6.0 Impact Assessment of Environmental Values - Option 1: Landform Levee

6.1 Methodology

The impact assessment methodology used is a systematic analysis of the proposed development in relation to the existing environment. The overall methodology used throughout Stage 3 and in the preparation of this EA Report is:

- establishing a basis of assessment
- conducting impact assessment on nominated environmental values and nominate mitigation measures
- establishing the significance of environmental impact on environmental values.

The Environmental Values considered in this impact assessment are presented in the Environmental Values Workshop Report prepared in Stage 2 (Ensham Resources, 2017).

6.2 Climate

6.2.1 Potential Impacts

Any potential impacts of Option 1 on EVs relevant to climate would be due to impacts from climate change. There is potential for climate change to influence potential impacts on other EVs listed in Section 4.0. The potential impacts to these other EVs are discussed below for Option 1 where relevant.

6.2.2 Management and Mitigation

No specific management and mitigation measures are proposed for climate for this Option. Where climate change predictions influence other EVs and management and mitigation measures are required, these are noted where relevant below.

6.3 Land

6.3.1 Potential Impacts

The potential impacts to the EVs listed in Section 4.0 are provided in the following sections.

6.3.2 Visual Amenity

Figure 6.1 provides a conceptual visualisation of the final landform for Option 1. From a visual landscape perspective, the Option 1 levee would not be inconsistent with the existing landform, with an increase to levee height of 1 to 2m in some sections. The visual setting would be similar to the surrounding landscape, with the landforms and slopes rehabilitated to be visually consistent with the surrounding environment. A treed corridor would be created adjacent to highwall between Corkscrew Creek and Nogoa River, which would reduce any visual impacts that may be associated with the residual voids. Option 1 is not expected to have any material impact on the visual amenity of the area.
6.3.3 Landform Assessment

A landform assessment for the Option 1 landform was undertaken by WSP (2018c). The assessment included the development of landform design criteria, landform design and stability optimisation, material movement optimisation, and landform visualisation, and it incorporated findings from the geotechnical assessment also undertaken by WSP (refer Section 6.3.1.4).

The landform design was based on achieving key rehabilitation goals including the landform being safe, stable and non-polluting, with a self-sustaining vegetation cover in accordance with the completion criteria.

The landform assessment identified that in order to achieve a safe, stable landform, regrading of the residual voids would be required, including the highwalls, endwalls and spoil dumps. Details of the landform design criteria adopted for this Option are listed in Table 3.1. A geochemical assessment was undertaken by RGS (2018) to characterise the existing hydrogeochemistry of the materials on site (RGS Environmental Pty Ltd (RGS), 2018). This assessment indicated that the existing spoil material is non-acid forming and benign, and hence the final landform can be considered to be non-polluting in regard to leachate.

The landform has been designed to exclude rehabilitated areas from the floodplain up to and including 0.1% AEP event (1 in 1000). For rain that falls on inward facing slopes and the rehabilitated land, this water would collect in the lower areas of the rehabilitated land and migrate to groundwater with no harm to the environment. Water draining from outward facing slopes to the receiving environment would have low salinity and present minimal risk to the environment. There is no risk of water within the rehabilitated landform (inward facing slopes) flowing to the receiving environment unless an extreme flood event occurs (e.g. greater than a 1 in 1000 flood for this catchment).

Depending on the nature of spoil material adjacent to the residual void, the inward and outward facing spoil would be regraded to a maximum slope of 10 to 15%. The regraded slopes on spoil dumps would be topsoiled and grassed, and benches would be seeded with tree species currently proven with existing rehabilitation.
Landform levees may be constructed from spoil material provided it complies with technical requirements for levee construction materials in terms of clay content, linear shrinkage and dispersivity. Compaction of this material to an engineering standard would be undertaken to prevent excess settlement, and development of localised preferential drainage paths that could lead to piping failure in these embankments over time. The levee structures would be topsoiled and grassed to reduce erosion potential.

6.3.4 Landform Stability

A geotechnical assessment was undertaken by WSP (2018b) to evaluate the stability and erosion potential of the final landforms.

For this Option, highwalls and low wall spoil piles would be regraded and left as long-term stable structures. Permanent landforms, which would incorporate and raise the height of the existing levee structures by approximately 1 to 2 m in some locations, would be constructed with flatter batter slopes (1V:4H and 1V:6.7H) than the existing slopes (1V:7H and 1V:10H).

A slope stability analysis was undertaken of the Option 1 landform, which assessed a conservative, worse-case scenario assuming a 10m high levee (existing levees range from approximately 4 to 8m in height), a water surface at the top of the levee, and fully saturated embankment conditions. A Factor of Safety (FOS) of 1.5 was adopted for the assessment as the minimum required to ensure the long-term stability of the final landforms.

This analysis found the FOS for the final regraded landform ranged from 1.53 for batter slopes of 1V:4H, to 2.17 for batter slopes of 1V:6.7H. These results exceed the minimum 1.5 FOS adopted for the Project, and therefore the final landforms for this option are expected to be long-term stable. This option also proposes flatter batter slopes than the existing levees as well as revegetation of the final landform, which would reduce erosion potential.

As part of this assessment, stability and erosion potential of the existing highwalls and spoil piles, which mostly comprise Tertiary clays overlying weathered/fresh Permian rock, were characterised by WSP (2018b), who concluded:

- In its current configuration, Tertiary clays would not be considered long-term stable, given they typically have a marked loss of strength when wet and tend to be prone to instability and severe erosion;
- Weathered/fresh Permian rock tends to slake and soften over time and can be susceptible to erosion. Instability could also develop around exposed faults or geological structures.

The above risks are addressed by achieving a FOS of >1.5. The final landform would have considerably improved batter slopes for highwall, endwall and spoil in terms of erosion potential, compared with the existing un-rehabilitated landform. Low wall spoil slopes would be regraded to no greater than 15%, topsoiled and/or ameliorated to promote and sustain vegetation growth, consistent with the current completion criteria in the EA. Highwall and endwall batters would be regraded to reduce erosion potential. Scour protection would also be installed on sections of the outward-facing landforms to reduce erosion potential where required. Alternatively, buttressing may be adopted where regarding is not economically or spatially viable.

The above factors, incorporating the adopted Option 1 Levee Design Criteria outlined in Table 3.1, would result in a safe and stable outcome.
6.3.5 Land Use and Agricultural Potential

Option 1 would return an area of land that is compatible for agricultural use that is very like that of the pre-mining available area. All inward and outward slopes (88% of all rehabilitated areas) would be regraded to a maximum of 10-15% which is sufficiently gentle for pasture crops, grazing and operation of agricultural equipment. There is the potential for some areas in the rehabilitated landform for groundwater to daylight at rest which will be reached after approximately 100 years post-mining. It is unlikely that Option 1 would have any adverse impact on the long-term available area for agriculture. The balance of terrain greater than 15% would be revegetated suitable for native vegetation use.

6.3.6 Management and Mitigation

Successful delivery of the Option 1 Levee Design Criteria outlined in Table 3.1 post closure would mean that monitoring and maintenance would be required. Post relinquishment, recognised agricultural land management practices to manage vegetation cover would be appropriate to minimise erosion potential.

6.4 Surface Water

6.4.1 Potential Impacts

The potential impacts to the EVs listed in Section 4 are provided in the following sections.

6.4.2 Water Quality and Balance Assessment

HEC (2018b) undertook an assessment of the water quality and balance for Option 1 using GoldSim modelling to determine long term water quantity and quality predictions. The modelling incorporated the results of the hydrogeochemical characterisation of the spoil material and pit walls undertaken by RGS Environmental Pty Ltd (2018) (RGS) and the estimates of groundwater flux in to and out of each of pit as modelled by HS (2018).

Based on the results of modelling rounds conducted for earlier Stages of the RVP process, HEC has modelled:

- Pit A and Pit B as separate pits;
- Pit C and Pit D as one pit (“Pit CD”);
- Pit E as one pit.

In response to ongoing refinement of the groundwater modelling and landform design, the floor levels of Pit F South, Pit F North and Pit Y, have been raised to be approximately 5 metres above the modelled groundwater level. Consequently, groundwater and seepage from in-pit spoil will be beneath the floor level of the rehabilitated landform and will not daylight. Only surface water runoff will report to the lowest point in the landform and from there will drain through the backfill material to the groundwater table. For this reason, these pits are not expected to hold water for extended periods and modelling of the water quality and balance in these voids was not undertaken. The following two scenarios were modelled for Pit A to Pit E:

- Base Case (referred to in the HEC report as “Model Run 1”). This scenario was based on 258 years of rainfall and evaporation data (determined based on the 129 years (1889-2017) of available records from the SILO Data Drill for a location near to the Ensham Mine, and this data set was then repeated to simulate 258 years) to model an equilibrium water level in the rehabilitated landform. Rainfall was included in the model as direct rainfall into the rehabilitated landform and as an input to the catchment
runoff model. Evaporation from the storages was calculated in the model by multiplying storage surface area by daily pan evaporation rate and by a pan factor.

- Climate Change (referred to in the HEC report as “Model Run 2”). This scenario was based on 258 years of rainfall and evaporation data, which factored climate change predictions of average changes to annual rainfall of an 8% reduction to the year 2050, and average changes to annual evaporation of 7% increase to the year 2050.

Inflows to the rehabilitated landforms were assumed to comprise direct rainfall over the rehabilitated landform water surface, surface runoff and baseflow from the rehabilitated landform catchment area, and groundwater inflow. Outflows were assumed to be derived from evaporation and groundwater outflow. In addition, it was assumed that contained water could be transferred between the rehabilitated landforms via internal seepage to adjacent rehabilitated landforms (applies to/from Pit A and Pit B, and to/from Pit CD and Pit E).

Water quality modelling was undertaken to assess water volumes and concentrations over the 258-year simulation period for the following:

- Solutes: calcium, chloride, magnesium, potassium, sodium and sulfate;
- Metals: arsenic, molybdenum, and selenium; and
- Salinity (derived from total dissolved solids).

The modelling results for the two scenarios indicated the following:

- Base Case:
  - The predicted long-term water levels in all pit voids are similar to or a few metres higher than the groundwater rest level and are well below the external spill level.
  - The predicted outflows from all modelled pits are dominated by evaporation. Seepage loss occurs from Pit A to Pit B, and from Pit E to Pit CD.
  - The predicted solute concentrations for all pits rise slowly over time, reflecting the impact of ongoing evaporation. For Pit A and Pit E the rise in concentrations of solutes is delayed by approximately 50 years due to seepage outflows to adjoining pits in the initial period of the simulation.

- Climate Change:
  - The model results for Option 1 with climate change are only marginally different to the Base Case. The predicted impacts of climate change (i.e., reduced rainfall and increased evaporation) result in:
    - Lower water levels in all pit voids than for the Base Case by a few metres;
    - Reduced rainfall and runoff inflows to the pit voids;
    - Relatively minor changes in water quality resulting in salinity that is generally up to 15% higher than the base case. Some water quality concentrations are slightly
reduced for the climate change case due to changes in the relative proportion of inflow from different sources.

6.4.3 Water Quality from residual landform

There is no proposal to utilise the void water for irrigation, farm supply, stock use, aquaculture, recreation, or industrial purposes, and therefore there would be no impacts on these EVs due to any adverse water quality conditions that may exist within the voids. In addition, there are no identified impacts in relation to void water being unacceptable for visual recreation purposes.

6.4.4 Downstream River Quality

Under Option 1, the risk of water within the rehabilitated landform (inward facing slopes) flowing to the receiving environment is extremely improbable (i.e. less than 1 in 1000 for this catchment). Therefore, this Option is not likely to impact water quality objectives for any downstream users for irrigation, farming, stock use, aquaculture or human consumption purposes.

6.4.5 Evaporative Concentration on Salinity within the residual landform

The water quality modelling found the residual landforms of the modelled pits have salinity concentrations that trended upwards over the simulation period due water loss caused from evaporation. It should be noted that use of this water under Option 1 is not proposed. In addition, there is no groundwater outflow predicted from these pits. Hence, any increase in salinity or other contaminant concentrations will be confined to the voids.

6.4.6 Flood Modelling

HEC (2018a) undertook flood modelling of peak flow depths for Option 1 at the 10%, 5%, 1% and 0.1%\(^5\) AEP flood events using the TUFLOW software package. The TUFLOW model boundary conditions were based on hydrographs from the XP-RAFTS hydrological model (upstream boundary) and the rating curves (downstream boundary) developed as part of the 2013 KBR flood study for the area (HEC, 2018a).

The modelling compared Option 1 against the existing landforms.

The model results for peak flow depth are presented in Figures 6.4 to 6.7

As the Option 1 landform is consistent with the existing topography, these peak flow depths represent negligible difference compared to existing conditions. This modelling confirms that there is no measurable change to afflux either upstream or downstream from existing conditions. (HEC, 2018a).

6.4.7 Local Run-off Volumes to the River

There is unlikely to be any material change to run-off volumes as a result of the landform design, therefore impacts to local run-off volumes to the river are not expected.

\(^5\) Collectively these AEPs event represent the 1 in 10, 1 in 20, 1 in 100 and 1 in 1,000 AEP flood events respectively
Figure 6.4  Peak Flow Depth 10% AEP

(Source: HEC, 2018a)
Figure 6.5  Peak Flow Depth 5% AEP

(Source: HEC, 2018a)
Figure 6.6 Peak Flow Depth 1% AEP

(Source: HEC, 2018a)
Figure 6.7  Peak Flow Depth 0.1% AEP

(Source: HEC, 2018a)
6.4.8 Geomorphology Assessment

Geomorphological modelling for Option 1 was undertaken by WRM Water & Environment (WRM) (2018). This modelling incorporated flood model data (provided by HEC, 2018a) to assess the morphology of the Nogoa River floodplain. The modelling included an assessment of:

- The 10% AEP design flood event, to represent the behaviour of the river at the bank full flow conditions. The bank full flow is the maximum flow that the channel can carry before it overflows onto the adjacent floodplain. In geomorphologic studies, the bank full flow is often considered to be the stream forming flow, because it often exerts the greatest influence on channel geometry (WRM, 2018);
- The 1% AEP design flood event, to represent the behaviour of the river during a large and infrequent flood event; and
- A flood event 50% greater than the 0.1% AEP design flood event (i.e., an extreme event), to determine what would occur in the unlikely event that the levels of the landform levees are exceeded.

Compared to pre-mine conditions, the modelling shows that:

- there would be no change in peak velocities and shear stresses from pre-mine conditions for the 10% AEP flood;
- the differences between pre-mine and Option 1 flood velocities and shear stresses for the 1% AEP event are minor;
- where increases from pre-mine conditions occur for the 1% AEP event, the predicted velocities and shear stresses are no greater than pre-mine velocities and shear stress along the upstream reach of the river for the same event; and
- the extreme event (adopted as 1.5 x the 0.1% AEP event) would increase velocities and shear stresses along the Nogoa River channel and the adjacent floodplain for a distance of about 7 km, but these are no greater than pre-mine velocities and shear stress along the upstream reach of the river for the same event.

The assessment of pre-mine conditions found that the Nogoa River channel and floodplain would be stable in the short term and medium term. Therefore, the short and medium-term risks to the Nogoa River for Option 1 landform are low.

The modelling identified a very low risk of morphological change to the Nogoa River for Option 1 for extreme and rare events that overtop the landform. Option 1, however moderately reduces the risk of morphological change from existing conditions because the final landform levels are marginally higher and wider than the levees that are being replaced. If such an extreme event occurred, it would appear unlikely that the course of the Nogoa River or Anabranch would be altered.

These extreme or rare morphological risks would be reduced by the provision of designated overflow points on either side of the Nogoa River.
6.4.9 **Management and Mitigation**

Successful delivery of the completion criteria including the overtopping points, would mean that there are no specific management and mitigation measures required for post-relinquishment for this Option.

6.5 **Groundwater**

6.5.1 **Groundwater Modelling**

The groundwater investigation has been based on groundwater flow modelling using a model developed by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), most recently updated in 2016. The model has been re-calibrated by HS (2018) to include additional data up to February 2018.

The modelling was used to predict time-varying groundwater inflows/outflows and water levels in each of the rehabilitated landforms, as well as regional groundwater levels with particular focus on key bores in the groundwater monitoring network. The influence of recharge change in the spoil zones was simulated to be insubstantial with respect to long term evolution of pit stages. Hence, the calibrated model was adopted for both the existing climate and the climate change scenarios.

The results of the groundwater modelling show that the groundwater rest levels will stabilize at their long term values after approximately 100 years in most pits. Predicted groundwater rest levels for Option 1 are shown in Table 6.1 for each pit. Figure 6.1 shows the extent and depth of inundation of the final landform surface at the groundwater rest levels.

<table>
<thead>
<tr>
<th>Pit</th>
<th>Option 1 (mAHD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (south)</td>
<td>136.2</td>
</tr>
<tr>
<td>A (north)</td>
<td>135.2</td>
</tr>
<tr>
<td>B</td>
<td>133.4</td>
</tr>
<tr>
<td>C</td>
<td>127.6</td>
</tr>
<tr>
<td>D</td>
<td>121.9</td>
</tr>
<tr>
<td>E</td>
<td>139.0</td>
</tr>
<tr>
<td>F</td>
<td>150.3*</td>
</tr>
<tr>
<td>Y</td>
<td>171.2*</td>
</tr>
</tbody>
</table>

* Groundwater would be eliminated by raising the pit floor level above groundwater level
Figure 6.1 Landform Groundwater Levels
6.5.2 Potential Impacts

The potential impacts to the EVs listed in Section 4.0 are provided as follows.

The long term (typically beyond 100 years) groundwater inundation shown in Figure 6.1 shows:

- No groundwater inundation above the pit floor for F and Y Pits
- Minimal groundwater inundation in A Pit (depth of less than 9 m) and E pit (depth of less than 13 m) landforms
- Groundwater inundation in B pit landform to a maximum depth of about 33 m
- Groundwater inundation up to 50 m depth in C and D pit landforms.

Of the examined monitoring bores, the median maximum drawdown is 4.5 m and the median year of occurrence is about 2044 (26 years from present day). None of the identified private bores lie within the 5m water table predicted drawdown envelope. Full details of these bores and predicted groundwater drawdown impacts can be found in the Groundwater Report (HS, 2018).

The findings of the groundwater assessment indicate:

- Minor groundwater drawdown impacts on private bores used for farm or stock water supply, with negligible impact on the one identified irrigation bore due to its distance from the mine.
- Negligible impact on groundwater quality at any private bores.
- Negligible impact on aquatic ecosystem water quality as project activities would not cause additional groundwater discharge to any rivers.
- A slight beneficial effect on groundwater quality beneath the Nogoa River close to Pit B, due to a marginal increase in the natural leakage from the Nogoa River over the next 70 years.
- Longer term marginal increase in the flow in the Nogoa River due to a reduction in the natural loss of water from the Nogoa River to its associated alluvium.
- A finite period (of about 5-10 years) of minor drawdown in riverine alluvium adjacent to Pit B for Option 1.

6.5.3 Management and Mitigation

The successful delivery of the landform design criteria set out at Table 3.1 would mean that there are no specific management and mitigation measures proposed for this Option. Given the level of groundwater drawdown being less than 5 metres at the identified private bores and limited groundwater usage, no further mitigation measures are proposed.
6.6 Fauna and Flora

6.6.1 Potential Impacts

6.6.1.1 Terrestrial Flora

Based upon the Stage 3 Civil Design (WSP, 2018a), impacts on terrestrial flora species are expected to be minimal. It is anticipated that approximately 60 ha of non-regulated regrowth/previously disturbed vegetation adjacent to the existing levee walls would be cleared to allow for the realignment and regrading of the outward levee batters. This clearing has potential to impact in the short-term upon non-regulated regrowth habitats immediate to the existing levees on the floodplain.

No areas of known or potential habitat for threatened flora would be directly impacted by the realignment/regrading of sections of levee associated with this Option. No additional indirect impacts on terrestrial flora are expected.

Should this Option be selected as the final option, a preclearance field survey would be undertaken to confirm that there are no threatened species.

As part of the rehabilitation process following construction of the landform, Ensham proposes to establish a treed corridor using native tree species along the western (highwall) side of the rehabilitated landform. This corridor would be approximately 100 m in width and approximately 6.7 km long, linking the vegetation associated with Corkscrew Creek with the Nogoa River (refer Figure 3.1). In addition to creating this corridor, this would also augment the available habitats for flora and fauna species. This corridor is anticipated to be beneficial for a variety of native fauna species, through increasing the available vegetation cover and associated foraging opportunities in the locality, as well as increasing fauna movement opportunities in this landscape.

6.6.1.2 Terrestrial Fauna

Commonwealth and State listed Endangered species with potential to occur in the Project Area include Eastern Curlew (*Numenius madagascariensis*) and Australian Painted Snipe (*Rostratula australis*). The suitable habitat for these species within the Project Area is predominantly associated with the Nogoa River and its Anabranch. No clearing of riparian REs would occur as a result of this option, and as stated earlier, clearing would be restricted to approximately 60 ha of regrowth/previously disturbed land. As a result, no material impacts on species listed as Endangered are expected.

Several Commonwealth and State listed Vulnerable species are known to occur or have the potential to occur in the Project Area and are known to utilise RE 11.3.25e habitats. Based on available RE mapping, Option 1 is not expected to result in the removal of any REs, as clearing would occur in already disturbed areas adjacent to the existing mine levees.

No additional indirect impacts are expected to occur on any terrestrial fauna species known to utilise the Project Area as a result of this Option at the post-relinquishment phase.

Should Option 1 be selected as the final option, it is recommended that a preclearance field survey be undertaken.

No material indirect impacts (i.e. noise, dust) are expected to occur on any terrestrial fauna species known to utilise the Project area as a result of the Project at the post relinquishment stage of the project.
6.6.1.3 Aquatic Flora

Although no threatened aquatic flora species were identified as having potential to occur within 50 km of the Project Area, aquatic flora are known to occur within the Nogoa River. Option 1 is not expected to have any direct impact upon the Nogoa River or its Anabranch. No water would be actively returned to the Nogoa River or its Anabranch, therefore there should be no opportunity for water to cause indirect impacts to aquatic flora species.

A geochemical assessment was undertaken by RGS (2018) to characterise the existing hydrogeochemistry of the materials on site. This assessment indicated that the existing spoil material is non-acid forming and benign. As a consequence, there is expected to be a low potential for metals or metalloids to impact downstream environments.

The implementation of the proposed rehabilitation including self-sustaining vegetation cover, would minimise any impacts on aquatic flora due to erosion of the landform.

6.6.1.4 Aquatic Fauna

Two threatened turtle species were identified as having potential to occur within the Project Area. These species are known to occur within the Nogoa River. As no REs or riparian vegetation would be cleared as a result of this Option, no direct impacts are anticipated on these species.

6.6.1.5 Terrestrial Groundwater Dependent Ecosystems

Mapping prepared by the Queensland Government (2018) indicates that the riparian corridor associated with the Nogoa River is considered a potential terrestrial GDE. Groundwater assessment prepared by HS (2018) indicates that there are no linkages between the shallow Nogoa River aquifer, and the deeper alluvium or Rangal coal seam aquifers. Therefore, it is considered unlikely that there would be any impacts on terrestrial GDEs should Option 1 be selected.

