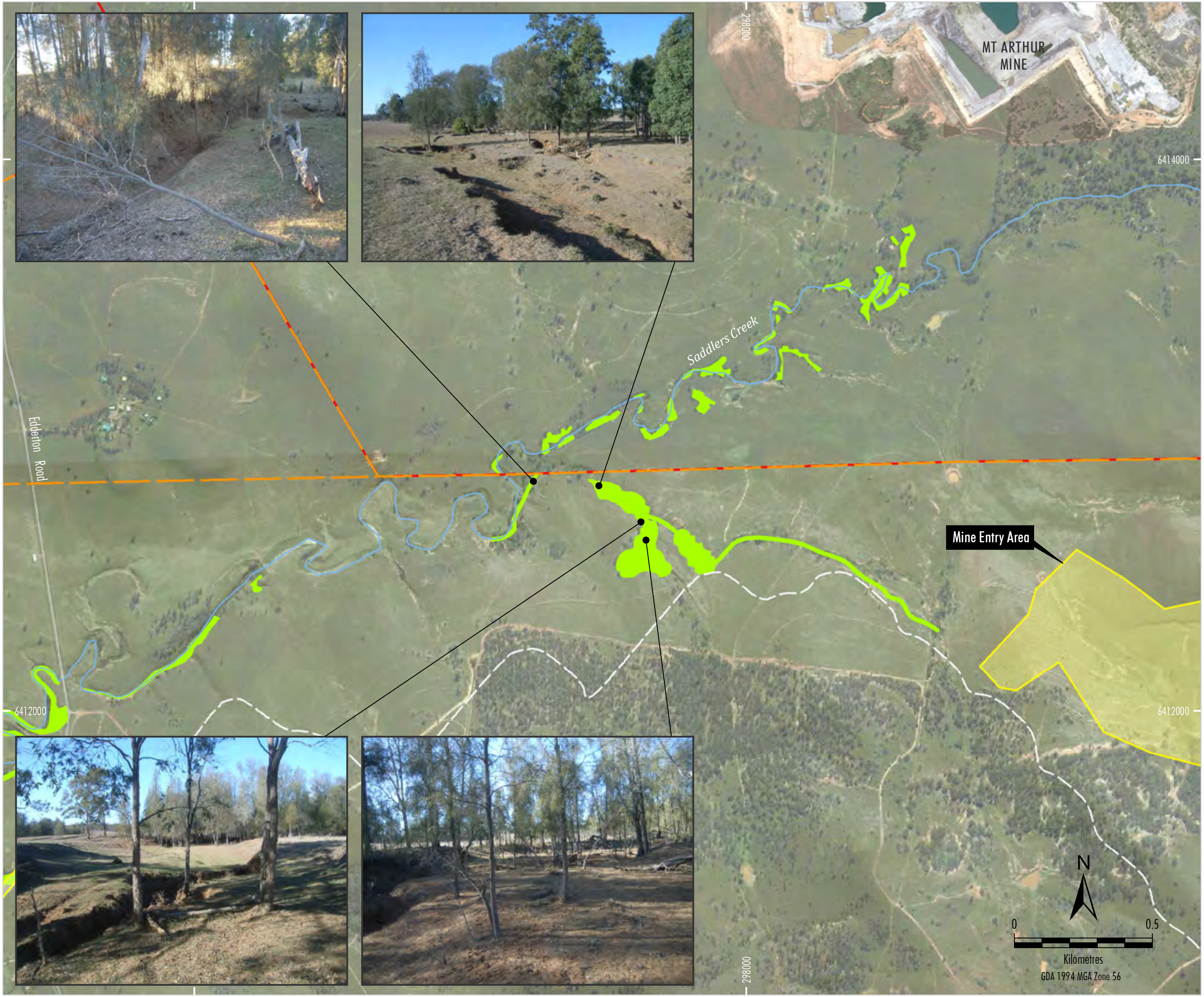
MALABAR COAL

M A X W E L L   P R O J E C T

**Swamp Oak Forest Identified in the Vicinity of the Project**

**Figure 6a**

SHM-18-03 Maxwell_EIS_App GDE_206A




LEGEND
Exploration Licence Boundary
Mining and Coal Lease Boundary
Indicative Surface Development Area
Extent of Conventional Subsidence (20 mm subsidence contour)
Swamp Oak Forest (PCT 1731)

*Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Hunter Eco (2019); Fluvial Systems (2019); MSEC (2019) Orthophoto Mosaic: 2018, 2016, 2011*