6.6.1.6 Stygofauna

The Project Area may support stygofauna in the two aquifer types present (alluvium and the deeper coal measures). Option 1 is unlikely to significantly impact any potential stygofauna habitat (namely the alluvial aquifer that extends along the Nogoa River and the Anabranch). The basis for this is:

- This Option would not result in the loss of habitat as the groundwater table would not be affected as water would not be abstracted or diverted from the Nogoa River.
- As the Nogoa River continues to receive recharge from the Fairbairn Dam, this would be beneficial to any groundwater biota which rely on good hydraulic conductivity to replenish food reserves in a normally depleted environment.
- Groundwater quality in the Alluvial aquifer in the Project area and surrounds is typically within the ranges considered acceptable for stygofauna.
- Connectivity along the aquifer remains intact and no obstructions are planned that would cause the isolation of areas, thereby allowing taxa to disperse.
6.6.1.7 Migratory Species

The RVP occurs in a historically operated coal mine area, and this group of highly mobile species can actively avoid operational activities as needed. Option 1 is therefore likely to have an insignificant impact on any migratory species.

6.6.1.8 Bioaccumulation

The residual surface waterbodies are likely to become brackish over time, and contaminants such as metals/metalloids including Arsenic, Molybdenum and Selenium would concentrate through evaporation. These contaminants have the potential to bio-accumulate in sediments and aquatic life within the residual surface waters. Pits F and Y would be designed to prevent the daylighting of groundwater. Accordingly, no bioaccumulation of salt or metals would occur in these landforms.

6.6.2 Management and Mitigation

Analysis of the HEC (2018c) Void Water Quantity and Quality Balance Modelling report indicates that there is potential for metals/metalloids to bioaccumulate within void waters. It is anticipated that due to the gradually increasing salinity and contaminant levels, the diversity of aquatic species within the resultant water bodies will decline over time. This will mean that this option could result in a waterbody only suitable for wading/resting for these species. It should be noted that the residual voids associated with Option 1 are not designed to create aquatic habitats.

Where practicable, avoidance of impacts on the riparian vegetation due to clearing and regrading of the outside levee batters that occur for Option 1 would be made where possible. To ensure this is achieved, it is recommended that a survey be undertaken to delineate the boundaries of the riparian REs to inform the further design. This will provide a current representation of the riparian REs, so that detailed design can be undertaken to avoid/minimise loss wherever practicable.

6.7 Biosecurity

6.7.1 Potential Impacts

There are no additional biosecurity risks associated with Option 1 that would not be managed effectively under the current land management practices for the Mine.

6.7.2 Management and Mitigation

The existing Weed and Feral Animal Management Procedure would be amended prior to implementation of Option 1, to ensure that this area is covered by the practices in that Procedure. Table 6.2 identifies mitigation measures for this option.
Table 6.2 Biosecurity Management Recommendations

<table>
<thead>
<tr>
<th>Period</th>
<th>Issue</th>
<th>Management Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ongoing Land Management</td>
<td>Inspection vehicles carrying weeds or pathogens.</td>
<td>Vehicles used for any inspections or monitoring activities are to be cleaned and inspected prior to entry and exit of the site.</td>
</tr>
<tr>
<td></td>
<td>Vegetated areas to be monitored following significant rainfall events.</td>
<td>Inspections to be undertaken to identify any outbreaks of restricted species. Where restricted species are identified, the owner or operator should control outbreaks in accordance with the control measures identified in the Weed and Feral Animal Management Procedure.</td>
</tr>
<tr>
<td></td>
<td>Presence of pest species.</td>
<td>Annual inspections for presence of restricted pest species. Outbreaks to be controlled using the measures identified in the Weed and Feral Animal Management Procedure.</td>
</tr>
<tr>
<td></td>
<td>Residual voids may encourage proliferation of aquatic weed species.</td>
<td>Annual inspections for presence of priority aquatic weed species. Outbreaks to be controlled using the measures identified in the Weed and Feral Animal Management Procedure.</td>
</tr>
</tbody>
</table>

6.8 Air and Emissions

6.8.1 Potential Emission Sources

During construction, dust emissions would be generated by earth moving equipment.

Greenhouse gas emissions would be generated during the construction of the selected option. Greenhouse gas emissions of 277,958 tCO2 equivalent total emissions have been estimated for Option 1 which is low relative to Option 3 construction emissions of 467,241 tCO2 equivalent (Deloitte, 2018).

Following construction of the rehabilitated landform, there would be no diffuse or point sources of pollution. Accordingly, it is not expected that there would be any air or odour impacts post construction. Additionally, there would be no fugitive emissions expected to be associated with Option 1.

6.8.2 Potential Impacts

Given the lack of emission sources associated with Option 1 post construction, there are not expected to be any short / long term impacts on air quality within the Project Area.

6.8.3 Management and Mitigation

Air emissions pre-relinquishment would be managed under the EA and in accordance with the site Dust Management Procedure.

No additional management and mitigation measures are recommended in respect of air quality for Option 1 post construction.
6.9 Noise and Vibration

6.9.1 Potential Impacts

During construction, noise and vibration emissions would be generated by earth moving equipment.

Following the construction of the rehabilitated landform, there would be no noise generating equipment remaining in the Project Area and there would be no noise or vibration impacts.

6.9.2 Management and Mitigation

During construction, noise and vibration impacts would be managed in accordance with the EA and the Site Noise and Vibration Management procedure. No additional management and mitigation measures would be required in respect of noise or vibration post construction for Option 1.

6.10 Waste Management

6.10.1 Potential Impacts

Option 1 would not generate any regulated waste.

Geochemical analysis, water quality modelling and flood modelling indicate that seepage from the spoil material would be captured in the voids and would not be released to surface waters.

6.10.2 Management and Mitigation

Waste Management pre-relinquishment would be undertaken in accordance with the current Ensham Mine Environmental Impact Management Plan – Waste. No additional management and mitigation measures are recommended in respect of waste management for Option 1.

6.11 Hazards and Safety

6.11.1 Safety

The rehabilitated landforms will be designed and a treed corridor would be created along the high wall to avoid the need for fencing or other access restrictions for safety reasons.

6.11.2 Potential Impacts

The creation of the treed corridor between Corkscrew Creek and the Nogoa River floodplain may create additional bushfire intensity areas (likely to be a medium potential) once the woody vegetation is established, as discussed in Section 5.10.

While a cyclone itself may not reach the Project Area, the associated rainfall front may bring increased rain, resulting in flooding. Flood risk and mitigation has been discussed in Section 6.4.

6.11.3 Management and Mitigation

As discussed in Sections 5.2 and 5.3, the design of the Option 1 levee addresses potential associated erosion and stability issues and flood risk.
Should additional bushfire intensity areas be created via the treed corridor (or other rehabilitation activities) they would be managed in accordance with applicable regulatory requirements.

No other specific management and mitigation measures are proposed for hazards and safety.
7.0 Impact Assessment of Environmental Values - Option 2 Assessment: Flood Mitigation and Beneficial Use

7.1 Climate

7.1.1 Potential Impacts

Any potential impacts of Option 2 on EVs relevant to climate would be due to impacts from climate change. There is potential for climate change to influence potential impacts on other EVs listed in Section 4.0. The potential impacts to these other EVs are discussed below for Option 2 where relevant.

7.1.2 Management and Mitigation

No specific management and mitigation measures are proposed for climate for this Option. Where climate change predictions influence other EVs and management and mitigation measures are required, these are noted where relevant below.

7.2 Land

7.2.1 Potential Impacts

The potential impacts to the EVs listed in Section 4.0 are provided in the following sections.

7.2.2 Visual Amenity

Figure 8.1 provides a conceptual visualisation of the final landform for Option 2. The Project Area would be rehabilitated to be visually consistent with the surrounding environment. Residual voids would remain as water sources which is common with other properties in the region. A treed corridor would be created adjacent to the highwall between Corkscrew Creek and the Nogoa River, which would reduce any visual impacts that may be associated with the residual voids. Option 2 is not expected to have any significant impact on the visual amenity of the area.

7.2.3 Landform Assessment

A landform assessment for the Option 2 landform was undertaken by WSP (2018c). The assessment included the development of landform design criteria, landform design and stability optimisation, material movement optimisation, and landform visualisation, and it incorporated findings from the geotechnical assessment also undertaken by WSP.

The landform design was based on achieving key rehabilitation goals including the landform being safe, stable and non-polluting. The landform assessment identified that in order to achieve a safe, stable landform, regrading of the residual voids would be required, including the highwalls, endwalls and spoil dumps. Details of the design criteria adopted for this Option are listed in Table 3.2. A geochemical assessment was undertaken by RGS (2018) to characterise the existing hydrogeochemistry of the materials on site. This assessment indicated that the existing spoil material is non-acid forming and benign, and hence the final landform including for water storage purposes, can be considered to be non-polluting in regard to leachate.
The landform has been designed to exclude rehabilitated areas from the floodplain up to and including 0.1% AEP event (1 in 1000). For rain that falls on inward facing slopes and the rehabilitated land, this water would collect in the residual voids for A, B, C and D-Pits. Those Pits when operating as a water storage would also receive flood flows from the Nogoa River through the proposed inlet structure. The lower areas of rehabilitated land for E, F and Y-Pits, would also collect run-off from the inward facing slopes, which water would subsequently migrate to groundwater with no harm to the environment. Water draining from outward facing slopes to the receiving environment would have low salinity and present minimal risk to the environment. The risk of uncontrolled release of water from the voids and other rehabilitated landforms (inward facing slopes) flowing to receiving environments is extremely improbable (e.g. greater than 1 in 1000 for this catchment).

Option 2 includes setting back the highwall in accordance with landform design criteria provided at Table 3.2 and regrading of the first inward facing slope opposite to the highwall rehabilitation at a maximum of 25%. The inward facing slopes would include rock mulching (above the full supply level) to reduce erosion potential, delivering the required erosion stability outcomes. Rehabilitation of low wall spoil between the inward facing slope and outward facing slopes will be a combination of slope angles no greater than 25% depending on the nature of spoil material adjacent to the residual void. Cross sections at 200m intervals for the full rehabilitated landform from A to Y and contour maps are provided in the landform report (WSP, 2018).

Low wall spoil slopes would be topsoiled and/or ameliorated to promote and sustain vegetation growth, consistent with the current completion criteria in the EA.

The final landform results in 77% of the rehabilitated area at a slope of 15% or less. Approximately 570 ha of land would be below the full storage water level in A, B, C and D-Pits. No surface treatment is proposed for these inundated areas as the mechanisms for erosion would be absent when the landform is submerged. The final landform has been designed so that it is suitable for water storage.

The slope of the outward facing spoil would be suitable for agricultural purposes.

7.2.4 Landform Stability

A geotechnical assessment was undertaken by WSP (2018b) to evaluate the stability and erosion potential of the final landforms.

For Option 2, highwalls, and lowwall spoil piles would be regraded and left as long-term stable structures, and the existing levees would be retained in their current form. Intake structures would be constructed through the levee embankments to capture a small fraction of larger magnitude flood event flows in the Nogoa River, and store this water in the residual voids within the floodplain (refer Section 6.3.4).

All rehabilitated landforms, including the water storage voids, would be regraded to achieve a minimum Factor of Safety (FOS) of 1.5, to maintain long-term stability.

The existing levees have a FOS in excess of 1.5 (WSP, 2018b), and as the slopes of the levees would not be altered for this Option, they are expected to maintain their long-term stability.

Similar to Option 1, WSP (2018b) characterised the stability and erosion potential of the existing highwalls and spoil piles, which mostly comprise Tertiary clays overlying weathered/fresh Permian rock, concluding that:
• In its current configuration, Tertiary clays would not be considered long-term stable, given they typically have a marked loss of strength when wet and tend to be prone to instability and severe erosion;
• Weathered/fresh Permian rock tends to slake and soften over time and can be susceptible to erosion. Instability could also develop around exposed faults or geological structures.

The above risks are addressed by achieving a FOS of greater than 1.5. The above factors, incorporating the adopted Option 2 landform design criteria outlined in Table 3.2, would result in a safe and stable outcome. The final landform would have considerably improved batter slopes for highwall, endwall and spoil in terms of erosion potential, compared with the existing un-rehabilitated landform.

7.2.5 Land Use and Agricultural Potential

Option 2 would return an area of land that is compatible for agricultural use on the outward facing slopes. The voids for A, B, C and D-Pits would be used for water storage. All inward and outward slopes for the rehabilitated landforms E, F and Y-Pits would be regraded to a maximum of 10-15% which is sufficiently gentle for pasture crops, grazing and operation of agricultural equipment. The balance of terrain for E, F and Y-Pits greater than 15% would be revegetated suitable for native vegetation use.

Ultimately, the augmentation of irrigation water supply has potential to have significant benefit for agricultural land uses, with the economic and social benefit of this potential outcome being assessed in separate reports.

7.2.6 Management and Mitigation

Successful delivery of the Option 2 Landform Design Criteria outlined in Table 3.2 would mean that there are no specific management and mitigation measures proposed for the landform, post-relinquishment. The future operator of the water supply facility would be responsible for maintaining the water storage facility and associated infrastructure.

Regular inspection and ongoing maintenance of the levees for Option 2 would be required to rectify and issues which could lead to instability in the long-term such as:

• erosion, cracking, settlement
• or piping
• scour from high water flow periods.

Recognised agricultural land management practices to manage vegetation cover would be appropriate for Pits E, F and Y to minimise erosion potential.

7.3 Assessment of Compliance to Water Plan Objectives

An assessment was undertaken by OD Hydrology (ODH, 2018) of the potential water supply yield from the Ensham Voids while ensuring compliance with the state’s water planning framework, represented by the Water Plan (Fitzroy Basin) 2011 (‘the Water Plan’). The assessment was undertaken using the Fitzroy River Basin hydrology/water allocation model developed by the Queensland Hydrology group of the Department of Environment and Science (DES) using the Integrated Quantity-Quality Model (IQQM) software.
Key objectives of the Water Plan include compliance with Environmental Flow Objectives (EFOs) and Water Allocation Security Objectives (WASOs). EFOs represent flow characteristics that should be maintained to support environmental objectives for the river system. The EFOs typically specify a desired relationship to flow characteristics in the undeveloped system (estimated from modelling with current water infrastructure removed) at several locations along the system. It is recognised that not all desirable flow characteristics are achievable in a developed system. Hence, the Water Plan identifies “must meet” EFOs and “should meet” EFOs.

WASOs within the Water Plan aim to protect the performance of water supply for all existing water users within the Fitzroy Basin. The WASOs identify the required annual or monthly reliability of supply to water users within the water supply system. All WASOs are “must meet” requirements.

In addition to the base case (existing approved development), the assessment considered three scenarios for the Ensham voids:

- **Scenario 1** – Stage 1 of Option 2 with water storage in the voids south of the river only and no constraints on water take due to water licensing rules;
- **Scenario 2** – Stage 2 of Option 2 with water storage in the voids north and south of the river and no constraints on water take due to water licensing rules;
- **Scenario 3** – Stage 1 of Option 2 with water take constrained by compliance with existing licensing rules.

The results of the assessment show that Option 2 can provide 8,000 ML per year of water in Stage 1 and 20,000 ML per year in Stage 2 with high reliability. All “must meet” EFOs and all WASOs were met under all assessed project scenarios.

The results of Scenario 3 show that current water licensing constraints would prevent the project from achieving these yield volumes, with a yield of 1,500 ML per year available under existing water licensing rules.

An assessment was also undertaken including the effects of climate change on river flows, local rainfall and evaporation. The modelling was undertaken using a representation of climate change impacts, based on information provided by DES for the Fitzroy basin. It was assumed the system was still required to meet EFOs and WASOs for existing conditions. This is a conservative assumption because there would inevitably be impacts on environmental flows and water supply security caused by climate change (unrelated to the Ensham project). Under these assumptions the results of the assessment show that the yield from the Ensham voids would be reduced by 50% compared to existing conditions (yield of 4 GL/a for Stage 1 and 10 GL/a for Stage 2).

### 7.4 Surface Water

#### 7.4.1 Potential Impacts

The potential impacts to the Water related EVs listed in Section 4.0 are provided in the following sections.

#### 7.4.2 Water Quality and Balance Assessment

HEC (2018b) undertook an assessment of the water quality and balance for Option 2 using GoldSim modelling to determine long term water quantity and quality predictions. The modelling incorporated the results of the hydrogeochemical characterisation of the spoil material and pit walls undertaken by RGS (2018), the estimates of groundwater flux in to and out of each of pit as modelled by HS (2018), and an estimate of
irrigation demand, based on data generated by ODH (2018) using an IQQM model of the Nogoa, Mackenzie and Lower Fitzroy system.

Based on the results of modelling rounds conducted for earlier Stages of the RVP process, HEC has modelled:

- Pit A and Pit B as separate pits;
- Pit C and Pit D as one pit ("Pit CD");
- Pit E as one pit.

In response to ongoing refinement of the groundwater modelling and landform design, the floor levels of Pit F South, Pit F North and Pit Y have been raised to be approximately 5 metres above the predicted groundwater level. Consequently, groundwater and seepage from in-pit spoil will be beneath the floor level of the rehabilitated landform and would not daylight. Only surface water runoff will report to the lowest point in the landform and from there will drain through the backfill material to the groundwater table. For this reason, these pits are not expected to hold water for extended periods and modelling of the water quality and balance in these voids was not undertaken.

The following four scenarios were modelled for each pit:

- First stage of Option 2 development, using only voids located to the south of the Nogoa River (referred to in the HEC report as “Model Run 3”). This scenario was based on modelled duration of 129 years, and assumes an irrigation demand of 8 GL/year and a supplemented water allocation of 1.5 GL/year\(^6\) added to Pit B.
- Full development of Option 2, using all floodplain voids (referred to in the HEC report as “Model Run 4”). This scenario was based on a modelled duration of 129 years, and assumes an irrigation demand of 20 GL/year and a total supplemented water allocation of 1.5 GL/year added to Pits B and CD.
- Assessment of potential elevated salinity during initial filling (referred to in the HEC report as “Model Run 5”). This scenario was based on a modelled duration of 27 years, and assumes an irrigation demand of 20 GL/year and a supplemented water allocation of 1.5 GL/year added to Pits B and CD. In addition to the long-term salt release rates, this scenario assumed an additional salt input from an initial release of salt from water contact with the highwall, and the initial washout of salt from in-pit spoil which could occur during the initial few fill cycles of the voids with water from the river and subsequent drawdown for beneficial use.
- Option 2 landform post-cessation of beneficial use (referred to in the HEC report as “Model Run 6”). This scenario was based on 258 years of rainfall and evaporation data (determined based on the 129 years (1889-2017) of available records from the SILO Data Drill for a location adjacent to the Ensham Mine, and this data set was then repeated to simulate 258 years) to model an equilibrium water level in the pit voids. Rainfall was included in the model as direct rainfall into the void and, as an input to the catchment runoff model. Evaporation from the storages was calculated in the model by multiplying storage surface area by daily pan evaporation rate and by a pan factor.

Inflows to the voids comprised direct rainfall over the void water surface, surface runoff and baseflow from the void catchment area, groundwater inflow and intake structure inflow from the Nogoa River. Outflows

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\(^6\) Ensham has an existing supplemented allocation of 1.5 GL/year from Fairbairn Dam.
were evaporation, groundwater outflow, pumped outflow to irrigation, and intake structure outflow to the Nogoa River.

Water quality modelling was undertaken to assess concentrations over the various simulation periods for each scenario for the following:

- Solutes: calcium, chloride, magnesium, potassium, sodium and sulfate;
- Metals: arsenic, molybdenum, and selenium; and
- Salinity (derived from total dissolved solids).

The modelling results for the four Option 2 scenarios indicated the following:

- **First stage of Option 2 development, using only southern reservoirs:**
  - The predicted water levels in Pit A and Pit B rise and receive inflow from the Nogoa River every 2 to 3 years on average. Water levels in Pit A are drawn down in line with Pit B due to the assumed high hydraulic conductivity from Pit A to Pit B.
  - The predicted water quality in Pit B is improved by the regular inflows from the Nogoa River which has the dual effects of:
    - Topping up the pit reservoirs such that there is sufficient water available to pump to irrigation; and
    - Diluting solute, metal and salinity concentrations, particularly salinity such that the irrigation salinity limit of 2,000 mg/L does not impact the ability of the reservoir to supply the irrigation demand. Topping up the reservoirs such that there is sufficient water available to pump to irrigation; and
  - The average irrigation demand of 8 GL/year is able to be supplied from Pit B.
  - A comparison of cumulative flow in the Nogoa River downstream of the pit reservoirs shows an average decrease in the river flow volume of 1.8% over the 129 year simulation period.

- **Full development of Option 2, using all floodplain voids:**
  - Pit B and Pit CD receive inflow from the Nogoa River every 2 to 3 years on average.
  - Pit A receives overflows from Pit B only when Pit B fills, which occurs every 4 to 5 years on average.
  - Pit E receives overflows from Pit CD only when Pit CD fills, which occurs every 4 to 5 years on average.
  - The predicted water quality in Pit B and Pit CD is improved by the inflows from the Nogoa River which has the dual effects of:
    - Topping up the pit reservoirs such that there is sufficient water available to pump to irrigation; and
    - Diluting solute, metal and salinity concentrations, particularly salinity such that the adopted irrigation salinity limit of 2,000 mg/L does not impact the ability of the reservoirs to supply the irrigation demand.
The average irrigation demand of 8 GL/year from the southern reservoir and 12 GL/year from the northern reservoir is able to be supplied with no predicted shortfall.

A comparison of cumulative flow in the Nogoa River downstream of the pit voids shows an average decrease in the river flow volume of 3.3% over the 127 year simulation period.

Assessment of potential elevated salinity during initial filling and drawdown:

- The predicted salinity in the southern reservoir and the northern reservoir was found to be higher over the 27 year simulation period, compared to the results from the previous scenario (full development of Option 2). However, inflows from the Nogoa River over the modelled period were sufficient to reduce salinity levels in these pits so that there would be no impact on supply of the estimated irrigation demand from these pits.

Option 2 Landform will allow:

- Pit B and Pit CD to receive inflows from the Nogoa River, every 2 to 3 years on average. Once filled, CD pit will overflow to Pit E, B pit will overflow to A pit.
- The predicted water quality in Pit B and Pit CD would be improved by the regular inflows from the Nogoa River.
- A comparison of cumulative flow in the Nogoa River downstream of the reservoirs shows an average decrease in the river flow volume of 0.9% over the 258 year simulation period.

### 7.4.3 Water Quality from Residual Landform

This option would utilise water stored in the reservoirs to augment irrigation demand in the region. This has the benefit of providing an annual yield of up to approximately 20 GL. To ensure the water quality is suitable for irrigation purposes, the supply to irrigation would be limited if salinity levels exceeded 2,000 mg/L. The benefits of this irrigation water supply are being quantified in separate economic and social assessments.

The potential uses for aquaculture, recreation, or industrial purposes have not been assessed as these would be at the discretion of the operator. There are no identified impacts in relation to void water being unacceptable for visual recreation purposes.

### 7.4.4 Downstream River Quality

The proposed culvert inlet structures for Option 2 will allow the immediate return of flood water to the river during the recession of large flood events that completely fill the voids. The quality of water that flows back to the river under these conditions will be very similar to the flood water quality. Simulation of the exchange of water between the reservoirs and the river shows that there will be no measurable impact on river water quality for 95% of the time that backflow to the river is occurring. During the remaining 5% of the time that backflow is occurring, the impacts will be minor. The predicted maximum salinity immediately downstream of the voids during backflow is approximately 400 mg/L compared to an adopted background concentration in the river of 115 mg/L during flood conditions. During non-flood conditions (flow less than 10,000 ML/d) the background range of salinity for the Nogoa River ranges from about 160 - 580 mg/L (10 percentile to 90 percentile). On this basis, Option 2 will not have an impact on water quality objectives for downstream users for irrigation, farming, stock use, aquaculture or human consumption.
7.4.5 Evaporative Concentration on Salinity within the Residual Landform

Inflows from the Nogoa River to the reservoirs would dilute any salinity levels in these reservoirs, similar to what happens in Fairbairn Dam in flood periods.

Pits A and E, which do not receive direct river inflows are likely to experience higher salinity compared to the adjoining Pits B and CD.

The minimum level of the rehabilitated landform in Pit F North, Pit F South and Pit Y will be approximately 5 m above the predicted long-term groundwater rest level. These pits will only receive surface water runoff which will drain through the backfill material to the groundwater table. Evaporative concentration of salinity is not anticipated to occur in these voids.

7.4.6 Flood Modelling

HEC (2018a) undertook flood modelling of peak flow depths for Option 2 at the 10%, 5%, 1% and 0.1% \(^7\) AEP flood events using the TUFLOW software package. The TUFLOW model boundary conditions were based on hydrographs from the XP-RAFTS hydrological model (upstream boundary) and the rating curves (downstream boundary) developed as part of the 2013 KBR flood study for the area (HEC, 2018a).

The modelling looked at both the voids full and voids empty scenarios and compared these against the existing landforms.

The model results for afflux (voids full and voids empty) are presented in Figures 7.3 to 7.8 (figures for other modelled results are available in the HEC, 2018a technical report). The results for both peak flow depth and afflux show that:

- With voids starting empty, for the 10% and 5% AEP events there is a predicted decrease in flood levels of up to 0.5m in some areas, with the majority of the area experiencing a less than 0.2m decrease. The corresponding peak flow depths are generally less than 2m with between 2 and 8m being experienced adjacent to watercourses;

- With voids starting empty, for the 1% AEP event, there is a predicted decrease of up to 0.2m in flood levels throughout the modelled area. The corresponding peak flow depths are generally up to 4m in overbank areas with up to 8m adjacent to channels;

- With voids starting full, for the 10% and 5% AEP events there is a predicted decrease of up to 0.5m in flood levels generally throughout the modelled area. Under the 10% and 5% AEP events there are portions of land upstream of the Project Area (primarily adjacent to Winton Creek and its tributaries) which is predicted to experience up to 0.1m increase;

- With voids starting full, for the 10% and 5% AEP events peak flow depths are generally less than 2m with between 2 and 8m being experienced adjacent to watercourses;

- With voids starting full, for the 1% AEP event there is a predicted decrease of up to 0.2m in flood levels generally throughout the modelled area.

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\(^7\) Collectively these AEPs event represent the 1 in 10, 1 in 20, 1 in 100 and 1 in 1,000 AEP flood events respectively
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Figure 7.3  Forecast Afflux 10% AEP - Voids Empty

(Source: HEC, 2018a)
Figure 7.4  Forecast Afflux 5% AEP - Voids Empty

(Source: HEC, 2018a)
Figure 7.5  Forecast Afflux 1% AEP - Voids Empty

(Source: HEC, 2018a)
Figure 7.6  Forecast Afflux 10% AEP - Voids Full

(Source: HEC, 2018a)
Figure 7.7   Forecast Afflux 5% AEP - Voids Full

(Source: HEC, 2018a)
Figure 7.8  Forecast Afflux 1% AEP - Voids Full

(Source: HEC, 2018a)
7.4.7 Local Run-off Volumes to the River

Due to the regrading of the outward facing levee structures, there may be some comparatively very minor changes to the catchment area reporting to Nogoa River compared to the catchment upstream. However, this is unlikely to materially change run-off volumes, therefore impacts to local run-off volumes to the river are not expected.

7.4.8 Geomorphology Assessment

Geomorphological modelling for Option 2 was undertaken by WRM Water & Environment (WRM) (2018). This modelling incorporated flood model data (provided by HEC, 2018a) to assess the morphology of the Nogoa River floodplain. The modelling included an assessment of:

- The 10% AEP design flood event, to represent the behaviour of the river at the bank full flow conditions. The bank full flow is the maximum flow that the channel can carry before it overflows onto the adjacent floodplain. In geomorphologic studies, the bank full flow is often considered to be the stream forming flow, because it often exerts the greatest influence on channel geometry (WRM, 2018);

- The 1% AEP design flood event, to represent the behaviour of the river during a large and infrequent flood event; and

- A flood event 50% greater than the 0.1% AEP design flood event (i.e., an extreme event), to determine what would occur in the unlikely event that the levels of the landform levees are exceeded.

Option 2, which utilises the post-mining voids to form water storages to capture a proportion of high flow flood water and store this water for potential beneficial use, maintains the existing levees to protect the voids from flooding. As a result, there would be no material difference in velocities and shear stresses along the river channels or the floodplain between Option 1 and Option 2. Therefore, the results described for Option 1 are relevant for Option 2.

On the basis that the changes in hydraulic behaviour for events up to the 1% AEP event are minor, the short and medium-term risks to the Nogoa River for Option 2 landform are low.

The modelling of the extreme event (adopted as 1.5 x the 0.1% AEP event) suggests that there remains a very low long-term risk of morphological change to the Nogoa River for Option 2 due to an overtopping event. However, there is little chance of the levee and embankment eroding to bed level because of the equalising effect of the water stored in the voids. On this basis, the long-term risk to the Nogoa River from this Option is considered low. However, some scour protection is recommended around the intake channels.

7.4.9 Management and Mitigation

Successful delivery of the completion criteria would mean that there are no specific management and mitigation measures proposed relating to rehabilitated landforms for post-relinquishment for this Option, other than the scour protection noted above.

Post-relinquishment, there will be a need for the ultimate land manager of the Project Area to undertake maintenance of the levee structures post flooding.
7.5  Groundwater

7.5.1  Groundwater Modelling

The groundwater investigation has been based on groundwater flow modelling using a model developed by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), most recently updated in 2016. The model has been re-calibrated by HS (2018) to include additional data up to February 2018.

The main findings of the modelling for Option 2 are that (HS, 2018):

- Pit waterbody stage groundwater discharge modelling implies that substantial ingress or egress of water between ground and pit could occur if water levels are more than a few metres from rest equilibrium conditions.

- Pit stages are expected to take many decades to achieve equilibrium level conditions. The underground workings scheduled for development between 2018 and 2020 are proximal to the open cut areas which either currently hold water or are predicted to hold water in the future. During near-future mine advancement, water from these areas is anticipated to recharge the underground mine. Following cessation of active dewatering in the underground, the enhanced groundwater connection between pit voids and underground voids would result in several decades of underground mine rebound at the expense of pit void stage recovery. Only after rebound of the underground water levels would pit water rise to predicted equilibrium levels.

- Without the influence of net water gain from captured flood flows, pit waterbodies are expected to have low water levels for several decades, before the waterbodies are able to recover towards (but never reaching) pre-mining water levels. Water levels for Option 2 would vary over time in response to inputs and outputs for beneficial use.

The presence of backfill material in the former pit areas additionally influences the rate of underground and pit rebound. High infiltration potential and the reduced capacity for evaporation in these areas provides a short travel time indirect pathway for recharging water to enter the underground and pit.

For Option 2, the pits are expected to gain water while water levels are below their natural rest levels. For higher forced water levels, the pits would lose water at significant rates to the underground groundwater system which would not have fully recovered within the next 100 years. This means that artificial topping up of water in storages from flood inflows could incur losses to the groundwater system (HS, 2018). These losses are accounted for in the water balance modelling (HEC 2018).
7.5.2 Potential Impacts

The potential impacts to the Groundwater related EVs listed in Section 4.0 are provided as follows.

Water levels in Pits A to E will be dominated by managed river inflows. For F and Y pits, there will be no groundwater inundation as the pit floor level will be raised above the groundwater rest level.

Groundwater modelling for Option 2 also indicates that there is minor to negligible impact to groundwater bore drawdown.

Modelling also showed that there would be reduced drawdown in the riverine alluvium adjacent to Pit B for Option 2, as pit water levels would be held higher than natural levels for flood mitigation and beneficial use.

The findings of the groundwater assessment indicate:

- Minor groundwater drawdown impacts on private bores used for farm or stock water supply, with negligible impact on the one identified irrigation bore due to its distance from the mine.
- Negligible impact on groundwater quality at any private bores.
- Negligible impact on aquatic ecosystem water quality as project activities would not cause additional groundwater discharge to any rivers.
- A slight beneficial effect on groundwater quality beneath the Nogoa River close to Pit B, due to a marginal increase in the natural leakage from the Nogoa River over the next 70 years.
- Longer term marginal increase in the flow in the Nogoa River due to a reduction in the natural loss of water from the Nogoa River to its associated alluvium.
- Relatively reduced drawdown in riverine alluvium adjacent to Pit B for Option 2, as pit water levels would be held high for flood mitigation and beneficial use.

7.5.3 Management and Mitigation

The successful delivery of the landform design criteria set out at Table 3.2, would mean that there are no specific management and mitigation measures proposed for post-relinquishment for this Option. Given the level of groundwater drawdown being less than 5 metres at the identified private bores and limited groundwater usage, no further mitigation measures are proposed.

7.6 Flora and Fauna

7.6.1 Potential Impacts

Terrestrial Flora

Based upon the Stage 3 Civil Design (WSP, 2018a), impacts on terrestrial flora species are expected to be minimal.

It is anticipated that approximately 3 ha of RE 11.3.25e would be cleared for the construction of the required water intake structures. There is also potential for the re-installation of the Ensham Mine pipeline across the Nogoa River, which may result in approximately 0.1 ha of disturbance to RE 11.3.25e adjacent to the existing alignment. The areas proposed for clearing for this Option are shown in Figure.
This clearing has potential to impact in the short term upon riparian habitats associated with the Nogoa River, some of which are recognised as habitat for threatened species. Should this Option be selected as the final option, a preclearance field survey would be undertaken to confirm that there are no threatened species.

Two intake structures, as well as the reconstruction of the Ensham Mine internal water pipeline would be constructed across a section of RE 11.3.25e (refer Figure 7.9). This community may provide habitat for threatened flora species including *Dichanthium queenslandicum*. Should this Option be selected as the final option, a preclearance field survey would be undertaken to confirm that there are no threatened species should Option 2 be selected. This would allow for any minor alignment changes to occur to avoid or minimise potential impacts should it be determined that these species occur.

As part of the rehabilitation process, following construction of the landforms associated with Option 2, a treed corridor using native tree species along the western (highwall) side of the rehabilitated landform will be established. This corridor would be approximately 100m in width and approximately 6.7 km long, linking the vegetation associated with Corkscrew Creek with the Nogoa River (refer Figure 3.2). In addition to creating this corridor, this would also augment the available habitats for flora and fauna species. This corridor is anticipated to be beneficial for a variety of native fauna species, through increasing the available vegetation cover and associated foraging opportunities in the locality, as well as increasing fauna movement opportunities in this landscape. Ecological values of this treed corridor could be further enhanced through appropriate fencing to restrict stock movement into the corridor.
Figure 7.9  Clearing Required for Option 2

Legend
- Project Area
- Option 2 Lease
- Proposed Water Pipelines Infrastructure
- Northern and Southern Inlets (Option 2 only)
- Ensham Mine Pipeline to be Re-installed
- Drainage Lines
- Rail Line
7.6.2 Terrestrial Fauna

Commonwealth and State listed Endangered species with potential to occur in the Project Area include Eastern Curlew (Numenius madagascariensis) and Australian Painted Snipe (Rostratula australis). The suitable habitat for these species within the Project Area is predominantly associated with the Nogoa River and its Anabranch. Although this option result in the clearing of approximately 3 ha of RE 11.3.25e, this is not expected to significantly impact upon these species, given these are highly mobile species that do not breed within Australia.

Several Commonwealth and State listed Vulnerable species are known to occur or have potential to occur in the Project Area, and are known to utilise RE 11.3.25e habitats. Based on available mapping, Option 2 is likely to result in the removal of approximately 3 ha of RE 11.3.25e. Should this Option be selected as the final option, a targeted field survey would be undertaken to confirm that there are no impacts to the habitat of listed species in the proposed disturbance areas.

No additional indirect impacts are expected to occur on any terrestrial fauna species known to utilise the Project Area.

7.6.3 Aquatic Flora

Although no threatened aquatic flora species were identified as having potential to occur within 50 km of the Project Area, aquatic flora are known to occur within the Nogoa River. Option 2 is expected to have minor impacts on the aquatic habitats of the Nogoa River or its Anabranch due to the construction of intake structures as well as the potential installation of a new pipeline across the Nogoa River.

A geochemical assessment was undertaken by RGS (2018) to characterise the existing hydro-geochemistry of the materials on site. This assessment indicated that the existing spoil material is non-acid forming and benign. As a consequence, there is expected to be a low potential for metals or metalloids to impact downstream environments.

7.6.4 Aquatic Fauna

Two threatened turtle species were identified as having potential to occur within the Project Area. These species are known to occur within the Nogoa River. Approximately 3 ha of RE 11.3.25e which may provide riparian habitat for these species would be cleared as a result of this Option. This disturbance is expected to have minimal direct impacts on these species.

On the basis that pits A and E are managed to ensure metal levels remain below bio-accumulation values (as specified in the water quality guidelines (ANZG, 2018), bio-accumulation is not expected to occur. Additionally, as pit F and Y floor levels will be above groundwater levels, bio-accumulation will not be an issue for these landforms.

7.6.5 Terrestrial Groundwater Dependent Ecosystems

Mapping prepared by the Queensland Government (2018) indicates that the riparian corridor associated with the Nogoa River is considered a potential terrestrial GDE. Groundwater assessment prepared by HS (2018) indicates that there are no linkages between the shallow Nogoa River aquifer, and the deeper alluvium or Rangal coal seam aquifers. Therefore, it is considered unlikely that there would be any impacts on terrestrial GDEs should Option 2 be selected.
7.6.6 Stygofauna

The Project Area may support stygofauna in the two aquifer types present (alluvium and the deeper coal measures). Option 2 appears unlikely to significantly impact any potential stygofauna habitat (namely the alluvial aquifer that extends along the Nogoa River and the Anabranch). The basis for this is:

- This Option will not result in the loss of habitat as the groundwater table will not be affected as water will not be abstracted or diverted from the Nogoa River except under high flow conditions.
- The Nogoa River continues to receive recharge from the Fairbairn Dam, this will be beneficial to any groundwater biota which rely on good hydraulic conductivity to replenish food reserves in a normally depleted environment.
- Groundwater quality in the Alluvial aquifer in the Project area and surrounds is typically within the ranges considered acceptable for stygofauna.
- Connectivity along the alluvial aquifer remains intact and would not be obstructed. Therefore, there would be no isolation of the aquifer areas, allowing taxa to disperse freely.

7.6.7 Migratory Species

Option 2 is likely to have an insignificant impact on migratory species. This option would ultimately result in the presence of residual waterbodies which are likely to provide some foraging and wading resources for these species.

7.6.8 Bioaccumulation

Pits F and Y would be designed to prevent the daylighting of groundwater. Accordingly, no bioaccumulation of salt or metals would occur.

7.6.9 Management and Mitigation

Where practicable, avoidance of clearing riparian vegetation for the construction of the intake channels and structures adjacent to the Pit B and Pit C levees by utilising the existing track crossing.

Prior to clearing, the areas would be clearly demarcated so that no areas that have not been previously disturbed are impacted, unless further preclearance surveys are undertaken.

A targeted field survey in the disturbance footprint in RE 11.3.25e would be undertaken to identify the presence of any suitable habitat for listed species within the proposed disturbance areas, and to develop appropriate mitigation measures if required.

The implementation of the proposed rehabilitation including self-sustaining vegetation cover would minimise the risk of impacts on aquatic flora due to erosion of the landform.

7.7 Biosecurity

7.7.1 Potential Impacts

There are no additional biosecurity risks associated with Option 2 that would not be managed effectively under the current land management practices for the Mine.
7.7.2 Management and Mitigation

The existing Weed and Feral Animal Management Procedure would be amended prior to implementation of Option 2, to ensure that the area is covered by the practices in that Procedure. Mitigation measures are outlined in Table 7.1.

Table 7.1 Biosecurity Management Recommendations

<table>
<thead>
<tr>
<th>Period</th>
<th>Issue</th>
<th>Management Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ongoing Land Management</td>
<td>Inspection vehicles carrying weeds or pathogens</td>
<td>Vehicles used for any inspections or monitoring activities are to be cleaned and inspected prior to entry and exit of the site</td>
</tr>
<tr>
<td></td>
<td>Vegetated areas to be monitored following significant rainfall events</td>
<td>Inspections to be undertaken to identify any outbreaks of restricted species. Where restricted species are identified, the owner or operator should control outbreaks in accordance with the control measures identified in the Weed and Feral Animal Management Procedure</td>
</tr>
<tr>
<td></td>
<td>Presence of pest species</td>
<td>Annual inspections for presence of restricted pest species. Outbreaks to be controlled using the measures identified in the Weed and Feral Animal Management Procedure</td>
</tr>
<tr>
<td></td>
<td>Residual voids may encourage proliferation of aquatic weed species</td>
<td>Annual inspections for presence of priority aquatic weed species. Outbreaks to be controlled using the measures identified in the Weed and Feral Animal Management Procedure</td>
</tr>
</tbody>
</table>

7.8 Air and Emissions

7.8.1 Potential Emission Sources

During construction, dust emissions would be generated due to the earth moving associated with the land rehabilitation activities and construction of site infrastructure.

The infrastructure proposed to be installed and utilised for Option 2 consists of:

- Pump stations and associated pipelines / channels to allow the transfer of water between pits and the Weemah Channel;
- Inlet / outlet structures (culverts) at Pit B and Pit C to facilitate the collection/release of flood water;
- Solar farm to assist in the offset of electricity supply required to operate the pumping system; and
- Diesel pump station at the Nogoa River.

Greenhouse gas total emissions associated with the construction of Option 2 are estimated at 142,612 equivalent tonnes CO2 (Deloitte, 2018) which is lower that option 1 (277,958 tonnes equivalent CO2) and option 3 (467,241 tonnes equivalent CO2). The Ensham site National Greenhouse and Energy Reporting baseline emissions level would not be exceeded for Option 2.

All pump stations associated with the transfer of water between pits and the Weemah Channel would be electric. Pipelines would be constructed from high density polyethylene and channels would be constructed...
with concrete. The solar farm has been designed to assist in the offset of electricity in operating the pumping system. As such it is expected there would be no emissions from this infrastructure.

The Nogoa River pump station is proposed to contain a skid-mounted single diesel pump which would only be used whilst maintenance flow pumping is required. This pump would generate a negligible source of air emissions.

7.8.2 Potential Impacts

Post construction, there would be negligible dust emissions. The pumps would be powered by solar energy and accordingly, there would be no greenhouse gas emissions. A single backup diesel pump would be used if required and would produce negligible greenhouse gases from a regional perspective.

7.8.3 Management and Mitigation

Air emissions pre-relinquishment would be managed under the current EA and the site Dust Management Procedure.

Ensham is proposing to offset its indirect greenhouse gas emissions via the installation of a solar farm to reduce the quantity of electricity required to operate the pumps required for the water distribution system.

7.9 Noise and Vibration

7.9.1 Potential Noise Generating Infrastructure

During construction, noise and vibration impacts would be managed in accordance with the EA.

The infrastructure proposed to be installed and utilised for Option 2 (WSP, 2018a) consists of:

- Pump stations and associated pipelines / channels to allow the transfer of water between pits and the Weemah Channel;
- Inlet / outlet structures (culverts) at Pit B and Pit C to facilitate the collection/release of flood water;
- Solar farm to assist in the offset of electricity in operating the pumping system; and
- Pump station at the Nogoa River.

Potential noise sources from this infrastructure are limited to the pump stations. Table 7.2 provides the proposed location, configuration of the pumps and the distances to the closest noise receptor.

Table 7.2 Pump Details and Distances to Sensitive Receptors

<table>
<thead>
<tr>
<th>Pump Location</th>
<th>#Pumps</th>
<th>Status</th>
<th>Type</th>
<th>Distance to Closest Receptor (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pit A – South</td>
<td>2</td>
<td>1 Duty / 1 Standby</td>
<td>Electric motor</td>
<td>3.8</td>
</tr>
<tr>
<td>Pit A – Central</td>
<td>2</td>
<td>1 Duty / 1 Standby</td>
<td>Electric motor</td>
<td>4.8</td>
</tr>
<tr>
<td>Pump Location</td>
<td>#Pumps</td>
<td>Status</td>
<td>Type</td>
<td>Distance to Closest Receptor (km)</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>--------</td>
<td>-------------------------</td>
<td>---------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Pit A – North</td>
<td>2</td>
<td>1 Duty / 1 Standby</td>
<td>Electric motor</td>
<td>4.7</td>
</tr>
<tr>
<td>Pit B</td>
<td>3</td>
<td>Duty</td>
<td>Electric motor</td>
<td>5.6</td>
</tr>
<tr>
<td>Pit C</td>
<td>3</td>
<td>Duty</td>
<td>Electric motor</td>
<td>7.4</td>
</tr>
<tr>
<td>Nogoa River</td>
<td>1</td>
<td>Duty</td>
<td>Skid-mounted diesel</td>
<td>5.7</td>
</tr>
<tr>
<td>Ramp 24</td>
<td>4</td>
<td>3 Duty / 1 Standby</td>
<td>Electric motor with VSD drive</td>
<td>6.2</td>
</tr>
<tr>
<td>Pit A – South (Weemah Channel Offtake)</td>
<td>3</td>
<td>2 Duty / 1 Standby</td>
<td>Electric motor with VSD drive</td>
<td>3.3</td>
</tr>
</tbody>
</table>

(Source: WSP, 2018a)

7.9.2 Potential Impacts

During construction, noise and vibration impacts would be managed in accordance with the EA. Based on the predicted sound power levels and the distance to the nearest receivers, the predicted noise levels from the pumping stations which are located within the pit extents are expected to meet the criteria under the Environmental Protection Policy (Noise) 2008 at all receivers.

7.9.3 Management and Mitigation

Noise and vibration impacts pre-relinquishment would be managed under the EA. Pump maintenance will be the responsibility of the future facility operator. No further mitigations would be required for the operation of the pump infrastructure.

7.10 Waste Management

7.10.1 Potential Impacts

Post relinquishment, Option 2 would have a small amount of waste hydrocarbons that would be considered regulated waste.