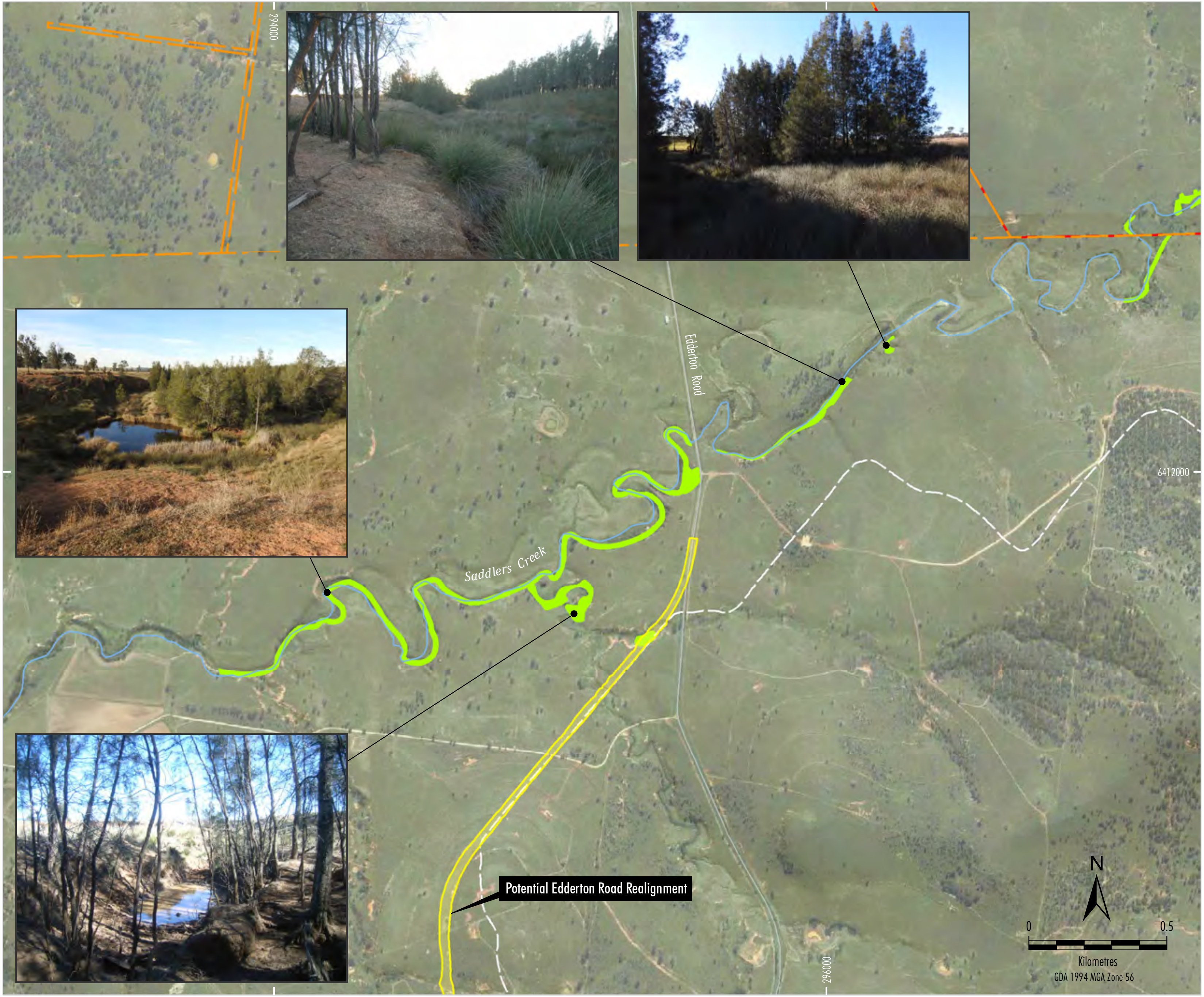
MALABAR COAL

MAXWELL PROJECT

**Swamp Oak Forest - Saddlers Creek (North)**

**Figure 6b**

SHM-18-03 Maxwell_EIS_App GDE_207A




LEGEND
Exploration Licence Boundary
Mining and Coal Lease Boundary
Indicative Surface Development Area
Extent of Conventional Subsidence (20 mm subsidence contour)
Swamp Oak Forest (PCT 1731)

*Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Hunter Eco (2019); Fluvial Systems (2019); MSEC (2019) Orthophoto Mosaic: 2018, 2016, 2011*