Waste potentially produced from infrastructure facilitating pumping water irrigation and the capture / release of flood water from / to the river under Option 2 is included in Table 7.3.
### Table 7.3  Option 2 Estimated Waste Quantities

<table>
<thead>
<tr>
<th>Waste</th>
<th>Estimated quantity</th>
<th>When generated</th>
<th>Waste Type</th>
<th>Possible waste hierarchy use/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric pumps</td>
<td>40 m³</td>
<td>At end of asset. During life of asset replacement of parts will be required</td>
<td>Non Regulated</td>
<td>Recycling (parts where practical) Dispose</td>
</tr>
<tr>
<td>Pump lubricating oils</td>
<td></td>
<td>During life of asset and at end of asset</td>
<td>Regulated</td>
<td>Recycling Dispose</td>
</tr>
<tr>
<td>HDPE Pipe</td>
<td>18 km above / below ground</td>
<td>At end of asset life</td>
<td>Non Regulated</td>
<td>Above ground - dispose Below ground – dispose in situ</td>
</tr>
<tr>
<td>Steel pipe</td>
<td>20 km below ground</td>
<td>At end of asset life</td>
<td>Non Regulated</td>
<td>Recycle or dispose in situ</td>
</tr>
<tr>
<td>Pontoon pump stations</td>
<td>6</td>
<td>At end of asset life</td>
<td>Non Regulated</td>
<td>Recycling (parts where practical) Dispose</td>
</tr>
<tr>
<td>Floating walkway</td>
<td>6</td>
<td>At end of asset life</td>
<td>Non Regulated</td>
<td>Dispose</td>
</tr>
<tr>
<td>Motor control centre</td>
<td>7</td>
<td>At end of asset life</td>
<td>Non Regulated</td>
<td>Dispose</td>
</tr>
<tr>
<td>Concrete associated with above infrastructure</td>
<td>170 m³</td>
<td>At end of asset life</td>
<td>Non Regulated</td>
<td>Dispose</td>
</tr>
<tr>
<td>Concrete inlet structures - culverts (B and C Pit)</td>
<td></td>
<td>At end of asset life</td>
<td>Non Regulated</td>
<td>Dispose</td>
</tr>
<tr>
<td>Concrete culverts</td>
<td>1,160 m³</td>
<td>At end of asset life</td>
<td>Non Regulated</td>
<td>Dispose</td>
</tr>
<tr>
<td>Concrete channels (B and C Pit)</td>
<td>37,800 m³</td>
<td>At end of asset life</td>
<td>Non Regulated</td>
<td>Dispose</td>
</tr>
</tbody>
</table>

Regulated waste may pose a contamination risk if not correctly disposed of off-site. All non-regulated waste streams can be recycled (offsite) or disposed of onsite.

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* Assumes all pumps would undergo at least one full replacement during life of asset
7.10.2 Management and Mitigation

Waste Management pre-relinquishment would be undertaken in accordance with the current Ensham Mine Environmental Impact Management Plan - Waste.

Disposing of all regulated waste offsite in a regulated landfill would reduce the potential impacts of contamination onsite.

Disposal of non-hazardous and non-regulated waste, such as concrete, safely onsite would reduce potential impacts from contamination. This may involve disposal and burial of this waste type at a designated location.

Recycling and reuse of pumping, piping and power infrastructure would be managed through a licenced waste collector.

7.11 Hazards and Safety

7.11.1 Safety

The rehabilitated landforms will be designed to avoid the need for fencing or other access restrictions.

Public access controls may be required for the operation of the water supply facilities post relinquishment. These controls will be the responsibility of the Operator.

7.11.2 Potential Impacts

Hydrocarbons may pose a small localised contamination risk in the event of a spill.

The creation of the treed corridor between Corkscrew Creek and the Nogoa River floodplain may create additional bushfire intensity areas (likely to be a medium potential) once the woody vegetation is established (refer Figure 5.25).

While a cyclone itself may not reach the Project Area, the associated rainfall front may bring increased rain, resulting in flooding. Flood risk and mitigation has been discussed in Section 7.4.

7.11.3 Management and Mitigation

Use of hydrocarbons would be managed in accordance with the appropriate Australian Standards and regulated waste disposed of offsite in licenced waste management facilities.

Should additional bushfire intensity areas be created via the treed corridor (or other rehabilitation activities) these would be managed in accordance with applicable regulatory requirements.

Flood risk and mitigation has been discussed in Section 7.4.

No other specific management and mitigation measures are proposed for hazards and safety.
8.0 Impact Assessment of Environmental Values - Option 3 Assessment: Backfill to PMF

8.1 Climate

8.1.1 Potential Impacts

Any potential impacts of Option 3 on EVs relevant to climate would be due to impacts from climate change. There is potential for climate change to influence potential impacts on other EVs listed in Section 4.0. The potential impacts to these other EVs are discussed below for Option 3 where relevant.

8.1.2 Management and Mitigation

No specific management and mitigation measures are proposed for climate for this Option. Where climate change predictions influence other EVs and management and mitigation measures are required, these are noted where relevant below.

8.2 Land

8.2.1 Potential Impacts

The potential impacts to the EVs listed in Section 4.0 are provided in the following sections.

8.2.2 Visual Amenity

Figure 3.5 provides a conceptual visualisation of the final landform for Option 3. The voids in the floodplain would be backfilled to the extent of the pre-mining PMF, and the flood protection levees would be removed. The area would be rehabilitated consistent with surrounding environment. A treed corridor would be created adjacent to highwall between Corkscrew Creek and Nogoa River. This would create a landscape that is visually similar to the surrounding environment. Option 3 is not expected to have any material impact on the visual amenity of the area.

8.2.3 Landform Assessment

A landform assessment for the Options landform was undertaken by WSP (2018c). The assessment included the development of landform design criteria, landform design and stability optimisation, material movement optimisation, and landform visualisation, and it incorporated findings from the geotechnical assessment also undertaken by WSP (described in Section 6.2.3).

The landform design was based on achieving key rehabilitation goals including the landform being safe, stable, and non-polluting, with a self-sustaining vegetation cover in accordance with the completion criteria.

The landform assessment identified that, to achieve a safe, stable landform, regrading of the residual voids would be required, including the highwalls, endwalls and spoil dumps. Details of the design criteria adopted for this Option are listed in Table 3.3. Cross sections at 200m intervals for the full rehabilitated landform from A to Y and contour maps are provided in the landform report (WSP, 2018).
A geochemical assessment was undertaken by RGS (2018) to characterise the existing hydro-geochemistry of the materials on site. This assessment indicated that the existing spoil material is non-acid forming and benign, and hence the final landform can be considered to be non-polluting in regard to leachate.

For the voids outside the extent of the PMF and depending on the nature of spoil material adjacent to the residual void, the inward and outward facing spoil would be regraded to a maximum slope of 10 to 15%. The regraded slopes on spoil dumps would be topsoiled and grassed, and benches would be seeded with tree species.

The voids in the PMF would be backfilled to pre-mining levels. This rehabilitated area is likely to experience differential settlement over time by way of collapse settlement when groundwater levels recover, followed by long-term creep. To avoid the formation of surface depressions in the footprint of the backfill, WSP has recommended that a surcharge of materials be placed in the voids to reduce the potential for large depressions forming in the landscape.

Removal of levees and roads would permit overland flood water flow across these backfilled areas, which may result in erosion, and in particular, along the alignment of Old Winton Creek in B-Pit. The magnitude and locality of settlement in these backfilled areas is likely to be unpredictable and variable.

### 8.2.4 Landform Stability

A geotechnical assessment was undertaken by WSP (2018b) to evaluate the stability and erosion potential of the final landforms.

The backfill for this Option would be derived from materials recovered from the Project Area, such as the spoil piles and the existing flood protection levee structures (which would be removed for this Option).

WSP (2018b) undertook a preliminary assessment of settlement characteristics of the proposed backfill within the extent of the PMF. The assessment found that a maximum settlement of backfilled material of approximately 2 metres is anticipated for the deepest sections of the voids. This settlement typically occurs over many years, and may result in topographical irregularities which may impede surface drainage or cause water to pond in surface depressions. However, given the extensive area to be backfilled, it would be difficult to predict the location and extent of differential settlement. Likewise, due to extensive areas and volumes of backfill required, systematic compaction of the backfilled areas is not feasible. Static surcharging of the replaced spoil material may reduce the risk of long-term settlement below the design level of the reinstated floodplain. However, this would require up to 2 metres of material to be placed above the original floodplain elevation to allow for settlement (WSP, 2018c).

The re-created landform within the PMF extent would also be exposed to flood waters during flood events, resulting in flow across, and inundation of, the backfilled areas. While this may aid compaction of the material over time, it may also lead to erosion and scouring. These backfilled surfaces would therefore need to be revegetated as soon as possible to reduce erosion potential.

For this Option, the pits located within the pre-mining floodplain would be backfilled to pre-mining levels. Parts of those pits straddling the boundary of the floodplain would also be backfilled, whilst remaining residual voids would have the highwall and endwall batters regraded to reduce erosion potential and to ensure they are long-term stable. The slopes of all residual voids would be regraded to achieve a FOS of greater than 1.5.
8.2.5 Land Use and Agricultural Potential

The nature of the backfilled voids within the extent of the PMF may render this land susceptible to sediment deposition and poor trafficability during and after rain events, and therefore may return less land suitable for agriculture than was the case prior to mining. Due to the requirement to maintain a consistent vegetative cover to reduce risk of erosion the backfilled area would be unsuitable for livestock and cropping. The appropriate future use would be native vegetation.

The rehabilitated landform in E, F and Y-Pits, would return an area of land that is compatible for agricultural use that is very like that of the pre-mining available area. All inward and outward slopes would be regraded to a maximum of 10-15% which is sufficiently gentle for pasture crops, grazing and operation of agricultural equipment.

8.2.6 Management and Mitigation

The risk of settlement over time and subsequent risk of ponding in the rehabilitated landform within the extent of the PMF, would require surcharge and may from time to time, require additional backfilling and an enduring management mechanism to avoid erosion and maintain vegetative cover.

To avoid exposure of unvegetated backfill to flood waters, the existing levees would need to be retained during backfilling of voids and rehabilitation operations, and only be removed when a sufficient cover of vegetation has established to protect the backfill materials.

Recognised agricultural land management practices to manage vegetation cover for E, F and Y Pits would be appropriate to minimise erosion potential.

8.3 Surface Water

8.3.1 Potential Impacts

The potential impacts to the EVs listed in Section 4.0 are provided in the following sections.

8.3.2 Water Quality and Balance Assessment

HEC (2018b) undertook an assessment of the water quality and balance for Option 3 using GoldSim modelling to determine long term water quantity and quality predictions. The modelling incorporated the results of the hydrogeochemical characterisation of the spoil material and pit walls undertaken by RGS (2018), and the estimates of groundwater flux in to and out of each of pit as modelled by HS (2018).

Pits that will be backfilled above the groundwater rest level (Pits B, CD, F South, F North and Y) were not included in the water balance model. Only part of Pit A and Pit E were included in the water balance model for this option.

The modelling results indicated the following:

- The predicted water levels in the rehabilitated landforms are well below the external spill level.
- The predicted outflows from rehabilitated landforms Pit A and Pit E are due to evaporation.
- The predicted water quality for Pit A and Pit E for concentrations of solutes, metals and salinity are predicted to increase slowly over time.
Full details of the modelling are discussed in the HEC Report (2018).

8.3.3 Downstream River Quality

Under Option 3, the rehabilitated landforms of Pit A and Pit E do not spill under modelled weather conditions to the receiving environment. Landforms for A South, B, C, and D all drain to the receiving environment. Therefore, this Option has a higher likelihood of impacting water quality objectives for downstream users through increased sediment loads than Options 1 and 2 if rehabilitated landforms are not managed as discussed in Section 8.2.6.

Identified downstream uses include irrigation, farming, stock use, aquaculture and human consumption.

Further details covering this can be found in the Geomorphology Report (WRM, 2018) and the Risk Assessment (Greg Rowan & Assoc, 2018).

8.3.4 Evaporative Concentration on Salinity within the residual landform

The residual landforms are likely to experience rising salinity concentrations over time due to the effects of evaporation. Use of this water under Option 3 is not proposed.

8.3.5 Changes in Flooding and Runoff Characteristics

8.3.6 Flood Modelling

HEC (2018a) undertook flood modelling of peak flow depths for Option 3 at the 10%, 5%, 1% and 0.1%9 AEP flood events using the TUFLOW software package. The TUFLOW model boundary conditions were based on hydrographs from the XP-RAFTS hydrological model (upstream boundary) and the rating curves (downstream boundary) developed as part of the 2013 KBR flood study for the area (HEC, 2018a).

The modelling compared Option 3 against the existing landforms.

The model results for afflux are presented in Figures 8.2 to 8.4 (figures for other modelled results are available in the HEC, 2018a technical report). The results for both peak flow depth and afflux show that:

- For the 1% AEP event a reduction of up to 0.9 m adjacent to Pit B and a reduction of approximately 0.7 m approximately 1 km upstream of the rehabilitated landforms is forecast. The forecast reduction in flood levels upstream of the rehabilitated landforms diminishes to a negligible change within approximately 5.5 km.

- For the 1% AEP event downstream results vary depending upon the location. Modelling also indicates a decrease in flood level in the main downstream Nogoa River channel within approximately 4 km of the Ensham Coal Mine. Predicted results indicate a localised increase of up to 0.33 m in an area immediately downstream of the existing Pit B. The general reduction in flood level extends over areas mainly adjacent to and upstream of the Ensham Coal Mine.

- The 10% AEP event is predicted to have little change in flood levels compared with the existing conditions downstream of the mine.

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9 Collectively these AEPs event represent the 1 in 10, 1 in 20, 1 in 100 and 1 in 1,000 AEP flood events respectively.
Figure 8.2  Modelled Afflux 10% AEP

(Source: HEC, 2018b)
Figure 8.3  Modelled Afflux 5% AEP

(Source: HEC, 2018b)
Figure 8.4 Modelled Afflux 1% AEP

(Source: HEC, 2018b)
8.3.7 Upstream Flood Levels

Compared with existing flood levels, modelling predicts a reduction in flood levels adjacent to and upstream of the Project Area, and within the main downstream Nogoa River channel. A reduction of approximately $0.7\text{ m}$ is predicted for the 1% AEP event approximately $1\text{ km}$ upstream of the mine. The predominant area of flood level reduction extends over areas adjacent to and mainly upstream of the Project Area.

8.3.8 Downstream Flood Levels

A localised flood level increase is predicted of up to $0.33\text{ m}$ for the 1% AEP event in an area immediately downstream of the existing Pit B and a very slight (less than $0.09\text{ m}$) increase in further downstream locations.

8.3.9 Local Run-off Volumes to the River

There may be some comparatively very minor changes to the catchment area reporting to Nogoa River compared to the catchment upstream. However this is unlikely to materially change run-off volumes, therefore impacts to local run-off volumes to the river are not expected.

8.3.10 Geomorphology Assessment

Geomorphological modelling for Option 3 was undertaken by WRM Water & Environment (WRM) (2018). This modelling incorporated flood model data (provided by HEC, 2018a) to assess the morphology of the Nogoa River floodplain. The modelling included an assessment of:

- The 10% AEP design flood event, to represent the behaviour of the river at the bank full flow conditions. The bank full flow is the maximum flow that the channel can carry before it overflows onto the adjacent floodplain. In geomorphologic studies, the bank full flow is often considered to be the stream forming flow, because it often exerts the greatest influence on channel geometry (WRM, 2018);

- The 1% AEP design flood event, to represent the behaviour of the river during a large and infrequent flood event;

- A flood event 50% greater than the 0.1% AEP design flood event (i.e., an extreme event) (this extreme event is considered to provide a better assessment of the long-term geomorphological impacts than the PMF); and

- The PMF to determine how this Option compares to the pre-mine conditions.

The model outputs were then compared against the pre-mine flooding conditions which provided the following results:

- There would be no material change in peak velocities and shear stresses from pre-mine conditions within the river channels and adjacent floodplains for all events.

- Velocities and shear stresses across the infilled Pit C are generally low for all events, suggesting that it would remain stable in the short and long term.

- Velocities and shear stresses are generally low across the infilled Pit B and are very low behind the elevated landform for the 10% and 1% AEP events suggesting some sediment deposition may occur for these events.
Higher velocities and shear stresses occur through the low point of the backfilled Pit B and across the top of the elevated landform sections for the extreme events suggesting that there is a higher erosion potential in these areas for the extreme events. Depending upon the success of the rehabilitation across the Pit B, downstream properties could be adversely affected by sediment eroded from the landform. Long term erosion and sedimentation would also occur from any exposed subsoils on the landform.

Extreme event velocities and shear stresses across the infilled Pit C are generally low indicating that the area remains as a backwater area of the river and therefore has a relatively low erosion potential. The results demonstrate that there would be no short, medium or long-term risks of accelerated morphological change to the Nogoa River and its floodplain for the Option 3 landform.

The expected low velocity zones across the surface of the rehabilitated landforms suggest these landforms would be stable in the short to medium term with potentially some sediment deposition occurring during moderate flood events. The stability through the low point of the backfilled Pit B and the elevated landform across the infilled Pit B surface would depend upon the success of the surface rehabilitation and achieving the proposed finish surface levels. If the rehabilitation of the surface of the rehabilitated landforms is not maintained and bare earth soils remain post mining, then some erosion of the surface would be expected during flood events, potentially leading to adverse impacts on downstream environmental values.

The extent of erosion would depend upon the erodibility of the soil. However, the low flood gradients and floodplain geometry would suggest that the erosion would not have a significant impact on the long-term floodplain morphology (WRM, 2018). The flood modelling shows that the rehabilitated landforms are not inundated by the PMF (HEC, 2018a). As a result, there are no material changes in peak flood velocities and shear stresses along the river channels or the floodplain from pre-mining conditions for this event and therefore there is minimal risk of accelerated morphological change as a result of Option 3 for this extreme event.

8.3.11 Management and Mitigation

The risk of settlement over time and subsequent risk of ponding in the rehabilitated landform within the extent of the PMF, would require surcharge and may from time to time, require additional backfilling and an enduring management mechanism to avoid erosion.

To avoid exposure of unvegetated backfill to flood waters, the existing levees would need to be retained during backfilling of voids and rehabilitation operations, and only be removed when a sufficient cover of vegetation has established to protect the backfill materials.

8.4 Groundwater

8.4.1 Groundwater Modelling

The groundwater investigation has been based on groundwater flow modelling using a model developed by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), most recently updated in 2016. The model has been re-calibrated by HS (2018) to include additional data up to and including February 2018.

The modelling was used to predict time-varying groundwater inflows/outflows and water levels in each of the rehabilitated landforms as well as regional groundwater levels with particular focus on key bores in the groundwater monitoring network.

The main findings of the modelling for Option 3 are that:
Where Pits B, C and D are backfilled to approximately the pre-mining floodplain elevation, these pits are predicted to not generate pit waterbodies. As groundwater would remain below the backfilled pit land levels, no groundwater would accumulate above ground.

Pit stages are expected to take many decades to achieve equilibrium level conditions. The underground workings scheduled for development between 2018 and 2020 are proximal to the open cut areas which either currently hold water or are predicted to hold water in the future. During near-future mine advancement, water from these areas is anticipated to recharge the underground mine. Following cessation of active dewatering in the underground, the enhanced groundwater connection between pit voids and underground voids would result in several decades of underground mine rebound at the expense of pit void stage recovery. Only after rebound of the underground water levels would pit water rise to predicted equilibrium levels.

Pit A and Pit E waterbodies are therefore expected to have low water levels for several decades, before the waterbodies are able to recover towards (but never reaching) pre-mining water levels. Predicted groundwater rest levels for Option 3 are shown in Table 8.1 for each pit.

The results of the groundwater modelling show that the groundwater rest levels will stabilise at their long term values after approximately 85 years in most pits. Figure 8.5 shows the extent and depth of inundation of the final landform surface at the groundwater rest levels.

Table 8.1 Predicted final equilibrium pit water levels for Option 3

<table>
<thead>
<tr>
<th>Pit</th>
<th>Option 3 (mAHD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (south)</td>
<td>147.2</td>
</tr>
<tr>
<td>A (north)</td>
<td>144.6</td>
</tr>
<tr>
<td>B</td>
<td>146.6^</td>
</tr>
<tr>
<td>C</td>
<td>147.8^</td>
</tr>
<tr>
<td>D</td>
<td>141.4^</td>
</tr>
<tr>
<td>E</td>
<td>129.0</td>
</tr>
<tr>
<td>F</td>
<td>149.3*</td>
</tr>
<tr>
<td>Y</td>
<td>170.5*</td>
</tr>
</tbody>
</table>

^ Groundwater levels beneath backfilled pits

* Groundwater would be eliminated by raising the pit floor level above groundwater level
Figure 8.5  Groundwater Rest Levels in Option 3 Landforms
The presence of backfill material in the former pit areas additionally influences the rate of underground and pit rebound. High infiltration potential and the reduced capacity for evaporation in these areas provides a short travel time indirect pathway for recharging water to enter the underground and pit.

The consequences of Option 3 are comparatively higher ultimate rest groundwater levels and more rapid rebound (compared with other Options). Rest groundwater levels in Option 3 are higher as pit water (in open voids) or groundwater (beneath rehabilitated landforms) is subject to less evaporation.

Where Pits B, C and D are backfilled (with Pit A partially backfilled) and built up, ultimate rest groundwater levels are elevated and not subject to direct evaporation. Groundwater levels are limited by the valley floor elevation and relatively high connection afforded by backfill hydraulic properties as opposed to undisturbed rock.

In summary, the main consequences of the findings are that the groundwater levels under Option 3 are expected to recover at a slightly faster rate and to be generally higher (by a few metres) in the long term adjacent to the residual voids.

8.4.2 Potential Impacts

The potential impacts to the EVs listed in Section 4.0 are provided in the following sections.

The long term (typically beyond 100 years) groundwater inundation shown in Figure 8.5 shows that:

- No groundwater inundation occurs above the pit floors for F and Y pits; and
- Minimal groundwater inundation in A and E pit landforms

Of the examined monitoring bores, the median maximum drawdown is 4.5 m and the median year of occurrence is about 2044 (26 years from present day). At most of the examined bores, drawdown would persist for a limited time. None of the identified private bores lie within the 5m water table drawdown envelope. Full details of these bores and predicted groundwater drawdown impacts can be found in the Groundwater Report (HS, 2018).

The findings of the groundwater assessment include the following (HS, 2018):

- Minor groundwater drawdown impacts on private bores used for farm or stock water supply, with negligible impact on the one identified irrigation bore due to its distance from the mine.

- Negligible impact on groundwater quality at any private bores.

- Negligible impact on aquatic ecosystem water quality as project activities would not cause additional groundwater discharge to any rivers.

- A slight beneficial effect on groundwater quality beneath the Nogoa River close to Pit B, due to a marginal increase in the natural leakage from the Nogoa River over the next 70 years.

- Longer term marginal increase in the flow in the Nogoa River due to a reduction in the natural loss of water from the Nogoa River to its associated alluvium.

- A finite period (of about 15-20 years) of moderate drawdown (approximately 20m) in the riverine alluvium adjacent to Pit B for Option 3.
8.4.3 Management and Mitigation

The successful delivery of the landform design criteria shown in Table 3.3 would mean that there are no rehabilitation specific management and mitigation measures proposed for post-relinquishment for this Option.

8.5 Flora and Fauna

8.5.1 Potential Impacts

8.5.1.1 Terrestrial Flora

As no remnant vegetation is proposed to be cleared for this option, there are not expected to be any significant impacts on native terrestrial flora, other than removal of re-growth species associated with rehabilitated areas. It has been assumed for this assessment, that disturbance of existing rehabilitated areas for the relocation of spoil to back fill voids can be done in accordance with the current mine approval (Umwelt, 2019).