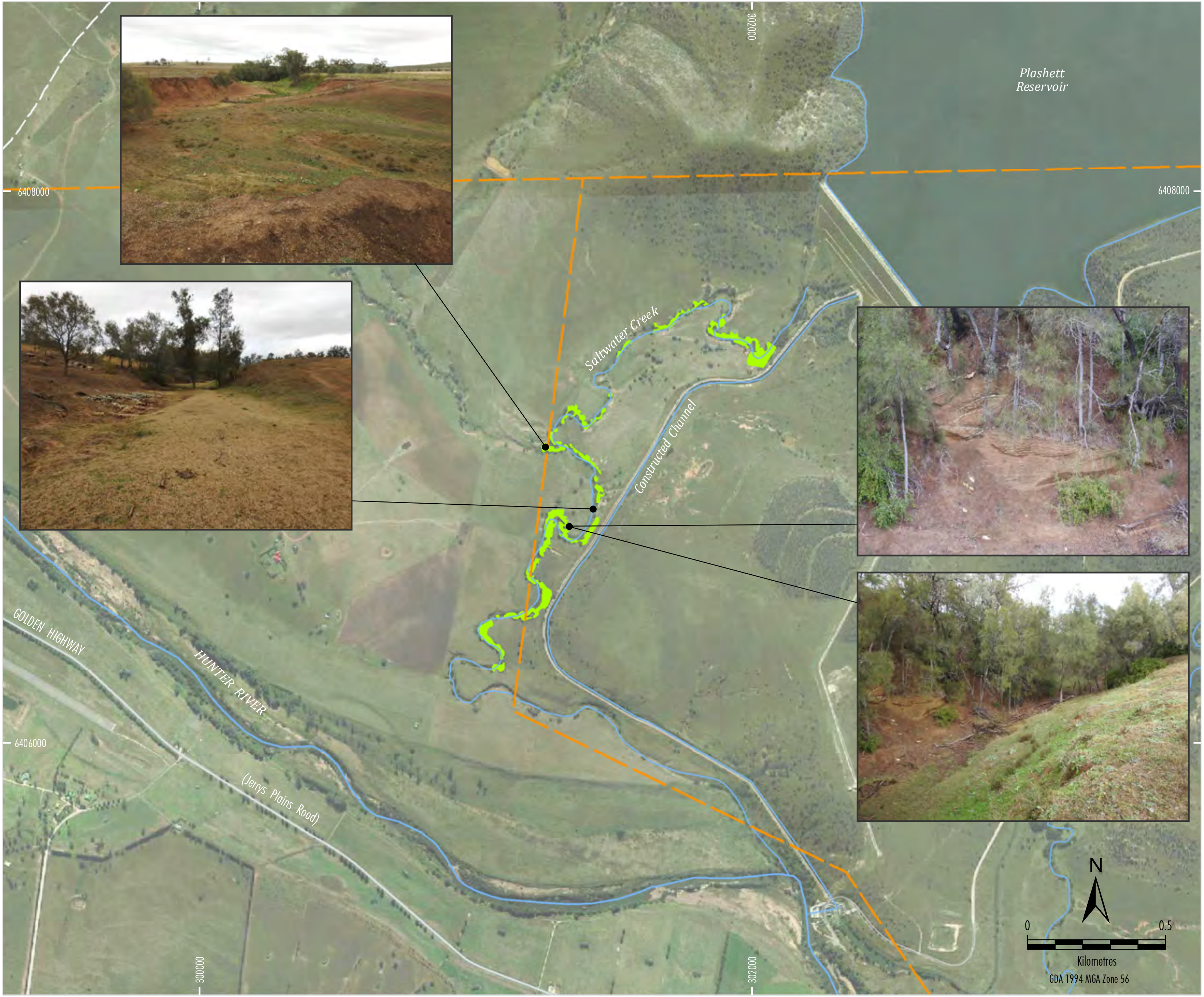
MALABAR COAL

MAXWELL PROJECT

**Swamp Oak Forest - Saddlers Creek (South)**

**Figure 6c**

SHM-18-03 Maxwell_EIS_App GDE_208A




LEGEND
Exploration Licence Boundary
Extent of Conventional Subsidence (20 mm subsidence contour)
Swamp Oak Forest (PCT 1731)

*Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Hunter Eco (2019); Fluvial Systems (2019); MSEC (2019)*
*Orthophoto Mosaic: 2018, 2016, 2011*

MALABAR COAL

MAXWELL PROJECT

**Swamp Oak Forest - Saltwater Creek**

**Figure 6d**

SHM-18-03 Maxwell_EIS_App GDE_209A

While there are no data on the root depth of Swamp Oak there are root depth data for some of its congeners. Canadell *et al.* (1996) report maximum root depths for *Casuarina pusilla* (2.4 m) and *Casuarina muelleriana* (2.0 m). Stone and Kalisz (1991) report depths for *Casuarina cristata* (>2.5 m) and *Casuarina equisetifolia* (4.0 m). Both *Casuarina equisetifolia* and *Casuarina cristata* are trees of approximately the same maximum size of Swamp Oak. It is therefore reasonable to assume for this assessment that the maximum root depth for Swamp Oak could be up to 4.5 m. Cramer et al (1999) reported Swamp Oak in a different environment (in Queensland) accessing groundwater at depths of 1.6 m and 3.0 m at the two sites studied (Hunter Eco, 2019).

Along the length of both Saddlers and Saltwater Creeks the creek bed is often deeply incised to over 3 m below the high bank. Swamp Oak grows from the stream bed level up to the high bank (a height at which trees are not likely to be able to access the groundwater table) indicating that the Swamp Oak along Saddlers and Saltwater Creeks are primarily accessing the stream baseflow and seepage in the soil profile rather than the deeper groundwater. This assessment is further confirmed by the restriction of the Swamp Oak to the immediate streamline; were they to be dependent on the deeper water table, they would be more widely dispersed (Hunter Eco, 2019).

Accordingly, the Swamp Oak are considered to be a Type 2 GDE (ecosystems dependent on the surface expression of groundwater) as defined in the *Australian Groundwater-Dependent Ecosystems Toolbox* (Richardson *et al.*, 2011).

No groundwater dependent, listed threatened species under the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* or NSW *Biodiversity Conservation Act, 2016* were identified in the vicinity of the Project (Hunter Eco, 2019).

There are no ‘high priority GDEs’ (as defined in the relevant water sharing plans) in the vicinity of the Project.

Vegetation mapping was not undertaken for the Hunter River for this Project. Notwithstanding, given the Hunter River is mapped as having high potential for groundwater interaction (Section 4.1 and Figure 3), potential impacts on any GDEs along the Hunter River have been considered in Section 5.

# 5 POTENTIAL IMPACTS ON GROUNDWATER DEPENDENT ECOSYSTEMS

GDEs in the vicinity of the Project are constrained to the shallow groundwater available in the alluvium associated with Saddlers Creek, Saltwater Creek and the lower sections of their tributaries. Potential impacts on any GDEs that may be present along the Hunter River have also been considered.

Pathways of potential Project impacts on GDEs have been identified by Hunter Eco (2019) and HydroSimulations (2019) as follows:

- A reduction in the availability of groundwater.
- Adverse changes to groundwater quality.

## 5.1 GROUNDWATER AVAILABILITY

The Groundwater Assessment prepared by HydroSimulations (2019) has evaluated the potential impacts of the Project on groundwater resources using a numerical regional groundwater model. Groundwater modelling included predictive modelling over the life of the Project as well as recovery modelling for a 1,000-year period post-mining.

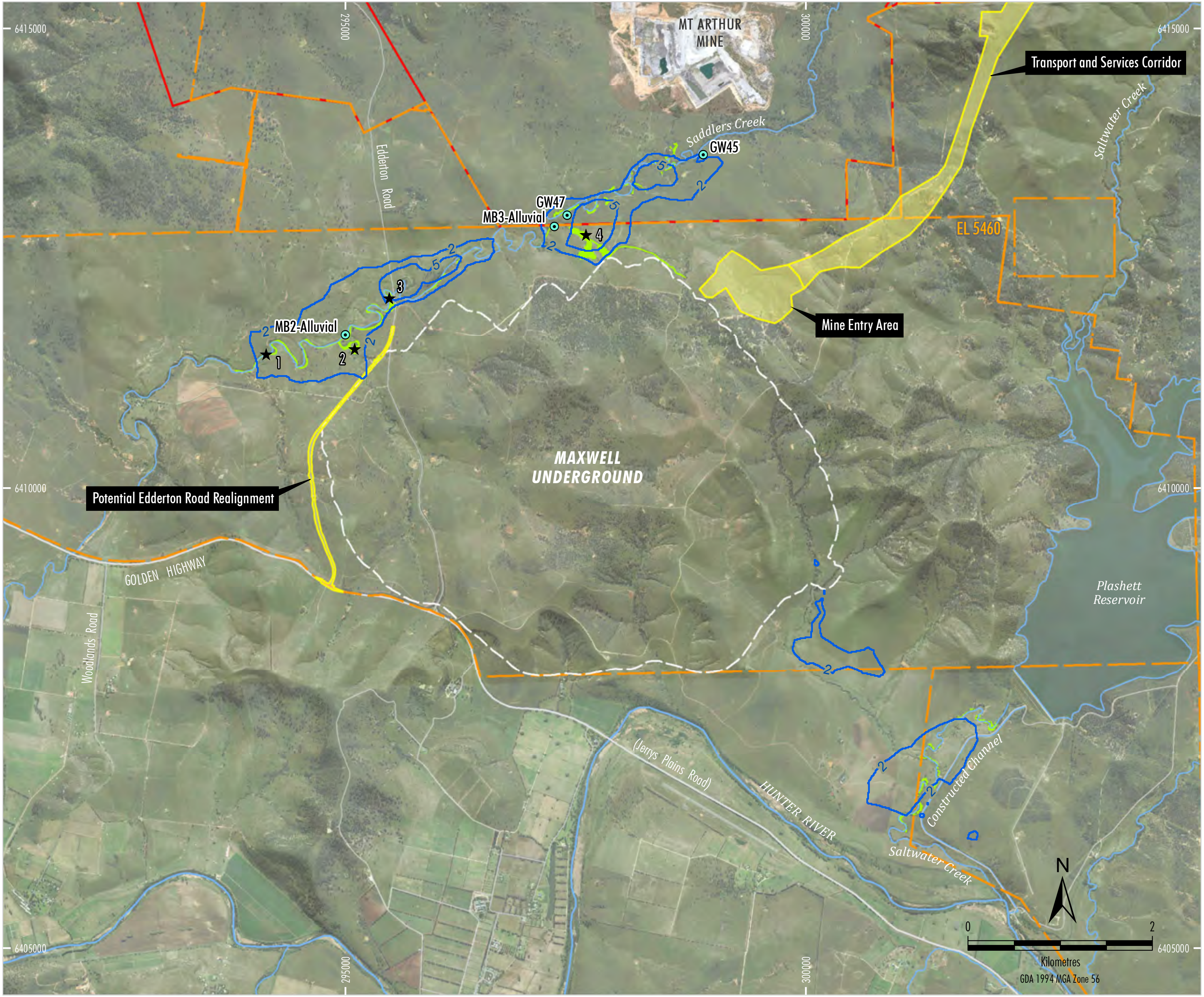
The extent of drawdown predicted in the alluvium as a result of the Project (including the Saddlers Creek alluvium, Saltwater Creek alluvium and Hunter River) is shown on Figure 7. Figure 7 shows:

- No drawdown greater than 2 m was predicted within the Hunter River alluvium.
- Drawdown exceeding greater than 2 m was predicted within the Saddlers Creek alluvium.
- Drawdown exceeding greater than 2 m was predicted within the Saltwater Creek alluvium.
- Drawdown exceeding greater than 2 m was predicted within the alluvium along a tributary of Saltwater Creek.

Hydrographs from the predictive and recovery groundwater modelling have been developed for four areas where Swamp Oak has been mapped along Saddlers Creek. The locations of the representative points are shown on Figure 7. The hydrographs are presented on Figures 8a and 8b and show the timing associated with groundwater level change due to the Project.