As part of the rehabilitation process following construction of the landform, a treed corridor using native tree species along the western (highwall) side of the rehabilitated landform would be established. This corridor would be approximately 100 m in width and approximately 6.7 km long, linking the vegetation associated with Corkscrew Creek with the Nogoa River (refer Figure 3.4). In addition to creating this corridor, this would also augment the available habitats for flora and fauna species. This corridor is anticipated to be beneficial for a variety of native fauna species, through increasing the available vegetation cover and associated foraging opportunities in the locality, as well as increasing fauna movement opportunities in this landscape. Ecological values of this treed corridor could be further enhanced through appropriate fencing to restrict stock movement into the corridor.

8.5.1.2 Terrestrial Fauna

Commonwealth and State listed Endangered species with potential to occur in the Project Area include the Eastern Curlew (Numenius madagascariensis) and Australian Painted Snipe (Rostratula australis). Based upon the assessment of the geomorphology of the final landform (WRM, 2018), Option 3 would not have deleterious impacts upon the habitats of these species downstream of the Project Area provided that the rehabilitation of the land is maintained in the long term.

The Project Area has several Commonwealth listed Vulnerable species known or with potential to occur on the site. Impacts upon the habitats of terrestrial species are not considered significant for this Option, particularly as there would be no additional disturbance of remnant habitats beyond that already approved for the mine.

8.5.1.3 Aquatic Flora

Although no threatened aquatic flora species were identified as having potential to occur within 50 km of the Project Area, aquatic flora are known to occur within the Nogoa River. Option 3 is not expected to have any impacts on the aquatic habitats of the Nogoa River or its Anabranch.

A geochemical assessment was undertaken by RGS (2018) to characterise the existing hydro-geochemistry of the materials on site. This assessment indicated that the existing spoil material is non-acid forming and benign. As a consequence, there is expected to be a low potential for metals or metalloids to impact downstream environments.
As above, Option 3 would not have deleterious impacts upon the habitats of these species downstream of the Project Area provided that the rehabilitation of the land is maintained in the long term.

8.5.1.4 Aquatic Fauna

Two threatened turtle species were identified as having potential to occur within the Project Area. These species are known to occur within the Nogoa River. Option 3 would have no direct impacts upon these species as all works would be restricted to the approved mine footprint. Based upon predicted water quality, it is anticipated that no indirect impacts would occur to these species. However, these species are known to occur within the broader Nogoa River, and as such Option 3 has potential to indirectly impact upon these species through sedimentation. As above, Option 3 would not have deleterious impacts on these species downstream of the Project Area provided that the rehabilitation of the land is maintained in the long term.

8.5.1.5 Terrestrial Groundwater Dependent Ecosystems

Mapping prepared by the Queensland Government (2018) indicates that the riparian corridor associated with the Nogoa River is considered a potential terrestrial GDE location. Studies undertaken in Stage 3 (Umwelt, 2019) indicate that there is low potential for impacts on terrestrial GDEs.

8.5.1.6 Stygofauna

The Project Area may support stygofauna in the two aquifer types present (alluvium and the deeper coal measures). Option 3 appears unlikely to significantly impact any potential stygofauna habitat (namely the alluvial aquifer that extends along the Nogoa River and the Anabranch). The basis for this is:

- This Option would not result in the loss of habitat as the groundwater table would not be affected as water would not be abstracted or diverted from the Nogoa River.
- As the Nogoa River continues to receive recharge from the Fairbairn Dam, this would be beneficial to any groundwater biota which rely on good hydraulic conductivity to replenish food reserves in a normally depleted environment.
- Groundwater quality in the Alluvial aquifer in the Project area and surrounds is typically within the ranges considered acceptable for stygofauna.
- Connectivity along the alluvium aquifer remains intact and would not be obstructed. Therefore, there would be no isolation of aquifer areas, allowing taxa to disperse freely.

8.5.1.7 Migratory Species

Option 3 is likely to have an insignificant impact on any migratory species.

8.5.2 Management and Mitigation

Appropriate land management practices would need to be adopted for this Option to reduce impacts to vegetation and erosion potential following flood events in areas that experience large degrees of differential settlement.
8.6 Biosecurity

8.6.1 Potential Impacts

There are no additional biosecurity risks associated with Option 3 that would not be managed effectively under the current land management practices for the Mine.

8.6.2 Management and Mitigation

The existing Weed and Feral Animal Management Procedure would be amended prior to implementation of Option 3, to ensure that this area is covered by the practices in that Procedure. Mitigation measures are shown in Table 8.2.

Table 8.2 Biosecurity Management Measures

<table>
<thead>
<tr>
<th>Period</th>
<th>Issue</th>
<th>Management Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ongoing Land Management</td>
<td>Inspection vehicles carrying weeds or pathogens</td>
<td>Vehicles used for any inspections or monitoring activities are to be cleaned and inspected prior to entry and exit of the site</td>
</tr>
<tr>
<td></td>
<td>Vegetated areas to be monitored following significant rainfall events</td>
<td>Inspections to be undertaken to identify any outbreaks of restricted species. Where restricted species are identified, the owner or operator should control outbreaks in accordance with the control measures identified in the Weed and Feral Animal Management Procedure</td>
</tr>
<tr>
<td></td>
<td>Presence of pest species</td>
<td>Annual inspections for presence of restricted pest species. Outbreaks to be controlled using the measures identified in the Weed and Feral Animal Management Procedure</td>
</tr>
<tr>
<td></td>
<td>Rehabilitated landforms with water may encourage proliferation of aquatic weed species</td>
<td>Annual inspections for presence of priority aquatic weed species. Outbreaks to be controlled using the measures identified in the Weed and Feral Animal Management Procedure</td>
</tr>
</tbody>
</table>

8.7 Air and Emissions

8.7.1 Potential Emission Sources

Potential dust emission sources would come from construction the landform.

Greenhouse gas total emissions associated with the construction of option 3 are 467,241 tonnes equivalent CO2. Option 2 greenhouse gas emissions are estimated at 142,612 equivalent tonnes CO2 (Deloitte, 2018) and option 1 (277,958 tonnes equivalent CO2), making Option 3 considerably higher than Option 1 or 2. The Ensham site National Greenhouse and Energy Reporting baseline emissions level would not be exceeded for Option 3.

Following construction of the rehabilitated landform, there would be no diffuse or point sources of pollution and it is not expected that there would be any air or odour impacts. Additionally, there would be no fugitive emissions expected to be released from the landforms associated with Option 3.
8.7.2 Potential Impacts

Given the lack of emission sources associated with Option 3 post construction, there is not expected to be any short / long term impacts on air quality within the Project Area.

8.7.3 Management and Mitigation

Air emissions for the construction phase would be managed under the EA and the Ensham site Dust Management Procedure. No additional management and mitigation measures post construction would be required in respect of air quality for Option 3.

8.8 Noise and Vibration

8.8.1 Potential Impacts

Noise and vibration sources would be generated by earth moving equipment during the land rehabilitation process. Following the construction of the rehabilitated landform, there would be no noise generating equipment remaining in the Project Area, and there would be no noise impacts. Additionally, as no vibrating equipment or activities would remain under Option 3, there would be no impacts from vibration.

8.8.2 Management and Mitigation

Noise and vibration impacts would be managed under the EA and the Ensham site Noise and Vibration Management Procedure. No additional management and mitigation measures would be required in respect of noise or vibration for Option 3.

8.9 Waste Management

8.9.1 Potential Impacts

Option 3 would not generate any regulated waste or other non-regulated sources of waste post construction.

8.9.2 Management and Mitigation

No additional management and mitigation measures are recommended in respect of waste management for Option 3 post construction.

8.10 Hazards and Safety

8.10.1 Natural and Induced Hazards

8.10.1.1 Major Hazard Facility

A major hazard facility is not proposed as part of Option 3.

8.10.1.2 Hazardous Substances

There would not be any hazardous substances used as part of Option 3 post construction.
8.10.2 Safety

The backfilled area would not be trafficable in all conditions and may be subject to slumping.

The rehabilitated landforms (A, E, F and Y-Pits) would be designed to avoid the need for fencing or other access restrictions.

8.10.3 Potential Impacts

The creation of the treed corridor between Corkscrew Creek and the Nogoa River floodplain may create additional bushfire intensity areas (likely to be a medium potential) once the woody vegetation is established (refer Figure 3.5).

While a cyclone itself may not reach the Project Area, the associated rainfall front may bring increased rain, resulting in flooding. Flood risk and mitigation has been discussed in Section 8.3.

8.10.4 Management and Mitigation

Potential erosion and stability issues are addressed in Sections 8.2 and 8.3, for the management of the backfill.

Should additional bushfire intensity areas be created via the treed corridor (or other rehabilitation activities) they will be managed in accordance with applicable regulatory requirements.

No other specific management and mitigation measures are proposed for hazards and safety.
9.0 Cumulative Impacts

9.1 Introduction

This section describes the cumulative impacts of the Residual Void Project on identified Environmental Values by each of the Preferred Options. The potential cumulative impacts are considered at a localised level across the Project Area as well as from activities undertaken in the region.

Regional cumulative impacts occur when two or more projects are sufficiently proximate that their combined impacts may be significant.

9.2 Project Setting

Open cut mining is scheduled to cease at Ensham Mine by the end of 2023, with underground bord and pillar operations continuing until 2031. The land located both upstream and downstream of the Project area is currently used for agricultural purposes. Major projects currently being assessed in the region by the Department of State Development, Manufacturing, Infrastructure and Planning are shown in Figure 9.1 (http://statedevelopment.qld.gov.au/assessments-and-approvals/coordinated-projects-map.html). Figure 9.1 shows that there are no large projects proposed for the immediate or adjacent regional area of the Project area. The nearest proposed projects under consideration are the Clermont Coal Mine located approximately 120 km to the north west, and the Central Queensland Gas Pipeline project located approximately 90 km to the north east. In regard to existing operations, Figure 9.2 (MinesOnLine) shows mining projects operating in the region. The nearest mining operations are located in the vicinity of Blackwater located approximately 40km to the east, and Tieri approximately 35 km to the north.

9.3 Potential Impacts to Environmental Values

An assessment of environmental aspects and, by default, associated environmental values has been undertaken and described in the following sections.

Climate

During the construction phase, the earthmoving equipment used for rehabilitating the landforms would generate greenhouse gas emissions. For Options 1 and 2, greenhouse gas emissions are estimated at 142,612 equivalent tonnes CO2 and option 1 277,958 tonnes equivalent CO2, which is considered to be negligible from a regional level. While Option 3 would generate a greater level of greenhouse gases (467,241 tonnes CO2 equivalent) due to relatively larger volumes of soil that are required to be moved for backfill of voids to the PMF, this is still a low level. There would be no impact from the rehabilitated landforms post-relinquishment as there would be no emissions sources. Option 2 would be operating electric pumps using primarily locally generated solar power and therefore there would be no significant greenhouse gas emissions generated.

Overall, it is considered that there would be negligible cumulative impacts from the construction phase on climate change for Options 1 and 2 while Option 3, due to the associated significant backfill earth moving works, would generate a low level impact compared to the 2017 Australian emissions generation of 550 million CO2 equivalent tonnes.
Noise

Options 1 and 3 would have no noise or vibration generating equipment post rehabilitation, and therefore there is no potential for these options to contribute to the acoustic setting. Option 2 would operate 6 electric pumps and 1 diesel pump which would have negligible impact on the overall acoustic environment.

Construction and operation of the underground would be in accordance with the EA.

Accordingly, there would be no cumulative impact from noise or vibration for any of the Preferred Options.

Air Quality

All options will generate dust from the associated earthworks required to generate the respective landforms. Dust levels will be managed under the existing environmental authority during the construction and rehabilitation stages. Following completion of the rehabilitation works, the landforms would generate negligible dust levels provided vegetation cover is maintained.

Hence, the risk of cumulative air quality impacts is very low.

Ecology

Option 1 will require clearing up to approximately 60 ha of regrowth on the western side of the existing levees for regrading to 10 to 15% slopes in areas previously cleared for construction of those levees. Option 2 will require clearing of up to 3 ha of RE 11.3.25e for the construction of the required water intake structures and approximately 0.1 ha of disturbance to RE 11.3.25e for the re-installation of the Ensham Mine pipeline across the Nogoa River. Option 3 will not require any specific clearing of vegetation.

Given the small area of clearing for Options 1 and 2, there would be negligible cumulative impacts for loss of habitat value in the region.

Biosecurity

The construction phase should introduce no additional biosecurity risks associated with any of the options provided procedures and land management practices of pest and weed management are followed. Post rehabilitation, provided standard land management practices of weed and pest control are undertaken, there should be no additional biosecurity risks. Given the absence of other regional projects that could interact with this project, no cumulative impacts are expected with regards to biosecurity.

Flooding

Flood modelling has been undertaken to assess flooding impacts and these are addressed in the flooding assessments in this report. By using 2018 topographic data as a base for the flood model, the modelling has taken in account existing infrastructure, for example, existing levees, along a 50 km reach of the Nogoa River covering a total area of about 950 km² that extends upstream and downstream of Ensham Mine. Therefore, the cumulative impacts of the Project and all existing floodplain infrastructure is taken into account in the modelling. No major floodplain developments are identified within the model extent at this time. On this basis, the impacts identified by the modelling represent the cumulative impacts of the Project and all existing floodplain development.
Figure 9.1  Proposed Regional Projects

Source: MinesOnLineMaps
Figure 9.2  Existing Mining Projects

Source: MinesOnLineMaps
Water

Cumulative impacts of the Project on the quality and quantity of receiving surface waters have been considered in the surface water balance modelling. The surface water balance includes the interaction of the Project with the Nogoa River, including the quality and quantity of water that flows into and out of the voids from the river under Option 2. The adopted Nogoa River flow sequence used in the model includes historical data, supplemented with modelled flows that account for all existing water infrastructure in the catchment. This ensures that any impacts generated by the Project are integrated with overall catchment development to reflect the cumulative impacts of the Project and current development. The water balance model results show a very minor risk of impact on river water quantity for Option 2, with all current environmental flow objectives and water supply objectives able to be met. Very minor impacts on water quality are predicted which would not affect the environmental values of receiving waters in the Nogoa River.

For Options 1 and 3, modelling shows that there is no surface water interaction between the voids and the Nogoa River using historical climate data, because any water within the rehabilitated landforms is separated from the river. Under Option 3, there are potential runoff quality impacts from the void catchment area returned to the river through backfilling if rehabilitated landforms are not managed to maintain vegetative cover. However, such impacts would be expected to be minor when considered on a cumulative basis within the total Nogoa River catchment area to Ensham Mine of 27,130 km$^2$.

The groundwater modelling undertaken for the Project covers a large area, extending more than 10 km in every direction from the surface and underground mine workings. Cumulative impacts have been assessed by extending the model well beyond the mine and by calibrating the model to recorded bore data across the model extent. Model results show significant drawdown in the groundwater table extending only a few kilometres from the mine workings. As neighbouring mining projects are more than 30 km away, there will not be significant cumulative impacts on groundwater.

Given the very low risk of impact to the downstream water quality identified for all options, and the absence of other nearby projects, cumulative impacts on downstream environmental values are considered to be negligible.

Overall, given the landform design there are not expected to be any cumulative impacts to the Nogoa River water quality.

Waste Management

Post construction, none of the options would generate any regulated waste.

Option 2 would generate waste such as pumps, metal pipes and concrete post its asset life. This waste would be collected by a licenced waste collector and recycled wherever possible.

Based on the above findings, there would be no cumulative impacts in regard to waste for the Project.

Land

In the context of regional land use, the disturbed area of Ensham Mine is relatively small. Given that the Project is separated from other major open cut mining operations by more than 30 km, there will not be any cumulative visual impacts or land use impacts.
10.0 OPTION ASSESSMENT

10.1 Assessment Criteria

An assessment of impacts on EVs has been undertaken as a part of the technical studies prepared by the Stage 3 technical specialists. The technical specialists have assigned a ranking to each EV for each of the preferred options. The adopted scoring criteria are shown in Table 10.1. A ranking value of zero represents no impact to an EV. Negative rankings represent likely adverse impacts on the EV, while positive rankings reflect likely benefits to the EV. The definitions of the scoring criteria used within Table 10.1 are provided in Table 10.2.

Table 10.1  Adopted Scoring Criteria for Assessment of EVs

<table>
<thead>
<tr>
<th>Scoring Criteria</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant negative impact for this consideration</td>
<td>-3</td>
</tr>
<tr>
<td>Medium negative impact for this consideration</td>
<td>-2</td>
</tr>
<tr>
<td>Minor negative impact for this consideration</td>
<td>-1</td>
</tr>
<tr>
<td>No impact/benefit for this consideration</td>
<td>0</td>
</tr>
<tr>
<td>Minor benefit for this consideration</td>
<td>+1</td>
</tr>
<tr>
<td>Medium benefit for this consideration</td>
<td>+2</td>
</tr>
<tr>
<td>Significant benefit for this consideration</td>
<td>+3</td>
</tr>
</tbody>
</table>

Table 10.2  Adopted Definitions of Scoring Criteria for Assessment of EVs

<table>
<thead>
<tr>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Significant impact/benefit</strong> – results in a change which is important, notable or of consequence to the EV having regard to its intensity/frequency. For an impact the change will result in not being able to meet published standards (if there are any). For a benefit the change should meet best practice standards (if there are any published)</td>
</tr>
<tr>
<td><strong>Medium impact/benefit</strong> – results in a change which is potentially important, notable or of consequence to the EV having regard to its intensity/frequency. For an impact, the change will result in occasions where the criterion will not meet published standards (if there are any). For a benefit the change should meet good practice standards (if there are any published)</td>
</tr>
<tr>
<td><strong>Minor impact/benefit</strong> – results in a change which is identifiable but is not important, notable or of consequence to the EV having regard to its intensity</td>
</tr>
<tr>
<td><strong>No impact/benefit</strong> – results in no discernible change, or is of no consequence to the EV</td>
</tr>
</tbody>
</table>

*Note: The definition of significant impact has been based on the Federal Government’s definition of significant impact contained within its “Matters of National Environmental Significance, Significant Impact Guidelines 1.1, Environment Protection and Biodiversity Conservation Act 1999”*
10.2 Assessment of Potential Impacts of Each Option on EVs

A summary of the scoring of the potential impacts of each option, as provided by the technical specialists involved in the Stage 3 RVP, is provided in Table 10.3. The considerations relevant to each of the EVs have been determined by Ensham, and are described in Section 4.0. The results shown in Table 10.3 will feed into the triple bottom line process in Stage 4 to assist in determining the Preferred Option for the RVP.