Groundwater drawdown in the alluvium would develop slowly over time, reaching a maximum hundreds of years post-mining. The maximum predicted drawdown in the Saddlers Creek alluvium would occur at a rate of approximately 1 m every 50 years (Figures 8a and 8b).

The drawdown in the alluvium remains sustained over time due to the assumptions in the recovery model with constant averaged rainfall and Saddlers Creek modelled as dry. This results in reduced potential recharge to the alluvium compared to conditions that have been observed along Saddlers Creek, providing a conservative estimate of impacts (HydroSimulations, 2019).




LEGEND

- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Swamp Oak Forest (PCT 1731)
- Representative Swamp Oak Location
- Alluvial Monitoring Bore
- Predicted Alluvial Drawdown Contour (m)

*Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); HydroSimulations (2019); Hunter Eco (2019); MSEC (2019) Orthophoto Mosaic: 2018, 2016, 2011*

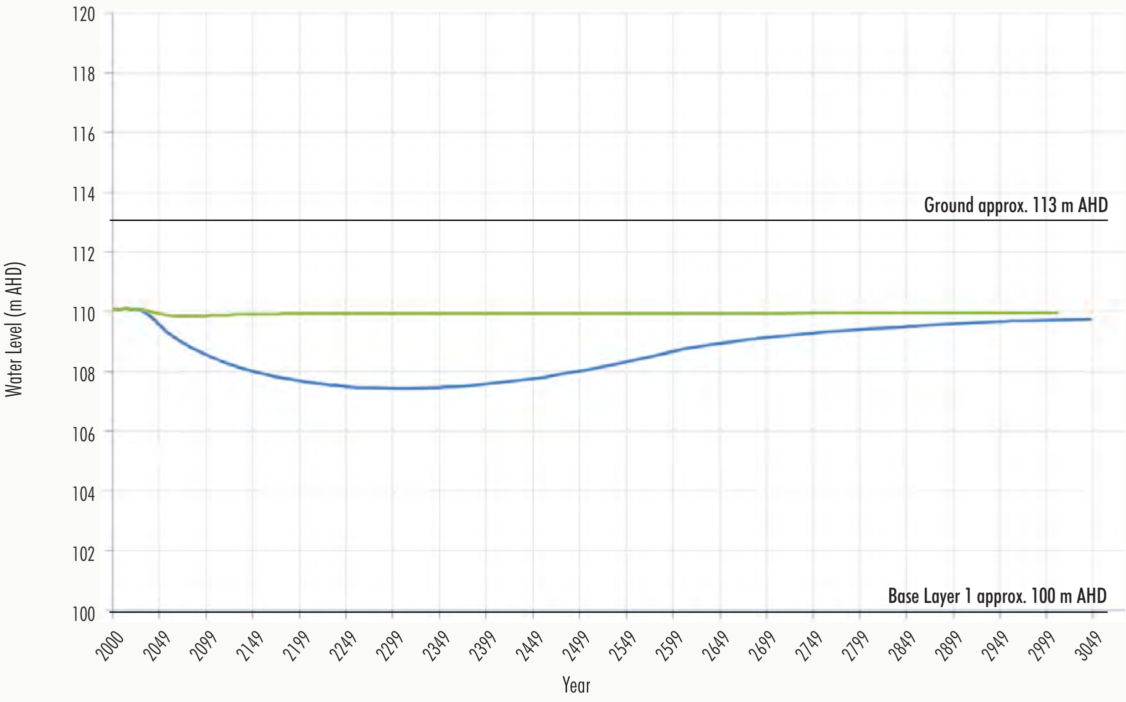
MALABAR COAL

MAXWELL PROJECT

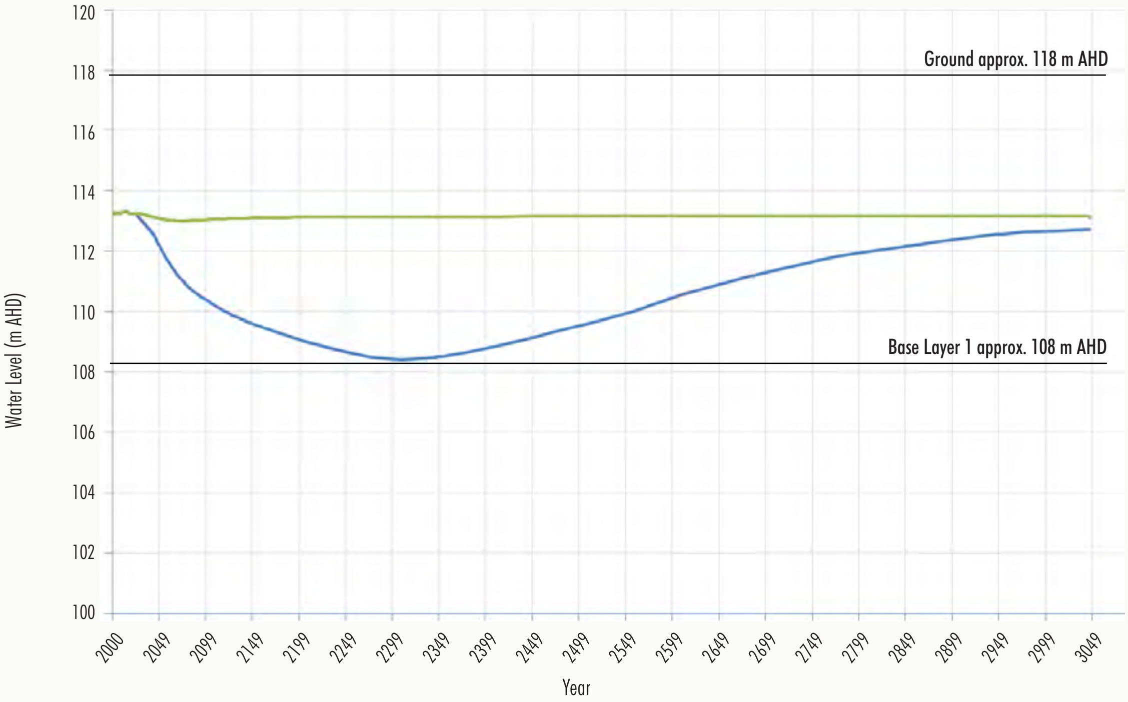
**Extent of Predicted Alluvial Drawdown**