**Table 10.3 Summary of Potential Impacts of Each Option on Environmental Values**

<table>
<thead>
<tr>
<th>Environmental Aspect</th>
<th>Environment Value</th>
<th>Consideration</th>
<th>Scoring Notes</th>
<th>Option 1: Landform Levee</th>
<th>Option 2: Flood Mitigation &amp; Beneficial Use</th>
<th>Option 3: Backfill to PMF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ranking</td>
<td>Evidence</td>
<td>Ranking</td>
</tr>
<tr>
<td>Climate</td>
<td>Increased vulnerability of other EVs</td>
<td>NA</td>
<td>This scoring of this EV is addressed by all EVs listed below</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Climate</td>
<td>Dust</td>
<td>Quantity of dust generated over the life of the option</td>
<td>0</td>
<td>No dust generating sources to remain</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Odour</td>
<td>Quantity of odour generated over the life of the option</td>
<td>0</td>
<td>No odour generating sources exist under this option</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fuel usage</td>
<td>Quantification of fossil fuels consumed in delivering this option</td>
<td>0</td>
<td>No sources of fossil fuels required to operate this option post relinquishment</td>
<td>-1</td>
</tr>
<tr>
<td>Land</td>
<td>Visual amenity</td>
<td>Visual impact</td>
<td>Compared to the regional context</td>
<td>0</td>
<td>Landforms and slopes would be rehabilitated to be consistent with the surrounding environment. A treed corridor would be created adjacent to highwall between Corkscrew Creek and Nogoa River, which would reduce any visual impacts of the final landform</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Slope failure</td>
<td>Risk of failure generated over the life of the option</td>
<td>3</td>
<td>All slopes have been regraded to achieve a FOS of &gt;1.5. Spoil slopes are no greater than 15%</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Aspect</td>
<td>Environment Value</td>
<td>Consideration</td>
<td>Scoring Notes</td>
<td>Option 1: Landform Levee</td>
<td>Option 2: Flood Mitigation &amp; Beneficial Use</td>
<td>Option 3: Backfill to PMF</td>
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<td></td>
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<td></td>
<td></td>
<td>Ranking</td>
<td>Evidence</td>
<td>Ranking</td>
</tr>
<tr>
<td>Landform stability</td>
<td>Erosion</td>
<td>Erosion of landform generated over the life of the option</td>
<td>3</td>
<td>All spoil slopes &lt;33% would be topsoiled and / or ameliorated to promote and sustain vegetation growth. Spoil slopes are no greater than 15%. Slope lengths are restricted with benches at intervals. Highwall and endwall batters flattened to retard erosion</td>
<td>2</td>
<td>All spoil slopes &lt;25% would be topsoiled and / or ameliorated to promote and sustain vegetation growth. All slopes that equal 25% would be rock mulched with tree seed to reduce erosion potential. Slope lengths are no greater than 25%. Slope lengths are restricted with benches at intervals. Highwall and endwall batters flattened to retard erosion</td>
</tr>
<tr>
<td>Incompatible land uses</td>
<td>Land suitability class</td>
<td>Compared to the regional context</td>
<td>-1</td>
<td>Some areas around the residual voids would be too steep for post-mining land use</td>
<td>2</td>
<td>Residual void would become a water storage, which can be regarded as an improvement to land suitability class when compared to surrounding regional land.</td>
</tr>
<tr>
<td>Agricultural potential</td>
<td>Long term available area</td>
<td>Compared to pre-mine available area</td>
<td>0</td>
<td>Residual voids and spoil dumps regraded at 10-15% topsoiled and revegetated - land suitable for pasture development</td>
<td>2</td>
<td>Creation of sustainable water resource for augmentation of existing irrigation scheme. Residual voids and spoil dumps regraded partially to 10-15%, topsoiled and revegetated - land suitable for pasture development</td>
</tr>
<tr>
<td></td>
<td>Downstream river quality</td>
<td>Impacts to agricultural water quality objectives for life of option</td>
<td>0</td>
<td>Pit voids are contained (no spill)</td>
<td>-1</td>
<td>Additional load added but only during high flow events so likely minor impacts</td>
</tr>
<tr>
<td></td>
<td>Water availability</td>
<td>Quantity of water available to downstream users compared to current</td>
<td>0</td>
<td>Pit voids are contained (no spill)</td>
<td>-1</td>
<td>Harvested Nogoa River flows would no longer report downstream but only during high flow events so likely minor impacts</td>
</tr>
<tr>
<td>Contaminated Land Potential</td>
<td>NA</td>
<td>The scoring of this EV is addressed by the Waste Generation &amp; Environmental Dispersal EV listed below</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Environmental Aspect</td>
<td>Environment Value</td>
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<td></td>
<td>Ranking</td>
<td>Evidence</td>
<td>Ranking</td>
</tr>
<tr>
<td>Aquatic ecosystems</td>
<td>(biodiversity &amp;</td>
<td>Downstream</td>
<td>Impact on aquatic ecosystem water quality objectives for life of option</td>
<td>0</td>
<td>No impacts on downstream river quality are likely</td>
<td>0</td>
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<tr>
<td>(habitat)</td>
<td></td>
<td>river quality</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>Aquatic GDEs (physofauna)</td>
<td>Compared to current aquifer water quality and drawdown at impacted area</td>
<td>0</td>
<td>No impacts on aquatics GDEs are likely</td>
<td>0</td>
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<tr>
<td></td>
<td></td>
<td>Groundwater</td>
<td>Impact on aquatic ecosystem water quality objectives for life of option</td>
<td>-1</td>
<td>Minor drawdown in riverine alluvium adjacent to B pit</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>drawdown</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>Groundwater</td>
<td>Impact on aquatic ecosystem water quality objectives for life of option</td>
<td>0</td>
<td>No impacts on runoff quality are likely</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Impact on run off quality</td>
<td>Impact on aquatic ecosystem water quality objectives for life of option</td>
<td>0</td>
<td>No impacts on runoff quality are likely</td>
<td>0</td>
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<tr>
<td>Water</td>
<td></td>
<td>Void water</td>
<td>Water quality modelling indicates suitability for irrigation within the region</td>
<td>0</td>
<td>Irrigation not proposed</td>
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<td>Irrigation use</td>
<td></td>
<td>Downstream</td>
<td>Impact on irrigation water quality objectives for life of option</td>
<td>0</td>
<td>Pit voids are contained (no spill)</td>
<td>-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>river quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Groundwater</td>
<td>Groundwater drawdown impact on users</td>
<td>0</td>
<td>One identified bore 10km from Pit A South beyond drawdown extent</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>drawdown</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Groundwater</td>
<td>Impact on groundwater quality objectives for life of option</td>
<td>0</td>
<td>No change in groundwater flow direction at 10km</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>quality</td>
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<td></td>
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<td></td>
<td></td>
<td>Water availability</td>
<td>Water supply infrastructure for increasing irrigation potential</td>
<td>0</td>
<td>No or very limited civil infrastructure is required to support the desired outcomes of this Option, hence there are no impacts or benefits associated with this option.</td>
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<td>Farm Supply</td>
<td></td>
<td>Void water</td>
<td>Water quality modelling indicates suitability for farm supply within the region</td>
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<td>Farm supply not proposed</td>
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<tr>
<td></td>
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<td>Downstream</td>
<td>Impact on farm supply water quality objectives for life of option</td>
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<td>Pit voids are contained (no spill)</td>
<td>-1</td>
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<tr>
<td></td>
<td></td>
<td>river quality</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Groundwater</td>
<td>Groundwater drawdown impact on users</td>
<td>-1</td>
<td>All identified bores to have less than 5m water table drawdown</td>
<td>-1</td>
</tr>
<tr>
<td>Environmental Aspect</td>
<td>Environment Value</td>
<td>Consideration</td>
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<td>Ranking</td>
<td>Evidence</td>
<td>Ranking</td>
</tr>
<tr>
<td>Water</td>
<td>Farm Supply</td>
<td>Groundwater quality</td>
<td>Impact on groundwater quality objectives for life of option</td>
<td>0</td>
<td>No feasible mechanism for change in beneficial use</td>
<td>0</td>
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<tr>
<td></td>
<td>Void water quality</td>
<td>Water quality modelling indicates suitability for stock use within the region</td>
<td>0</td>
<td>Stock use not proposed</td>
<td>2</td>
<td>Stock use would be similar to irrigation use</td>
</tr>
<tr>
<td></td>
<td>Downstream river quality</td>
<td>Impact on stock use water quality objectives for life of option</td>
<td>0</td>
<td>Pit voids are contained (no spill)</td>
<td>-1</td>
<td>Additional load added but only during high flow events so likely minor impacts</td>
</tr>
<tr>
<td></td>
<td>Groundwater drawdown</td>
<td>Groundwater drawdown impact on users</td>
<td>-1</td>
<td>All identified private bores to have less than 5m water table drawdown</td>
<td>-1</td>
<td>All identified bores to have less than 5m water table drawdown</td>
</tr>
<tr>
<td></td>
<td>Groundwater quality</td>
<td>Impact on groundwater quality objectives for life of option</td>
<td>0</td>
<td>No feasible mechanism for change in beneficial use</td>
<td>0</td>
<td>No feasible mechanism for change in beneficial use</td>
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<tr>
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<td>Aquaculture</td>
<td>Downstream river quality</td>
<td>Impact on aquaculture water quality objectives prior to supply</td>
<td>0</td>
<td>Pit voids are contained (no spill)</td>
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<tr>
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<td>Void water quality</td>
<td>Water quality modelling indicates suitability for aquaculture within the region</td>
<td>0</td>
<td>Aquaculture not proposed</td>
<td>0</td>
<td>Aquaculture not proposed</td>
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<tr>
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<td>Human Consumption</td>
<td>Downstream river quality</td>
<td>Impact on human consumption water quality objectives (pre-treatment) for life of option</td>
<td>0</td>
<td>Pit voids are contained (no spill)</td>
<td>-1</td>
</tr>
<tr>
<td></td>
<td>Primary Recreation</td>
<td>Void water quality</td>
<td>Water quality suitability for primary recreation use within the voids</td>
<td>0</td>
<td>Primary recreation not proposed</td>
<td>0</td>
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<tr>
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<td>Secondary Recreation</td>
<td>Void water quality</td>
<td>Water quality suitability for secondary recreation use within the voids</td>
<td>0</td>
<td>Secondary recreation not proposed</td>
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<tr>
<td></td>
<td>Visual Recreation</td>
<td>Void water quality</td>
<td>Water quality suitability for visual recreation use within the voids</td>
<td>0</td>
<td>There are no identified impacts in relation to void water being unacceptable for visual recreation purposes</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Industrial Use</td>
<td>Void water quality</td>
<td>Water quality suitability for industrial uses within the region</td>
<td>0</td>
<td>Industrial use not proposed</td>
<td>0</td>
</tr>
<tr>
<td>Environmental Aspect</td>
<td>Environment Value</td>
<td>Consideration</td>
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<td></td>
<td>Ranking</td>
<td>Evidence</td>
<td>Ranking</td>
</tr>
<tr>
<td>Flooding</td>
<td>Changes in flooding &amp; runoff characteristics</td>
<td>Upstream flood levels</td>
<td>Compared with existing conditions</td>
<td>0</td>
<td>Preferred option 1 is consistent with existing conditions hence there is negligible forecast afflux (compared with existing conditions).</td>
<td>2</td>
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<tr>
<td></td>
<td></td>
<td>Downstream flood levels</td>
<td>Compared with existing conditions</td>
<td>0</td>
<td>Preferred option 1 is consistent with existing conditions hence there is negligible forecast afflux (compared with existing conditions).</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Impact on local run-off volumes to river</td>
<td>Compared to current mine footprint</td>
<td>0</td>
<td>Relatively small changes to catchment area reporting to Nogoa River compared to catchment upstream</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Velocity/erosion potential</td>
<td>Compared with existing conditions</td>
<td>1</td>
<td>There are no short or medium-term risks of accelerated morphological change and there would be a minor reduction in the residual long-term risks from an increase in the levee height, which would reduce the frequency of an overtopping event. An overtopping event during a very rare and extreme event would erode the river bank, potentially to bed level, to cause a morphological change. Given that there is a low probability that an overtopping event would occur, the benefit of this improvement compared to existing conditions is only minor.</td>
<td>1</td>
</tr>
<tr>
<td>Environmental Aspect</td>
<td>Environment Value</td>
<td>Consideration</td>
<td>Scoring Notes</td>
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<td>Biosecurity</td>
<td></td>
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<td>Ranking</td>
<td>Evidence</td>
<td>Ranking</td>
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<tr>
<td>Flora and Fauna</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>-1</td>
</tr>
<tr>
<td>Terrestrial Ecosystems</td>
<td>Habitat / Wetlands/ Riparian Areas</td>
<td>Compared to current extant vegetation (area)</td>
<td>This option is expected to have minimal impacts on REs, and the associated habitats they provide, however there is expected to be a minor ecological benefit through the creation of a treed corridor, which may provide a potential fauna linkage from Corkscrew Creek to the Nogoa River.</td>
<td></td>
<td></td>
<td>There would be minor impacts associated with the construction of the intake structures and the potential requirement for the re-installation of the pipeline crossing the Nogoa River on RE 11.3.25e. While there would be a minor ecological benefit in the planting of a treed corridor linking Corkscrew Creek to the Nogoa River, this benefit is outweighed by the loss of remnant vegetation and associated potential habitats for the construction of the intake structures and pipeline.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
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Residual Void Project – Stage 3 Environmental Assessment Report
<table>
<thead>
<tr>
<th>Environmental Aspect</th>
<th>Environment Value</th>
<th>Consideration</th>
<th>Scoring Notes</th>
<th>Option 1: Landform Levee</th>
<th>Evidence</th>
<th>Ranking</th>
<th>Evidence</th>
<th>Ranking</th>
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<th>Ranking</th>
<th>Evidence</th>
<th>Ranking</th>
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<tbody>
<tr>
<td></td>
<td>Quality conducive to ecosystem health</td>
<td>Dust</td>
<td>Quantity of dust over the life of the option</td>
<td>0</td>
<td>No dust generating sources to remain</td>
<td>0</td>
<td>No dust generating sources to remain</td>
<td>0</td>
<td>No dust generating sources to remain</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Quality conducive to ecosystem health</td>
<td>Odour</td>
<td>Quantity of odour over the life of the option</td>
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<td>No odour generating sources to remain</td>
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<td>No odour generating sources to remain</td>
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<td>No odour generating sources to remain</td>
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<tr>
<td></td>
<td>Quality conducive to ecosystem health</td>
<td>Other air contaminants</td>
<td>Quantity of nitrogen oxides, sulphur dioxides, carbon monoxide and particular matter over the life of the option</td>
<td>0</td>
<td>No other sources of air contaminants to remain</td>
<td>0</td>
<td>Single diesel pump to remain at Nogoa river pump station. Unlikely that air emissions from this single pump would impact ecosystem health</td>
<td>0</td>
<td>No other sources of air contaminants to remain</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Quality conducive to aesthetics</td>
<td>Dust</td>
<td>Quantity of dust over the life of the option</td>
<td>0</td>
<td>No dust generating sources to remain</td>
<td>0</td>
<td>No dust generating sources to remain</td>
<td>0</td>
<td>No dust generating sources to remain</td>
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<td>Quality conducive to aesthetics</td>
<td>Odour</td>
<td>Quantity of odour over the life of the option</td>
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<td>No odour generating sources to remain</td>
<td>0</td>
<td>No odour generating sources to remain</td>
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<td>No odour generating sources to remain</td>
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<td>Quality conducive to aesthetics</td>
<td>Other air contaminants</td>
<td>Quantity of nitrogen oxides, sulphur dioxides, carbon monoxide and particular matter over the life of the option</td>
<td>0</td>
<td>No other sources of air contaminants to remain</td>
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<td>Single diesel pump to remain at Nogoa river pump station. Unlikely that air emissions from this single pump would impact aesthetics</td>
<td>0</td>
<td>No other sources of air contaminants to remain</td>
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<td>Odour</td>
<td>Quantity of odour over the life of the option</td>
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<td>Quality conducive to human health</td>
<td>Other air contaminants</td>
<td>Quantity of nitrogen oxides, sulphur dioxides, carbon monoxide and particular matter over the life of the option</td>
<td>0</td>
<td>No other sources of air contaminants to remain</td>
<td>0</td>
<td>Single diesel pump to remain at Nogoa river pump station. Unlikely that air emissions from this single pump would impact human health</td>
<td>0</td>
<td>No other sources of air contaminants to remain</td>
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<td>No dust generating sources to remain</td>
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<td>Quantity of nitrogen oxides, sulphur dioxides, carbon monoxide and particular matter over the life of the option</td>
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<td>No other sources of air contaminants to remain</td>
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<td>Single diesel pump to remain at Nogoa river pump station. Unlikely that air emissions from this single pump would impact agricultural usage</td>
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<td>No other sources of air contaminants to remain</td>
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<td>Acoustics (Noise and Vibration)</td>
<td>Noise</td>
<td>Impacts to fauna as a result of noise generated from the life of the option</td>
<td>0</td>
<td>No noise sources to remain</td>
<td>0</td>
<td>Noise unlikely to impact fauna</td>
<td>0</td>
<td>No noise sources to remain</td>
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<tr>
<td></td>
<td>Acoustics (Noise and Vibration)</td>
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<td>Salinity issues in the void over the life of the option</td>
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<td>Increase in concentration of salts and metals is expected in some voids however use of that water is not proposed</td>
<td>-1</td>
<td>Increase in concentration of salts and metals is expected in some voids however use of that water is not proposed</td>
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<td>Hazards and Safety</td>
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<td>This EV is addressed by other EVs listed above.</td>
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<td>EV vulnerability due to climate change</td>
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<td>This EV is addressed by other EVs listed above.</td>
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11.0 Risk Assessment

A Residual Void Options Analysis Risk Assessment (Rowan & Associates 2018) was undertaken to review the outcomes of the technical investigations of the three preferred options identified in Stage 1 of the RVP, using a recognised Hazard and Operability Studies (HAZOPs) methodology.

This study was used to identify potential hazards and operational problems that could result from the proposed project design. The study was used to identify potential deviations from the expected normal operating conditions inherent in the design that could lead to hazardous situations or future operational difficulties.

This risk assessment process involved the systematic scrutiny of the three design options against the three key performance criteria:

- Safety
- Stability; and
- Non-polluting

The risk assessment identified possible deviations from the planned "normal operating conditions" and reviewed proposed Preventative Control strategies designed to prevent these deviations, together with any Recovery or Contingency strategies planned to mitigate the consequences of any deviations should they occur. The quality and effectiveness of these strategies was then qualitatively assessed to assign the "level of confidence" in the effectiveness of the proposed control strategies.

The resultant "Risk Rating" was then used to provide the opportunity to make a considered determination of the acceptability, or otherwise, of each identified risk. The Risk Rating findings include:

- For both Option 1 and Option 2, the risk assessment has shown that the level of confidence for the proposed designs indicates that the success rate of the proposed design is predominantly greater than 90%; and
- For Option 3, the risk assessment has shown that the level of confidence for the proposed design varies up to a success rate of up to 70 to 90%.
12.0 References


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*Environmental Protection (Water) Policy 2009 – Nogoa River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Nogoa River Sub-basin (Qld)*

*Environmental Protection (Water) Policy 2009 – Comet River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Comet River Sub-basin (Qld)*

Environmental Values Workshop Report Stage 2 Residual Void Project

Food Standards Australia New Zealand (FSANZ), 2007, *Australia New Zealand Food Standards Code*.


*Water Plan (Fitzroy Basin) 2011 (Qld)*


### 13.0 Glossary and Abbreviations

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<thead>
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<th>Acronym/Term</th>
<th>Abbreviation/Meaning</th>
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<tr>
<td>AEP</td>
<td>Annual Exceedance Probability</td>
</tr>
<tr>
<td>AGE</td>
<td>Australasian Groundwater and Environmental Consultants Pty Ltd</td>
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<td>AHD</td>
<td>Australian Height Datum</td>
</tr>
<tr>
<td>AMD</td>
<td>Acid and Metalliferous Drainage</td>
</tr>
<tr>
<td>ANC</td>
<td>Acid Neutralising Capacity</td>
</tr>
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<td>ARI</td>
<td>Average Recurrence Interval</td>
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<td>Biosecurity Plan</td>
<td>Central Highlands Regional Council Biosecurity Plan 2017-2022</td>
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<td>BoM</td>
<td>Bureau of Meteorology</td>
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<td>CEC</td>
<td>Cation Exchange Capacity</td>
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<tr>
<td>CFD</td>
<td>Computational Fluid Dynamics</td>
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<td>CHDC</td>
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<td>CHRC</td>
<td>Central Highlands Regional Council</td>
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<td>CPT</td>
<td>Cone Penetration Testing</td>
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<td>CRG</td>
<td>Community Reference Group</td>
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<td>DES</td>
<td>Queensland Department of Environment and Science</td>
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<td>DNRME</td>
<td>Queensland Department of Natural Resources, Mines and Energy</td>
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<td>EA</td>
<td>Environmental Authority</td>
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<td>EFO</td>
<td>Environmental Flow Objectives</td>
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<tr>
<td>EHP</td>
<td>Queensland Department of Environment and Heritage Protection (former)</td>
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<td>EIS</td>
<td>Environmental Impact Statement</td>
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<td>Ensham</td>
<td>Ensham Resources Pty Ltd (Ensham), operates Ensham Mine on behalf of the Ensham Joint Venture participants (Bligh Coal Limited, Idemitsu Australia Resources Pty Ltd and Bowen Investment (Australia) Pty Ltd)</td>
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<td>Environment Protection and Biodiversity Conservation Act 1999 (Cth)</td>
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<td>EPP Noise</td>
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<td>EPP Water</td>
<td>Environmental Protection (Water) Policy 2009</td>
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<td>EV</td>
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<td>FOS</td>
<td>Factor of Safety</td>
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<td>GDE</td>
<td>Groundwater Dependent Ecosystem</td>
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<td>HEC</td>
<td>Hydro Engineering and Consulting Pty Ltd</td>
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<td>Abbreviation/Meaning</td>
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<tr>
<td>HS</td>
<td>HydroSimulations</td>
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<td>IQQM</td>
<td>Integrated Quantity-Quality Model</td>
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<td>KRA</td>
<td>Key Resource Area</td>
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<td>MNES</td>
<td>Matters of National Environmental Significance</td>
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<td>ML</td>
<td>Mining Lease</td>
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<td>MSES</td>
<td>Matter of State Environmental Significance</td>
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<td>Mtpa</td>
<td>Million tonnes per annum</td>
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<td>NAF</td>
<td>Non-acid Forming</td>
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<td>NC Act</td>
<td>Nature Conservation Act 1992 (Qld)</td>
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<td>PAA</td>
<td>Priority Agricultural Area</td>
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<td>PALU</td>
<td>Priority Agricultural Land Use</td>
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<td>PMF</td>
<td>Probable Maximum Flood, referred to as the lateral extent of the predicted probable maximum flood inundation, effectively delineating the maximum extent of the floodplain.</td>
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<td>PMST</td>
<td>Protected Matters Search Tool</td>
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<td>For the purposes of this report, the Project Area consists of the Ensham Mine MLs, i.e.: ML7459, ML7460, ML70049, ML70326, ML70365, ML70366 and ML70367</td>
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<td>PSD</td>
<td>Particle Size Distribution</td>
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<td>ROP</td>
<td>Resource Operating Plan</td>
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<td>RVP</td>
<td>Residual Void Project, a component of work required under the terms of EA Condition G16</td>
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<td>SCA</td>
<td>Strategic Cropping Area</td>
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<td>SPP</td>
<td>State Planning Policy</td>
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<td>SWCC</td>
<td>Soil Water Characterisation Curve</td>
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<td>TEC</td>
<td>Threatened Ecological Communities</td>
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<td>Terms of Reference for the Residual Void Project</td>
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<td>Vegetation Management Plan</td>
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<td>WASO</td>
<td>Water Allocation Security Objective</td>
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<td>Water Plan</td>
<td>Water Plan (Fitzroy Basin) 2011</td>
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<td>WoNS</td>
<td>Weeds of National Significance</td>
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<td>WRM Water &amp; Environment Pty Ltd</td>
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<td>Water Management Plan</td>
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<td>WQO</td>
<td>Water Quality Objective</td>
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STAGE 3 ECOLOGICAL ASSESSMENT REPORT

Ensham Residual Void Project

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Ensham Resources Pty Ltd

Project Director: Barbara Crosley
Project Manager: Toby Grogan
Technical Manager: Richard Floyd
Report No.: 7029/R02/V9
Date: March 2019

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Executive Summary

Background

The Ensham Mine is an open cut and underground, bord and pillar coal mine located approximately 35 kilometres (km) east of Emerald along the Nogoa River in Central Queensland. The mine commenced production in 1993 and operates under existing mining leases (MLs) and a single Environmental Authority (EA).

Condition G16 of the EA requires that Ensham complete and submit a Residual Void Project (RVP) to identify appropriate outcomes for the mine voids, to the administering authority by 31 March 2019. Ensham prepared a Terms of Reference (ToR) for the RVP, which was approved by the administering authority on 21 July 2017. The ToR allows Ensham to develop the RVP over five stages.

This report has been prepared to address Stage 3 of the RVP and involves the assessment of ecological Environmental Values with potential to be affected by the RVP. This assessment has been undertaken of the ecological Environmental Values that occur both on the Project area (consisting of ML7459, ML7460, ML70049, ML70326, ML70365, ML70366 and ML70367) and within the locality of the Project area (the area within 5 km of the Project area).

This report presents the current ecological condition of the Project area (based on a desktop assessment), and provides an impact assessment and identifies remaining gaps to be addressed in the Ecological Impact Assessment (EIA) once the preferred option selection has been made. This assessment is based upon the requirement to assess post relinquishment impacts only.

Summary of Stage 3 Preferred Options

The preferred options addressed within this report consist of:

- **Preferred Option 1:**
  Landform Levee (Option 1: LL) - This option will convert the current engineered levees into permanent landforms, augmenting the existing earthworks to exclude the residual voids from the floodplain.

- **Preferred Option 2:**
  Flood Mitigation and Beneficial Use (Option 2: FMBU) - This option will capture a small fraction of flood event flows from the Nogoa River, and store this water in the residual voids. It will be released to the Weemah Channel in a controlled manner for irrigation purposes.
• Preferred Option 3: 
  Backfill to Probable Maximum Flood (PMF) Level (Option 3: BTP) - This option will backfill residual 
  mining voids within the extent of the PMF to the approximate pre-mining elevations/surface levels.

A treed corridor is proposed by Ensham to be planted along the highwalls associated with each option 
adjacent to Pit A and Pit B between Corkscrew Creek to the Nogoa River. This is treed corridor is intended 
to prevent vehicles driving over residual high walls once an option has been selected and constructed with 
the added benefit of providing a new linkage between remnant vegetation associated with both Corkscrew 
Creek and the Nogoa River.

Summary of Baseline Ecological Conditions

The following broad terrestrial habitats were identified from the Regional Ecosystem (RE) mapping 
prepared by DES (2017) (Version 10.1) for the Project area and locality included:

- Riparian wetlands consisting of ‘Of Concern’ RE 11.3.25(e) and ‘Endangered’ RE 11.3.3, as well as 
  ‘Endangered’ RE 11.4.8.
- Woodland consisting of ‘No Concern’ RE 11.5.9, RE 11.7.2 and RE 11.7.4 and ‘Of Concern’ RE 11.7.1.
- Open Forest consisting of ‘Endangered’ RE 11.3.1.
- Disturbed Lands/Pasture/Cropping/Rehabilitation.

Aquatic habitats of the Project area and locality include the Nogoa River, which flows through the Project 
area from west to east. During peak flows, the main channel forms an Anabranch that subsequently 
becomes isolated from the main channel as conditions dry. The main channel and anabranch support 
riparian vegetation and aquatic habitats. Winton Creek, and an un-named creek entering the Nogoa River 
from the west, also support riparian vegetation and aquatic habitats.

The review undertaken in this report identified three flora species of conservation significance, namely 
*Cerbera dumicola*, *Dichanthium queenslandicum* and *Acacia spania* as having been recorded either on the 
Project area, or in habitats in proximity to the Project area and as such may also occur in the Project area. 
Of these species, Option 1 and Option 2 have potential to impact upon suitable habitat of *Dichanthium 
queenslandicum*.