**Figure 7**

SHM-18-03 Maxwell_EIS_App GDE_210C




Representative Swamp Oak Location 1




Representative Swamp Oak Location 2

SHM-18-03 Maxwell_EIS_App GDE_001A

LEGEND
Predicted Water Level (with Project)
Predicted Water Level (without Project)

Refer Figure 7 for Representatvie Swamp Oak Locations.

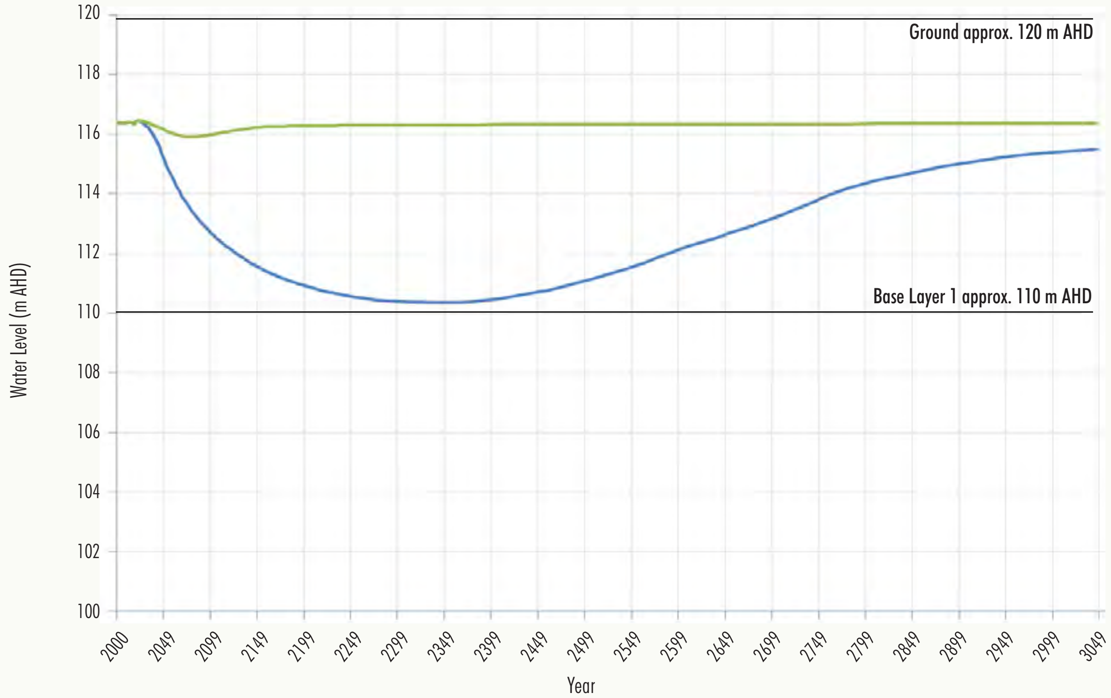
*Source: HydroSimulations (2019)*

MALABAR COAL

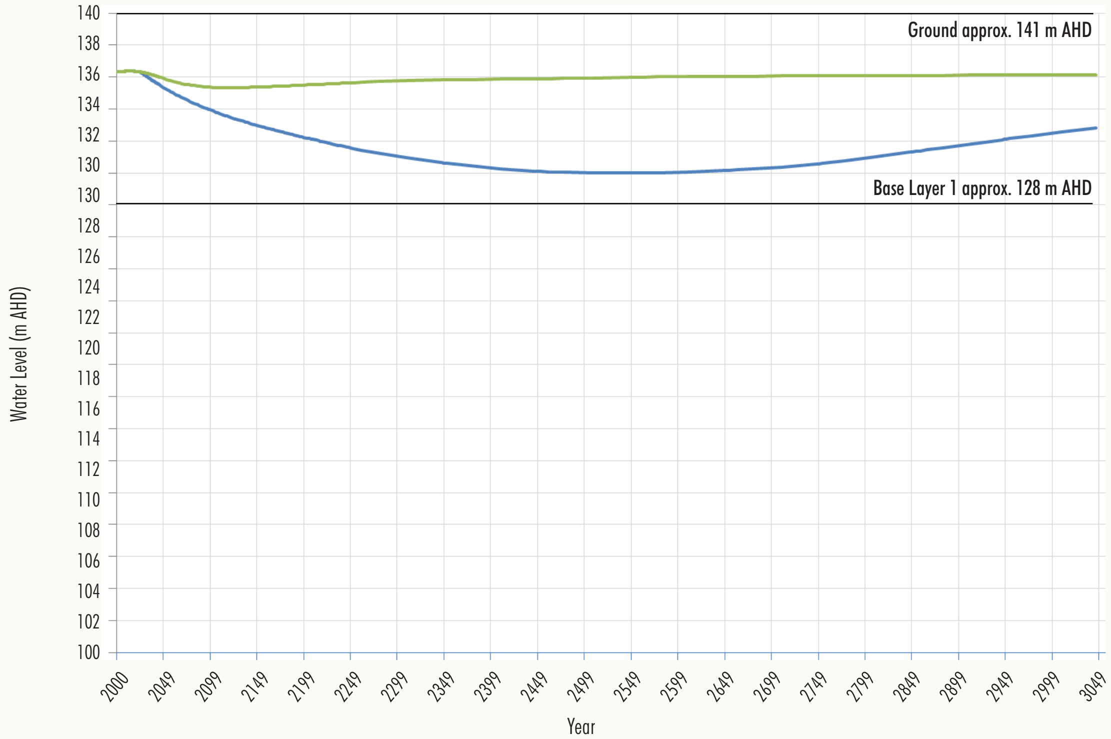
M A X W E L L   P R O J E C T

Predicted Hydrographs
at Representative Swamp Oak Locations

**Figure 8a**




Representative Swamp Oak Location 3




Representative Swamp Oak Location 4

SHM-18-03 Maxwell_EIS_App GDE_002A

LEGEND

Predicted Water Level (with Project)

Predicted Water Level (without Project)

Refer Figure 7 for Representatvie Swamp Oak Locations.

*Source: HydroSimulations (2019)*

MALABAR COAL

M A X W E L L   P R O J E C T

Predicted Hydrographs
at Representative Swamp Oak Locations

**Figure 8b**

The potential impact of the Project on baseflow in Saddlers Creek, Saltwater Creek and the Hunter River has been determined by HydroSimulations (2019). The assessment concluded the following:

- no impact on baseflow in Saddlers Creek or Saltwater Creek; and
- a maximum baseflow reduction of 0.55 megalitres per year (ML/year) in the Hunter River.

In the context of the Hunter River regulated system, a baseflow loss of 0.55 ML/year is negligible. Hence, the Project would not measurably affect baseflow in the downstream waterways (WRM, 2019).

The Swamp Oak along Saddlers Creek and Saltwater Creek are Type 2 GDEs that are dependent on the surface expression of groundwater (i.e. baseflow) (Section 4.3.2). Consequently, it is unlikely that the predicted Project groundwater drawdown would adversely impact the Swamp Oak along either Saddlers or Saltwater Creeks (Hunter Eco, 2019).

Stygofauna were recorded in the Hunter River and Saddlers Creek alluvial aquifer, although none of the taxa collected are endemic to the Project area and surrounds. Negligible drawdown has been predicted for the Hunter River alluvium as a result of the Project. Some drawdown of alluvial groundwater along Saddlers Creek is expected, although habitat connectivity between the downstream reaches of Saddlers Creek and the Hunter River alluvial aquifers would be maintained. In consideration of the above, Eco Logical (2019) concluded the Project is not likely to have a significant impact on stygofauna.

## 5.2 GROUNDWATER QUALITY

The Project is predicted to reduce upward leakage from the Permian coal measures to the overlying alluvium in localised areas along Saddlers Creek, Saltwater Creek and the Hunter River. These results demonstrate that as the Permian coal measures become depressurised, flow from the Permian to the alluvium reduces (HydroSimulations, 2019).

This can be considered beneficial as it reduces the inflow rate of higher salinity groundwater from the Permian to the overlying alluvium. Accordingly, the Project is considered to have negligible adverse impacts on groundwater quality in the alluvium (HydroSimulations, 2019).

In consideration of the above, Hunter Eco (2019) and Eco Logical (2019) determined that the Project would not have an impact on GDEs due to adverse changes to groundwater quality.

# 6 MITIGATION MEASURES AND MONITORING

Water Management Plans (including a Groundwater Management Plan) would be prepared for the Project as part of the Extraction Plan process (i.e. Extraction Plans would be prepared progressively over the life of the Project).

Every five years the validity of the groundwater model predictions would be assessed and if the data indicates significant divergence from the model predictions, an updated groundwater simulation model would be constructed.

## 6.1 GROUNDWATER LEVEL MONITORING

Groundwater monitoring would be undertaken in accordance with the Groundwater Management Plan (as part of the Water Management Plan). Manual groundwater level monitoring would be conducted for all monitoring bores, with dataloggers installed within selected bores to gather temporal variations in water levels. Data would also be downloaded from the existing Vibrating Wire Piezometers, pressure readings recorded and converted to groundwater elevations within a central database.

Ongoing monitoring would enable natural groundwater level fluctuations (such as responses to rainfall) to be distinguished from potential groundwater level impacts due to depressurisation resulting from Project. Ongoing monitoring of groundwater levels would also be used to assess the extent and rate of depressurisation against model predictions.

Yearly reporting of the water level results from the monitoring network would be included in the Annual Review. The reporting would include a comparison to climate trends and surface water monitoring results to identify changes in the surface water and groundwater interactions. The Annual Review would also identify if any additional monitoring sites are required, or if optimisation of the existing monitoring sites should be undertaken.