The review process identified that terrestrial fauna species of conservation significance, including Curlew 
Sandpiper, Red Goshawk, Grey Falcon, Squatter Pigeon, Koala, Ornamental Snake, Yakka Skink, Grey Snake, 
Dunmall’s Snake, Satin Flycatcher and Rufous Fantail as having potential to occur in the Project area. 
Several of these species are known to utilise habitats in close proximity to the RVP areas. In addition to the 
terrestrial species, a number of aquatic bird species including the Australian Painted Snipe and a variety of 
migratory bird species are known to occur or have potential to occur in this area.

No conservation significant aquatic flora or insect species were identified during the literature review 
process.

Two conservation significant turtle species are known to occur within the Nogoa River, namely the Fitzroy 
River Turtle and the Southern Snapping Turtle.

A number of weed and pest species are known to occur in the Project area.

Summary of Impact Assessment

The impacts arising from the preferred options are generally expected to occur within the existing 
disturbed/cleared mining areas. The following identifies potential impacts that may occur outside of the 
existing approved mine footprint:
• The landform levees proposed for Option 1, specifically the proposed regrading of the outer slopes of the levee walls will result in the levees being widened up to 40 metres (m). This Option will result in the clearing of non-regulated regrowth/previously disturbed vegetation and has limited potential for disturbance of threatened species habitat.

• Option 2: FMBU will involve construction of intake structures to capture water from the Nogoa River and the Anabranch and will impact approximately 3 ha of riparian vegetation (11.3.25e) associated with this river. The existing water pipeline, previously used to pump water between pits, may also require replacement where it crosses the Nogoa River, just west of the convergence of the Nogoa River and the Anabranch.

• Options 3: BTP is considered unlikely to result in the loss of any regional ecosystems or associated habitats outside the approved mine footprint.

Summary of Rankings of Impacts on Ecological Environmental Values of the Project area

An assessment of the potential impacts of each of the three preferred options on relevant environmental values (EVs) has been undertaken based on the outcomes of the studies presented in this report. Table ES1.1 below provides a summary of the assessment using the adopted ranking criteria ranging from -3 (significant negative impact), 0 (no impact or benefit), to +3 (significant benefit).

Table ES1.1 Summary of Assessment Rankings for Impacts on Ecological Environmental Values Associated with Option 1, Option 2 and Option 3

<table>
<thead>
<tr>
<th>Environmental Aspect</th>
<th>Environmental Value</th>
<th>Parameter</th>
<th>Option 1 LL</th>
<th>Option 2 FMBU</th>
<th>Option 3 BTP</th>
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<td></td>
<td></td>
<td></td>
<td>Option life - perpetuity</td>
<td>Option life</td>
<td>Option life - perpetuity</td>
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<td>Aquatic GDE’s (Stygofauna)</td>
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<td></td>
<td>Impact on run-off quality</td>
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<td>Ecology (Flora and Fauna)</td>
<td>Terrestrial Ecosystems</td>
<td>Habitats/Wetlands/Riparian Areas</td>
<td>+1</td>
<td>-1</td>
<td>+1</td>
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<td></td>
<td></td>
<td>Terrestrial Subterranean Fauna Habitat</td>
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<td>Ecosystem Vulnerability</td>
<td>Pests</td>
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<td>Weeds</td>
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<td></td>
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<tr>
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<td>Bioaccumulation</td>
<td>Void Water Quality</td>
<td>-1</td>
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The impact on EV of ‘Aquatic Ecosystems (Biodiversity & Habitat)’ was assessed by considering downstream river quality, aquatic groundwater dependent ecosystems (stygofauna) and impact on run-off quality. All options were identified as scoring 0 on each of the parameters, as it is expected that there will be minimal downstream impacts on water quality, impacts on aquatic groundwater dependent ecosystems (stygofauna) or impacts on run-off quality based on study findings.
The impact on EV of ‘Terrestrial Ecosystems’ was assessed by considering impacts on Habitats/Wetlands/Riparian areas (consisting of an amalgamation of vegetation, threatened species habitat, essential habitat, wildlife corridor areas, wetlands/riparian areas) and terrestrial subterranean fauna habitat.

Analysis of impacts on habitats/ wetlands/riparian areas identified that:

- Option 1 resulted in a score of +1. This option is expected to have minimal impacts on REs, and the associated habitats they provide, however there is expected to be a minor ecological benefit through the creation of a treed corridor, which may provide a potential fauna linkage from Corkscrew Creek to the Nogoa River.

- Option 2 scored -1 as there will be approximately 3 ha of clearing associated with the construction of the intake structures and the potential requirement for the re-installation of the pipeline crossing the Nogoa River on RE 11.3.25e. While there would be a minor ecological benefit in the planting of a treed corridor linking Corkscrew Creek to the Nogoa River, this benefit is outweighed by the loss of remnant vegetation and associated potential habitats for the construction of the intake structures and pipeline.

- Option 3 scored +1 as this option is not expected to impact upon any habitats/ wetlands/riparian areas or subterranean fauna habitat, but a treed corridor will be planted providing a potential fauna linkage between Corkscrew Creek to the Nogoa River.

An analysis of impacts on terrestrial subterranean fauna habitat identified that all options were identified as scoring 0, as there are no impacts on identified terrestrial subterranean fauna within the Project area.

The impact on EV of ‘Ecosystem Vulnerability’ was assessed by considering impacts associated with pests, weeds and over abundant native species. All options were scored 0, as on-going management practices will be implemented, which will include weed, pest and overabundant native species management.

The impact on EV of ‘Bioaccumulation’ was assessed by consideration of the Stage 3 Water Quality Results prepared by Hydro Engineering & Consulting (HEC) (2018). Option 1 scored -1 as the resultant waters within the respective remaining voids will progressively deteriorate in quality, through evapo-concentration of both salts and metals/metalloids including Arsenic, Molybdenum and Selenium, and have the potential to bio-accumulate in sediments and aquatic life within the resulting void waters. It is anticipated that the resultant waters associated with Option 1 will gradually become inhospitable to aquatic invertebrate and fish species, thereby reducing the potential use of the residual water bodies to a wading resource only. There will be no bio-accumulation with respect to Options 2 and 3 as there will either be no void water remaining or the void water will be managed to eliminate the prospect of bio-accumulation.

**Summary of Recommendations**

It is recommended that targeted ecological surveys be undertaken in potential disturbance areas for the selected option should that option result in impact beyond the existing approved mine footprint (i.e. expansion of levee footprints for Option 1: LL or for the proposed intake structures and the potential re-installation of the existing water pipeline that crosses the Nogoa River for Option 2: FMBU).
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Appendices

Appendix A  Assessment of Potential Occurrence of Conservation Significant Flora
Appendix B  Assessment of Potential Occurrence of Conservation Significant Fauna
1.0 Introduction

1.1 Background

Ensham Mine, an open cut and underground bord and pillar coal mine located approximately 35 kilometres (km) east of Emerald in Queensland (refer to Figure 1.1), is operated by Ensham Resources Pty Ltd (Ensham), a wholly owned subsidiary of Idemitsu Australia Resources Pty Ltd (Idemitsu), on behalf of the Ensham Mine Joint Venture (JV) Partners. The JV Partners and holders of the Environmental Authority (EA) are Bligh Coal Limited, Idemitsu and Bowen Investment (Australia) Pty Ltd. EA EPML00732813, dated 28 July 2017, is the relevant environmental authority under which Ensham operates the mine.

Condition G16 of the EA states that a Residual Void Project (RVP) must be completed and submitted to the administering authority for review and comment by 31 March 2019. The minimum content of the RVP is specified within Condition G16 of the EA as:

a) Terms of Reference;
b) Residual Void Study;
c) Progress Reports; and
d) Rehabilitation Success Criteria for Voids.

In compliance with Condition G19 of the EA, “the Residual Void Project (RVP) must be carried out in accordance with the approved Terms of Reference”. Terms of Reference (ToR) (Ensham Resources, 2017a) were approved by Queensland’s Department of Environment and Science (DES, formerly the Department of Environment and Heritage Protection, DEHP) on 21 July 2017.

Condition G20 of the EA identifies the minimum content of the RVP identified in Condition G16.

In accordance with the ToR, the RVP has been divided into five stages:

- Stage 1 – Project Definition and Options Identification;
- Stage 2 – Preferred Options Technical Studies;
- Stage 3 – Preferred Options Detailed Design;
- Stage 4 – Most Preferred Option Identification; and
- Stage 5 – Regulatory Documentation.

Stage 1 – Project Definition and Options Identification for the RVP has been completed. The Stage 1 Options Assessment Report has been finalised and issued to DES, the Department of Natural Resources, Mines and Energy (DNRME) and the Community Reference Group (CRG). The report was independently peer reviewed and revised to address peer review comments. The final report has been delivered to DES, DNRME and the CRG.

The Options Analysis workshop held in Stage 1 of the RVP identified two options:

- Option 1: Landform Levee; and
- Option 2: Flood Mitigation and Beneficial Use.

DES required a third option, Backfill to Probable Maximum Flood level, be included in the study.
All three options have been advanced through Stage 2 and into Stage 3 of the RVP and are referred to as the ‘preferred options’. The preferred options as provided by Ensham are discussed in Section 3.1 to Section 3.3 of this report.

Stage 2 identified the Environmental Values (EVs) in the immediate and surrounding area of Ensham Coal Mine and determined which EVs are likely to be affected by each preferred option. Similar to Stage 1, the Stage 2 EV report and technical studies have been Independently Peer Reviewed and issued in final to DES, DNRME and the CRG.

Stage 3 builds on the technical studies completed in Stage 2 to develop feasibility level designs required to prevent or minimise the potential impacts to EVs for each preferred option. Detailed designs for each of the preferred options will inform a risk assessment of each option and includes as a minimum:

- The long-term stability of the final landform;
- Safety of access to the site; and
- The short, medium and long-term risks associated with each preferred option.

The output of Stage 3, in addition to the associated technical reports, will be an Environmental Assessment report for each preferred option, which identifies the design and management practices, which will be implemented to minimise impacts on the identified EVs.

On completion, each preferred option report will be peer reviewed by an independent suitably qualified third party before submission to the administering authority for review and comment.

1.2 Purpose of this Report

The purpose of this report is to present the findings of the Stage 3 Ecological Assessment undertaken to evaluate the ecological EVs on and adjacent to the Project area and the potential for impacts associated with each of the three Preferred Options identified from Stage 1 of the RVP on those EVs. This report identifies benefits / impacts where applicable for each option and informs the overall Environmental Impact Assessment, the Economic Impact Assessment and the Social Impact Assessment reports.
1.3 Scope

This ecological assessment included the following key tasks:

- Review of relevant Commonwealth, state and local government environmental legislation and policies;
- Identification of any additional field surveys required;
- Identification of EVs potentially affected by the RVP Project; and
- Assessment of the impacts of each option on the identified EVs.

The RVP ToR specifies the environmental assessment to be undertaken for each of the three Preferred Options where applicable. The ToR provides the scope and level of detail to be considered as part of Stage 3 for each Preferred Option. Broadly, this component of the environmental assessment addresses the considerations that must form part of Stage 3 for each Preferred Option relevant to the Project area, as per the ToR.

An outline of the scope prescribed in the ToR is as follows:

- Site description;
- Description of the EVs as identified in the EV workshop report;
- A review of available baseline information relevant to the EVs and the Preferred Options;
- Assess the impacts on the EVs including:
  - Short-term and long-term impacts;
  - The scale, intensity, duration, irreversibility and the risk of harm;
  - Cumulative impacts;
- Management and mitigation measures; and
- The ability of the Preferred Options to meet acceptable environmental objectives and regulatory requirements.

The EVs investigated within this report, with respect to the RVP options, consist of the following:

- Land (terrestrial and aquatic flora and fauna habitats);
- Wetlands;
- Groundwater (Groundwater Dependent Ecosystems and subterranean fauna); and
- Surface Water (riparian or aquatic habitats).
1.4 Definitions

The following terms are used throughout this report:

- **Baseline Ecological Conditions** – the ecological values of the mine site as they appear at the time of this report (operations as approved under the current EA);

- **Project area** – comprises the Ensham Mining Leases (ML) ML7459, ML7460, ML70049, ML70326, ML70365, ML70366 and ML70367 (as shown in Figure 2.1);

- **MNES** – Matters of National Environmental Significance, which are matters protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) including listed threatened species and ecological communities and migratory species protected under international agreements;

- **MSES** – Matter of State Environmental Significance, which includes environmental values that are protected under relevant Queensland legislation including:
  - *Nature Conservation Act 1992* (NC Act);
  - *Marine Parks Act 2004*;
  - *Fisheries Act 1994*;
  - *Environmental Protection Act 1994* (EP Act);
  - *Regional Interests Planning Act 2014*;
  - *Vegetation Management Act 1999* (VM Act); and
  - *Environmental Offsets Act 2014*.

- **Locality** – An area within 5 km of the Project area; and

- **Study Area** – An area within a 50 km radius of the centroid of the Project area, which has been used for database searches to identify the potential presence of threatened species.

1.5 Format of Report

An overview of the layout of this report is presented below:

**Executive Summary**

**Section 1.0** Introduction

**Section 2.0** Site Description

**Section 3.0** Preferred Options

**Section 4.0** Methodology

**Section 5.0** Legislative Review Results

**Section 6.0** Summary of Other Relevant Stage 3 Technical Findings
Section 7.0   Ecological Baseline Results
Section 8.0   Biosecurity
Section 9.0   Gap Analysis
Section 10.0  Impact Assessment and Proposed Management and Mitigation Measures
Section 11.0  Summary of Impacts on Environmental Values
Section 12.0  Conclusions and Recommendations
2.0 Site Description

2.1 Ensham Mine

The Ensham Mine is an open cut and underground coal mine located 40 km east of Emerald along the Nogoa River in Central Queensland. It is a large scale operation currently producing up to 5.2 Million tonnes per annum (Mtpa) from dragline/truck/shovel operations in the northern pits and underground bord and pillar operations.

The EA covers seven mining leases (ML7459, ML7460, ML70049, ML70326, ML70365, ML70366 and ML70367) (see Figure 2.1). A summary of the ownership and sizes of the mining leases is provided in Table 2.1 below (Ensham Resources, 2017).

Table 2.1 Ensham Mine Tenements

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<td>6,154.00</td>
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<td>ML7460</td>
<td>774.34</td>
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<tr>
<td>ML70049</td>
<td>1,648.00</td>
<td>Lot 3 CP911009, Lot 2 SP254309</td>
<td>• MD, ME, EM, JD &amp; SM Shaw&lt;br&gt;• RH &amp; RJ Simmons</td>
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<td>Lot 31 CP864573</td>
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The Project area is located within freehold land owned by Ensham and on private land owned by the Shaw and Simmons (ML70049) families. The mine is serviced by administration and workshop facilities, an on-site workforce accommodation camp and includes a coal processing plant; rail loop and train loading facility (refer to Figure 2.1).
Ensham open-cut mine consists of 7 pits; A Pit to F Pit and Y Pit (Yongala pit). A Pit and B Pit lie south of the Nogoa River with A Pit divided into A Pit South and A Pit North and B Pit lying partly in the Nogoa floodplain, protected by 1 in 1,000 year Average Recurrence Interval (ARI) levees (Figure 2.1). C Pit to Y Pit lie to the north of the river, with C Pit and D Pit occupying part of the floodplain and are also protected by 1 in 1,000 year ARI levees. Y Pit is divided into three separate pits, Y Pit Southern, Y Pit Central and Y Pit Northern. In all, the complex comprises 10 pits although the floors of individual pits are not always contiguous and water may currently collect in one part and not another of the same pit.

2.2 Project Setting

The Ensham Mine lies within the Brigalow Belt North bioregion, which has a semi-arid to tropical climate with predominantly summer rainfall. The land types in this bioregion include undulating to rugged ranges and alluvial plains. The mine lies within the Fitzroy Basin which is the second largest seaward draining Basin in Australia. The Basin includes 11 catchments and an extensive river system that flow to the Fitzroy River and estuaries and eventually to the Great Barrier Reef.

The topography of the Project area is generally flat to gently undulating and includes the Nogoa River and its floodplain. The Nogoa River is naturally ephemeral but generally has constant low flows due to regulated water supply releases from Fairbairn Dam. Fairbairn Dam is located approximately 60 km upstream of the Project area. Within the Project area, the river has a secondary anabranch channel that flows intermittently during high flows to the main channel. Winton Creek traverses the mining area from the west and joins the Nogoa River near the eastern limit of the open cut area.

2.2.1 Geology

The surface geology of the Project area is described using the Emerald and Duaringa sheets of the Australia 1:250,000 Geological Series (Veevers et al., 1964, Malone et al., 1965).

The Nogoa floodplain, in which A, B and C Pits are located, is part of the Quaternary Alluvium and is bounded to the south-west by an area of extensive soil cover. The Tertiary geology in the northern sections of the Project area is comprised of claystone, sandstone, siltstone, pebbly sandstone and gravel. In the most northern part of the Project area, this geology has formed plateaus and dissected Tertiary sediments. Claystone, sandstone, siltstone, pebbly sandstone and gravels occur in all Ensham Pits.

In the north-west of the Project area, extensive areas of soil, sand and gravel from an undifferentiated time between the Quaternary and Tertiary, are interspersed with claystone, sandstone, siltstone, pebbly sandstone and gravel. Pit B, Pit C, Pit F and Pit Y are located in this geology. A small extension of the Upper Permian Fair Hill Formation consisting of lithic and feldspathic sandstone, conglomerate tuff, tuffaceous sandstone and mudstone is situated in central eastern sections of the Project area. This geology occurs in all pits as it is overlying the coal measure (La Tierra, 2017). A larger surface extent of this formation can be found to the east of the Project area.

The average thickness of the Quaternary layer occurring in the central mining areas is 14 m, ranging from 1 to 25 m. The economic coal in the Project area occurs in the Aries and Castor seams of the Rangal Coal Measures, which was formed in the Upper Permian (Hansen Consulting, 2006).

2.2.2 Groundwater

Groundwater occurs throughout Queensland in Mesozoic sedimentary basins and overlying Cainozoic deposits. Broad types of geologies that are sources of groundwater include unconsolidated sedimentary material (Quaternary alluvial and colluvial deposits, Quaternary sand deposits), consolidated sedimentary rocks (sandstone), fractured rocks (Cainozoic igneous rocks) and cavernous rocks (karst caves) (Harrington and Cook, 2014).
The groundwater occurrence in the alluvium at Ensham is highly variable, with thin saturated zones of poor quality water in deeper sections of an otherwise largely unsaturated formation (AGE, 2006). Water level data show the seasonal variability in groundwater to be limited and coincident with the heterogeneous distribution of these sediments (AGE, 2006). Generally, the groundwater in the alluvium was more saline than in the coal seam aquifers with groundwater tests results exceeding 5000 µS/cm (AGE, 2006). Shallow silts and clays in the Nogoa River appear to isolate the river, limiting leakage from the river into the basal sands and gravels. It is possible that leakage may occur where these clays are absent or where the basal sands are exposed within the river. However, this is conceptually thought to occur only in localised areas. This hydraulic separation of the alluvium from the Nogoa River means that whilst the water in the river is fresh, the underlying alluvium can be brackish to highly saline (HS, 2018).

The alluvium can therefore be considered as a largely unconfined system which is recharged by rainfall and upward leakage from the underlying Rewan Group or Rangal Coal Measures. The alluvium may also receive localised base flow recharge from the Nogoa River, in areas where clay and silt layers are absent (HS, 2018).

2.2.3 Surface Water

The major watercourses within the current receiving environment of the Study Area include Boggy Creek, Corkscrew Creek, Winton Creek, the Nogoa River (and Anabranch), and the Mackenzie River.

The Nogoa River flows through the Project area from northwest to southeast (refer to Figure 2.1). During peak flow, the main channel forms an Anabranch that subsequently becomes isolated as conditions dry. The main channel and anabranch support riparian vegetation and aquatic habitats. Winton Creek and an unnamed creek, entering the Nogoa River from the west, also support riparian vegetation and aquatic habitats.

Boggy Creek has been previously modified to permanently divert flows around the Ensham Mine voids. Boggy Creek skirts the eastern edge of the Y North and Y Central Pits then crossing between Y Central and Y South Pits then flowing south along the eastern edges of Pit E, Pit D and Pit C, before discharging into the Nogoa River to the south of the Ensham Mine. Boggy Creek is considered to be ephemeral; however several waterholes persist throughout much of the year. The portions of the Nogoa and Mackenzie River as shown in Figure 2.1 are considered perennial, largely as a result of regulated releases from Fairbairn Dam, though contain little flow during the dry season. Fairbairn Dam is located approximately 60 km upstream of the Project area.

2.2.4 Land Use

The Project area is surrounded by agricultural properties, which include non-irrigated and irrigated cropping on the floodplain of the Nogoa River, and stock grazing on areas beyond the floodplain. The neighbouring agricultural properties contain a number of isolated rural residences (Hansen Consulting, 2006).

The Project area occurs on a historically cleared landscape. Of the 3,500 hectares (ha) of the Project area identified for the original Ensham Mine EIS (prepared by Hollingsworth, Dames and Moore, 1990), it was calculated that 90% of the Project area had already been cleared for either cropping or grazing activities prior to mining commencing. Figure 2.2 shows a 1984 aerial photograph with the current mining leases shown in red outline. Large parts of the floodplain appear to have been cleared for cropping, while disturbance of the higher elevation of the Project area indicate clearing resulting from other agricultural activities.
3.0 Preferred Options

3.1 Option 1 - Landform Levee 1 Description

Having conceptually evolved since Stage 1, the proposed Option 1: LL will develop permanent landforms along the existing levee alignment to provide flood immunity for the 0.1% (1 in 1,000) Annual Exceedance Probability (AEP) flood event having had consideration of the risk of a Probable Maximum Flood (PMF) level event (as proposed in the Stage 2 assessment). Figure 3.1 illustrates the current placement of the landform.

When compared to the landform levee designed at a PMF level (as considered in Stage 2) the proposed 0.1% AEP landform along the existing levee alignment:

- Eliminates afflux impacts for upstream landholders in a greater than 0.1% AEP event.
- Eliminates any potential increased impacts on downstream landholders associated with widening the river floodplain.
- Eliminates the need to realign the Nogoa anabranch.

It is proposed to incorporate the existing levees into the landform design with overburden emplacement areas behind the levee being reshaped in a manner that achieves the minimum stable landform slope requirements.

In addition to any impacts associated with the existing farm levees and mining pit levees, flood levels in the vicinity of Ensham Mine are significantly affected by the confluence of flood flows from the Comet River and Nogoa River, which occurs immediately downstream of the mine. Pits would be subject to rehabilitation in accordance with the approved Ensham site Rehabilitation Management Plan and the landform design criteria.

A treed corridor will be developed along the western (highwall) side of the rehabilitated A and B pits to provide connectivity between Corkscrew Creek and the Nogoa River flood plain as seen in Figure 3.1.
3.2 Option 2 – Flood Mitigation and Beneficial Use

Option 2 proposes to utilise the post-mining voids to form water storages to capture a proportion of high flow flood water and store this water for potential beneficial use as shown in Figure 3.2. Flood water harvesting is able to quickly fill the post-mining voids with minimal downstream impact, achieving improved water quality to support a range of reuse options and/or environmental and social values.