## 6.2 GROUNDWATER QUALITY

Groundwater quality sampling would be conducted to monitor groundwater quality during and post-mining. Additional data would be collected prior to commencement of mining, particularly for bores recently installed as part of the Project.

Sampling would include the collection of field analytes of pH and electrical conductivity (EC) on a quarterly basis, as well as annual sampling for laboratory analysis of a full suite of analytes to determine any changes in beneficial groundwater, including:

- physio-chemical indicators – pH, EC, TDS;
- major ions – calcium, fluoride, magnesium, potassium, sodium, chloride, sulphate;
- total alkalinity as calcium carbonate ($CaCO_3$), bicarbonate ($HCO_3$), carbonate ($CO_3$); and
- dissolved and total metals – aluminium, arsenic, barium, boron, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, strontium, silver, vanadium and zinc.

Similar to the water level monitoring, yearly reporting of the water quality results from the monitoring network would be included in the Annual Review. The Annual Review would consider if any additional monitoring sites are required, or if optimisation of the existing monitoring sites, frequency of sampling and analytical suite should be undertaken.

## 6.3 STREAM HEALTH MONITORING

The extent of riparian vegetation and extent of erosion and sedimentation deposits would be used as an indicator of stream health.

Monitoring would be undertaken quarterly by taking photographs at each of the Saddlers Creek surface water monitoring sites. The photographs would be taken at the same location (identified by GPS or permanent photographic ID post) and taken of the relevant bed and bank features looking upstream and downstream.

These photographs would be documented with the location, direction and date as well as a log of erosional and depositional features at each location.

# 7 REFERENCES

Canadell, J., Jackson, R. B., Ehleringer, J. B., Mooney, H. A., Sala, O. E. and Schulze, E.D. (1996) *Maximum rooting depth of vegetation types at the global scale*. Oecologia, 108(4), 583–595.

Commonwealth Bureau of Meteorology (2018) *Groundwater Dependent Ecosystem Atlas*.

Cramer, V. A., Thorburn, P. J. and Fraser, G. W. (1999) *Transpiration and groundwater uptake from farm forest plots of Casuarina glauca and Eucalyptus camaldulensis in saline areas of southeast Queensland, Australia*, Agricultural Water Management, 39(2–3), 187–204.

Department of Land and Water Conservation (2002) *NSW State Groundwater Dependent Ecosystems Policy*.

Department of Primary Industries (2012) *Risk assessment guidelines for groundwater dependent ecosystems, Volume 1 – The conceptual framework*.

Doody, Hancock and Pritchard (2018) *Assessing Groundwater Dependent Ecosystems: IESC Information Guidelines Explanatory Note [Consultation Draft]*.

Eamus, D., Froend, R., Loomes, R. Hosea, 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, 97–114.

Eco Logical Australia Pty Ltd (2015) *Drayton South Coal Project – Stygofauna Impact Assessment*.

Eco Logical Australia Pty Ltd (2019) *Maxwell Project Aquatic Ecology and Stygofauna Assessment*.

Environmental and Natural Resource Solutions (2018) *Alluvial Drilling Report – Maxwell Project*.

Fluvial Systems Pty Ltd (2019) *Maxwell Project, Environmental Impact Statement, Technical Study Report, Geomorphology Report.*

Groundwater Imaging Pty Ltd (2018) *AgTEM Survey Investigating Groundwater on Maxwell Underground Coal Mine prospect*.

Hancock, P.J. and Boulton, A.J. (2008) *Stygofauna Biodiversity and Endemism in Four Alluvial Aquifers in Eastern Australia*. Invertebrate Systematics, 22.

Hancock, P.J. and Boulton, A.J. (2009) *Sampling Groundwater Fauna: Efficiency of Rapid Assessment Methods Tested in Monitoring Wells in Eastern Australia*. Freshwater Biology, 54.

Hatton, T. and Evans, R. (1998) *Dependence of ecosystems on groundwater and its significance to Australia*. Occasional paper no 12/98. Land and Water Resources Research and Development Corporation. August 1998.

Hunter Eco (2019) *Maxwell Project Biodiversity Development Assessment Report*.

HydroSimulations (2019) *Maxwell Project: Groundwater Assessment – In support of an EIS*.

Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (2018a) *Information Guidelines for the Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals*.

Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (2018b) *Advice to decision maker on coal mining project IESC 2018-098: Maxwell Project – Expansion*.

New South Wales Government (2012) *NSW Aquifer Interference Policy – NSW Government Policy for the licensing and assessment of aquifer interference activities*.

New South Wales Office of Environment and Heritage (2019) *BioNet Atlas*.

Mine Subsidence Engineering Consultants Pty Ltd (2019) *Maxwell Project Subsidence Assessment*.

NSW Office of Water (2012) *Risk Assessment Guidelines for Groundwater Dependent Ecosystems*.

Richardson, S., Irvine, E., Froend, R., Boon, P., Barber, S. and Bonneville, B. (2011) *Australian Groundwater-Dependent Ecosystems Toolbox*.

Stone, E.L. and Kalisz, P.J. (1991) *On the maximum extent of tree roots*, Forest Ecology and Management, 46, 56-102.

WRM Water & Environment Pty Ltd (2019) *Maxwell Project - Surface Water Assessment*.