This option is founded on the concept of capturing a small fraction of larger magnitude flood event flows in the Nogoa River, storing this water in residual voids and releasing it back to irrigation and industrial users via a series of pipes to the Weemah Channel and Yamala Inland Port. There will be no discharge to the Nogoa River by this option.

The design of rehabilitation should comply with the current site Rehabilitation Management Plan and landform design criteria to optimise water capacity. Overburden emplacement areas located adjacent to the water storage voids are to be reshaped in a manner that achieves stable landform slopes without resulting in significant void backfilling. Low wall areas are to be reshaped in-pit to achieve minimum stable slope requirements to ensure safe access and stability of exposed slope surfaces.

Option 2 would utilise storage afforded by residual voids remaining in A Pit and B Pit south of the Nogoa River, and C Pit and D Pit north of the river. The quantity of water likely to be required to operate the system – or put another way, the headroom storage in the pits – is likely to be negligible when compared to overall discharges during flood events from the Nogoa River catchment into the Mackenzie River located downstream of the Ensham Coal Mine. However, in the context of irrigation usage, the headroom storage represents a significant volume and a potential economic asset.

Future assessment and optimisation of Option 2 will consider the potential for interactive operation of the voids with Fairbairn Dam to improve water use efficiency across the water supply system.
Currently Fairbairn Dam’s southern irrigation channel, known as the Weemah Channel, extends eastward to within approximately 10 km of Ensham Coal Mine. Water captured from the upper Nogoa River catchment and retained in Queensland’s second largest but relatively shallow Fairbairn Dam, is subject to significant evaporative losses. Furthermore, allocated water releases from the dam into the Weemah Channel (and the corresponding northern Channel, the Selma Channel) experience significant seepage and seasonal evaporative losses before reaching their intended customers, particularly where these customers are close to the end of the Weemah Channel. This option includes linking the residual voids located to the south of the Nogoa River to the existing Weemah Channel with large diameter pipes and pumps to transfer water to and from the voids.

Water captured in Fairbairn Dam would be released into the Weemah Channel when hydrologic conditions are likely to result in minimal evaporative and seepage losses (i.e. at times when the catchment is receiving rainfall, the ground is saturated and evaporation is minimal). Whilst the water may not be required by customers at these times, the water would be transferred to the residual voids via the proposed Weemah Channel(s) (refer red line on Figure 3.3) and stored in the more evaporatively-efficient residual voids at Ensham. In times of irrigation water demand at the lower reaches of the Weemah Channel (i.e. where the evaporative and seepage distribution losses are likely to be greatest), water would be returned to the Weemah Channel from the residual voids via the Weemah Channel.

Because the Weemah Channel and proposed channel(s) lie on the southern side of the Nogoa River floodplain, it would be necessary to maintain a hydraulic connection between the residual voids on the northern flanks of the floodplain and those on the southern flanks. It is proposed that an upgrade of the existing water distribution main, that runs parallel with the main haulage route between B Pit and C Pit, be undertaken early in the project to provide the required hydraulic connection (refer blue line on Figure 3.3).

Option 2 proposes that pontoon-based pumping stations would be sited at each pit to transfer water as required. The Weemah Channel coming into the mining lease would be configured to deliver water initially to A pit. Similarly, pumping from the mine to the Weemah Channel would be done from A Pit.

An offtake from the pipe to Weemah Channel would be used to meet water demand for the prospective Yamala Inland Port located to the south west of Ensham Mine.

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Figure 3.2  Option 2 – Flood Mitigation and Beneficial Use
(Source: Ensham Resources Pty Ltd)
The intakes from the Nogoa River to B and C Pits would allow temporary storage of peak flood flows during flood events. As the river rises during a flood event, it would reach the overflow level of the inlet structures constructed in the levee (the intakes) and flow into the residual voids. The water would rise in the voids to reflect the height of the flood. As flood levels recede, water would ebb back into the river floodplain through the intakes to the base level of the intakes leaving the voids at full level. The intake level for B and C Pits has been considered as part of Stage 3.

A further key aspect of Option 2 is the depth of the residual voids. Shallow expansive voids experience greater evaporative water losses and hence potential salt concentration. Hence improved water quality outcomes are likely to be delivered with deeper inundated pits.

There remain several opportunities to manage power demands of the scheme including solar-power to generate an income to cover some or all of the overall annual operating cost of this option.

Residual voids that are not within the floodplain, for example E, F and Y pits, would be rehabilitated to achieve minimum stable slope requirements and comply with currently approved site Rehabilitation Management Plan and landform design criteria.

A treed corridor will be developed along the western (highwall) side of the rehabilitated A and B pits to provide connectivity between Corkscrew Creek and the Nogoa River flood plain as seen in Figure 3.2.
3.3 **Option 3 - Backfill to Probable Maximum Flood (BTP)**

Preferred Option 3 comprises backfilling residual mining voids located within the pre-mining floodplain up to the elevation of the original floodplain within the lateral extent of the pre-mining Probable Maximum Flood (PMF) level.

Conceptually, the residual voids lying within this PMF extent would be backfilled up to the approximate original (pre-mining) topography with an additional surcharging to accommodate settlement of the backfill. In practice, it may be necessary to extend the backfilling beyond the modelled extent of the PMF to ensure stability of the backfilled areas within the PMF extent and protect against collapse into the adjacent residual voids. Excess mining spoil, that is currently present in the floodplain and that is not required for backfilling of residual mining voids, would be retained as seen in Figure 3.4.

The existing levees constructed to protect the voids from flooding would be removed, with the material reused for backfilling voids. Material required to backfill residual voids would be drawn from the nearest cost-effective source e.g. low wall spoil. Any negative material balance will need to be met from adjacent low wall and high wall spoils.

Virgin rock typically exhibits an increase in volume when excavated - this is referred to as ‘bulking’. The degree of bulking will vary with the geo-mechanical properties and size distribution of the excavated rocks and the methods used in excavation and transport. Furthermore, it is likely to vary both along the linear extent of the open cut mine and within different parts of spoil tips created through the extraction of rock dominated by lithologies characterising the local stratigraphy. Re-excavation of spoil and re-emplacement within voids within the modelled PMF will again exhibit bulking. Whether subjected to dynamic compaction or allowed to settle with subsequent loading by overlying backfill, the spoil within the voids will inevitably exhibit uncontrolled settlement. This will lead to the development of low areas within the PMF extent which, though shallow, lie below the original level of the floodplain. These low areas will not necessarily be connected and are likely to collect surface water runoff but be subject to intense evaporation and surface accumulation of evaporative salts which would be flushed clean by fluvial flood events.

Static surcharging of the replaced spoil material may reduce the risk of long-term settlement below original floodplain. However, this will require material to be placed above the original floodplain elevation in direct contradiction of the intent of this option.

Beyond the modelled extent of the PMF, residual voids would be rehabilitated in accordance with a combination of Option 1 and Option 2 landform criteria requirements.

Replaced spoil, however comprehensively compacted, is unlikely to provide durability equal to the original virgin rock and hence during times of fluvial flood, of magnitudes such that the current floodplain pinch point between B Pit and C Pit begins to develop afflux, it is likely that the Nogoa River would scour spoil within the adjacent backfilled pits. This has the potential over time to result in sink holes and ultimately a repeat of the 2008/2010 inundation events with the Nogoa River cutting a channel into one or more backfilled pits and flooding the remaining un-backfilled parts of each pit. Additionally, impacts on turbidity downstream of the backfilled areas would need to be considered.

As part of the rehabilitation process, the establishment of a treed corridor along the western (highwall) side of the rehabilitated A and B pits is proposed to link Corkscrew Creek and the Nogoa River flood plain as seen in Figure 3.4.
Figure 3.4  Option 3 - Backfill to PMF
(Source: Ensham Resources Pty Ltd)
4.0 Methodology

The methodology for this report comprises three distinct phases:

- The identification of the ecological baseline of the Project area, including a review of relevant legislation and guidelines;

- A gap analysis to determine if any further ecological studies or data collection activities are required to meet the objectives of the RVP; and

- Impact assessment to determine the degree of potential impact on the identified EVs of the three preferred options. (It must be noted, impacts associated with mine operations, including the construction of the RVs, are considered covered by the approved EA).

4.1 Methodology for Identification of Ecological Baseline

The methodology for the identification of the ecological baseline of the Project area was broken into the following key tasks:

- Review of relevant environmental legislation;

- Review of relevant environmental guidance documents, such as policies and guidelines;

- Review of ecological databases and government vegetation mapping;

- Review of previous ecological reports;

- Determination of the likelihood of threatened species to occur in the Project area; and

- Consideration of Survey Guidelines.

The methodology for each of the above tasks is provided in the following sections.

The ecological baseline assessment also considered the findings of other relevant Stage 3 technical reports prepared for the Stage 3 RVP preferred options (described in Section 6.0).

4.1.1 Review of Environmental Legislation

The requirements of each of the following Acts or associated Regulations have been assessed to determine their relevance to the ecological values associated with the RVP:

- Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth);

- Planning Act 2016 (QLD);

- Mineral Resources Act 1989 (QLD);

- Environmental Protection Act 1994 (QLD);

- Environmental Protection Regulation 2008 (QLD);

- Environmental Offsets Act 2014 (QLD);
• Biosecurity Act 2014 (QLD);
• Environmental Protection (Water) Policy 2009 (QLD Government, 2013) (specifically Schedule 1 and the associated prescribed Environmental Values and water quality objectives);
• Fisheries Act 1994 (QLD);
• Nature Conservation Act 1992 (QLD);
• Nature Conservation (Wildlife Management) Regulation 2006 (QLD);
• Nature Conservation (Protected Plants) Conservation Plan 2000 (QLD); and
• Vegetation Management Act 1999 (QLD).

4.1.2 Review of Environmental Guidance Documents

Relevant guidance documents included in this review were:

• Commonwealth and State Survey Guidelines for Birds, Bats, Reptiles, and Mammals which provide indications of key habitats and distributions for threatened species;
• Queensland government mapping/databases used in the literature review for the preparation of this report included the following: Matters of State Environmental Significance (MSES);
• Review of the Queensland Back on Track Species Prioritisation Framework (Back on Track) (DES, 2017). The Back on Track framework is an initiative of the Queensland Government;
• Guideline for the Environmental Assessment of Subterranean Aquatic Fauna (DSITI, 2015);
• Australian Groundwater Dependent Ecosystems Toolbox Part 1: Assessment Framework (SKM, 2011);
• Queensland Wetland Policy;
• Queensland Guideline: Works that interfere with water in a watercourse—watercourse diversions (DNRM, 2014);
• Queensland Environmental Protection Water Policy (2009) Fitzroy River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Fitzroy River Sub-basin September 2011;
• Queensland Environmental Protection (Water) Policy (2009) Mackenzie River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin September 2011; and
• Ecological Assessment considerations under the Central Highlands Local Environmental Plan.

4.1.3 Review of Ecological Databases and Government Mapping

The desktop assessment for this report was undertaken in January 2018 and included a review of the Commonwealth and State databases listed below:

• The Department of Environment (DoEE) Protected Matters Search Tool to identify MNES within a 50 km radius of a central point (-23.45228, 148.49097) of the Project area, accessed 7 August 2017;
Terrestrial GDE, Subterranean GDE (Caves ecosystems) and Potential GDE Aquifer mapping provided in Queensland Globe (https://qldglobe.information.qld.gov.au/), accessed 7 August 2018;

The QLD Department of Environment and Science (DES) Wildlife Online database to identify any flora, fauna species listed under the Nature Conservation Act 1992 within a 50 km radius of a central point (-23.45228, 148.49097), accessed 7 August 2018;


Atlas of Living Australia to obtain a record of aquatic vertebrates occurring within an approximate 10 km radius of the Project area (https://biocache.ala.org.au/explore/your-area#-23.4069746|148.498168, accessed 7 August 2018;

Review of Regional Ecosystem (RE) mapping (Version 10.1) prepared by the Queensland Herbarium (2017) to determine the presence or proximity of endangered ecological communities identified under the Vegetation Management Act 1992 potentially occurring within an approximate 50 km radius of the Project area provided in Queensland Globe (https://qldglobe.information.qld.gov.au/), accessed 7 August 2018;

Bird data from Birds Australia Database as defined as a 50 km radius search from a central point (-23.45228, 148.49097) of the Project area; accessed 7 August 2018; and

Records from the Atlas of Living Australia within an approximate 50 km search radius of a central point (-23.45228, 148.49097) to the Project area, accessed 7 August 2018.

4.1.4 Review of Previous Ecological Reports

A review of previous terrestrial ecological studies relevant to the Study Area has been undertaken to identify the terrestrial ecosystems and habitat values including the following:

- Ensham Project: Brigalow Assessment Report (AARC, 2004);
- Ensham Coal Project Final Impact Assessment Study – Volume 1 Impact Assessment Study (Hollingsworth, Dames and Moore, 1996);
- Bio-condition Assessment Report, the Ensham Central Project (ECOSM, 2010);
- Ensham Central Project, Environmental Impact Statement (Hansen Consulting, 2006); and
- Ensham Central Project Supplementary Environmental Impact Statement (Hansen Bailey, 2009).

A review of previous aquatic studies of the Project area (including Hollingsworth, Dames and Moore (1996), Hansen Consulting (2006), Hansen Bailey (2009) and C&R Consulting (2010)) was undertaken to identify the aquatic ecosystems and habitat values within the Study Area. These studies identified aquatic flora and fauna species, groundwater dependent ecosystems and conservation significant species that may utilise these habitats.

The results of these ecological studies are described in more detail in Section 7.0.
Ecological assessments were also reviewed from nearby mine sites within the Study Area. These reports present field verified records of threatened communities and species for the Study Area. This information can provide an indication of what may be present in the Project area where similar habitats may occur. Publicly available information from the following sites was incorporated into the literature review of this report:

- Curragh North (formerly Pisces) Coal Project EIS Assessment (EPA, 2004);
- Central Northern Extension – Jellinbah Coal Mine, Environmental Authority Amendment – Supporting Information (AARC, 2015);
- EIS Report under the *Environmental Protection Act 1994*, Minyango Project- Blackwater Coal Pty Ltd (State-wide Environmental Assessments, DEHP, 2014); and

### 4.1.5 Likelihood of Threatened Species (Terrestrial and Aquatic) Occurrence

Based upon the analysis of habitats, records and species utilisation of particular habitats, species were assigned to one of the following categories:

- **Known to Occur**: this category includes all species or communities previously recorded on the Project area;
- **Potential to Occur**: this category includes species or communities previously recorded in proximity to the Project area, and which have potential habitat features available on site which may support the species; and
- **Unlikely to Occur**: this category includes those species for which the Project offers limited or no potential habitat, is outside their known range and/or is without broader habitat requirements.

### 4.1.6 Consideration of Survey Guidelines

The species identified as having potential to occur were also used for context for recommended survey requirements to satisfy Commonwealth and State regulations. When making recommendations regarding the scale and extent of additional survey, applicable guidelines relating to survey methodology were referred to where relevant. These guidelines are listed as follows:

- Survey guidelines for Australia’s threatened reptiles - Guidelines for detecting reptiles listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, Water, Heritage and the Arts (DEWHA), 2011a);
- Guidelines for detecting birds listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (DEWHA 2010a);
- Guidelines for detecting bats listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (DEWHA, 2010b);
- Guidelines for detecting mammals listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (DEWHA, 2011b);
- Flora Survey Guidelines – Protected Plants (DES, 2014);
- Terrestrial Vertebrate Fauna Survey Guidelines (DSITIA, 2014);
• Environmental Assessment Guideline No. 12 Consideration of Subterranean Fauna in Environmental Impact Assessment in WA (Environmental Protection Authority, 2013);

• Guideline for the Environmental Assessment of Subterranean Aquatic Fauna (DSITIA 2014);

• Australia-Wide Assessment of River Health: Queensland AusRivAS Sampling and Processing Manual, Monitoring River Heath Initiative Technical Report No 12 (DNRM, 2002); and

• Rapid assessment of rivers using macroinvertebrates: A procedure based on habitat-specific sampling, family level identification and a biotic index (Chessman, 1995).

4.2 Gap Analysis Methodology

The gap analysis utilised the results of the baseline ecological environmental assessment (provided in Section 7.0), as follows:

• An assessment was made of the suitability of the previous ecological surveys and assessments in the context of the three Options. The review considered the scope, seasonal considerations, accuracy/reliability, level of detail, and currency of the historical survey data and/or assessment results, as well as whether methods employed in the past meet current requirements;

• A review of ecological and environmental reports held by Ensham as well as databases held by the Commonwealth and State governments were interrogated to augment existing data sources;

• A description of any further ecological studies or data collection activities that will be required to meet the objectives of the RVP has been prepared in Section 10.0 of this report. This step considered the Project area and project footprints of each of the options. This step also considered processes or activities proposed as part of the options that have the potential to impact ecological values; and

• Further, an assessment has been made on the required survey levels for any subsequent approvals. This involved provision of advice on the likely level of survey effort (i.e. man hours, and recommended methods etc.) required to satisfy the requirements of an impact assessment under the EPBC Act or state government approvals for the Project area. This advice includes:
  o Recommended survey effort and duration;
  o Recommended season(s) for survey or if multiple seasons or years are required;
  o Consideration of Survey Guidelines; and
  o For each Option, comment on any survey schedule limitations in the context of reporting requirements for regulators.

4.3 Impact Assessment Considerations

The impact assessment utilised the information collated from the Baseline Ecological components of this report and other relevant technical studies prepared for Stage 3 (described in Section 6.0). Key project assumptions (provided by Ensham) are outlined in Section 1.0. These assumptions have been considered in this impact assessment and include:

• A focus on post relinquishment for impact assessment (at which time it is assumed all landforms will have been rehabilitated to a safe, stable and non-polluting condition).
• Each Option will not extend the footprint beyond that currently approved, except potentially Option 1 if the levee regrade on the river side extends into the riparian area; and specifically with Option 2, where intake structures will be constructed within the riparian areas to allow harvesting of high flow event waters via the pipeline to the Weemah Channel.

• A high level assessment only of the proposed pipeline connecting the RVP to the Weemah Channel. Detailed assessment will be undertaken of this Option 2: FMBU component, should Option 2 be ultimately selected.

The results of the Stage 3 technical studies including hydrology, water quality, geochemistry, civil design and landform design have been considered in this assessment where relevant, and appropriate management strategies have been provided. The risk of environmental harm and management strategies are identified within this Stage 3 Ecology report. The intensity, duration, and cumulative effect were considerations in determining the significance of the impacts.
5.0 Legislative Review Results

5.1 Review of Ecological Legislation and Policy

Table 5.1 and Table 5.2 identify Commonwealth, State and Local Government ecological legislation and policies that are potentially relevant to the RVP.

Table 5.1 Review of Applicable Ecological Legislation

<table>
<thead>
<tr>
<th>Legislation</th>
<th>Summary of Requirements</th>
<th>Relevant criteria for identification of Environmental Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Commonwealth</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environment Protection and Biodiversity</td>
<td>Provides regulatory mechanisms for the protection of MNES.</td>
<td>Protected matter search tool used to identify potential Matters of National Environmental Significance.</td>
</tr>
<tr>
<td>Conservation Act 1999 (EPBC Act)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning Act 2016</td>
<td>The Planning Act 2016 establishes a state wide, applicant driven development assessment system, by which local governments (and state agencies in particular circumstances) assess and make decisions on the various land-use and development proposals the public propose.</td>
<td>The Planning Act applies to activities outside the Mining Lease.</td>
</tr>
<tr>
<td>Mineral Resources Act 1989</td>
<td>Provides for the assessment, development and utilisation of mineral resources to the maximum extent possible under primary consideration of sound economics, and land use management.</td>
<td>The environmental effects of mining activities are regulated under an environmental authority under the Environmental Protection Act 1994.</td>
</tr>
<tr>
<td>Environmental Protection Act 1994 and</td>
<td>This Act and Regulation set out the environmental approval process for mining activities in Queensland and provides the framework for administering the process of granting an Environmental Authority for Environmentally Relevant Activities.</td>
<td>An amendment to the existing Ensham EA may be sought.</td>
</tr>
<tr>
<td>Environmental Protection Regulation 2008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Act 2000</td>
<td>The project is located within the Fitzroy River catchment and subject to the Water Resource (Fitzroy Basin) Plan 2011 (Fitzroy WRP) and its implementation tool, the Fitzroy Basin Resource Operations Plan (January 2004, amended October 2011). The Fitzroy WRP regulates the taking of overland flow water from the Fitzroy Basin.</td>
<td>Riverine Protection Permit Exemption Requirements set out criteria that must be met for filling or excavation in a watercourse, other than in accordance with a Riverine Protection Permit.</td>
</tr>
<tr>
<td>Legislation</td>
<td>Summary of Requirements</td>
<td>Relevant criteria for identification of Environmental Values</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Fisheries Act 1994</strong></td>
<td>Provides for the use, conservation and enhancement of the community’s fisheries resources and fish habitat by providing for, amongst other things, the protection of fish habitats.</td>
<td>No fish habitat as identified in this Act occurs on or adjacent to the Project area. Refer to Guide for determination of waterways using the spatial data layer Qld Waterways for waterway barrier works.</td>
</tr>
<tr>
<td><strong>Nature Conservation Act 1992 and Nature Conservation (Wildlife Management) Regulation 2006</strong></td>
<td>The NC Act deals with the legal status and management of listed threatened flora and fauna species identified under the Nature Conservation (Wildlife Regulation 2006). It prohibits the destruction or removal, unless authorised, of listed threatened flora and fauna species.</td>
<td>Protected flora and fauna are identified under the Nature Conservation (Wildlife) Regulation. A ‘Flora Survey Trigger Map for Clearing Protected Plants in Queensland’ identifies high risk areas where plants that are endangered, vulnerable or near threatened wildlife are present or are likely to be present.</td>
</tr>
<tr>
<td><strong>Vegetation Management Act 1999</strong></td>
<td>In determining MSES, Biodiversity Status as contained within the mapping prepared for the Vegetation Management Act 1999 is relevant to assessments under the Environmental Protection Act 1994.</td>
<td>The regional ecosystem description database identifies regional ecosystems and their conservation status.</td>
</tr>
<tr>
<td><strong>Environmental Offsets Act 2014</strong></td>
<td>Under the Environmental Offsets Act 2014 an environmental offset is defined as an activity undertaken to counterbalance a significant residual impact of a prescribed activity on a prescribed environmental matter.</td>
<td>Following approval of the final design of the selected option, an assessment will be required to determine if there is, or the scale of, any significant residual impact on any MSES.</td>
</tr>
<tr>
<td><strong>Biosecurity Act 2014</strong></td>
<td>The Act provides comprehensive biosecurity measures to safeguard the Queensland economy, its agricultural and tourism industries, its environment and way of life, from pests, diseases and contaminants.</td>
<td>The RVP will consider relevant measures to remove, control and limit the spread of pests and diseases.</td>
</tr>
<tr>
<td><strong>Central Highlands Regional Council</strong></td>
<td><strong>Biodiversity Overlay Code</strong></td>
<td>Identifies regional planning consideration including MSES.</td>
</tr>
</tbody>
</table>
## Table 5.2 Review of Applicable Ecological Policy

<table>
<thead>
<tr>
<th>Policy</th>
<th>Summary of Requirements</th>
<th>Implication for RVP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Commonwealth Survey Guidelines</strong></td>
<td>Provides Commonwealth standards for the ecological survey of threatened flora, fauna and ecological communities.</td>
<td>Any required future flora or fauna surveys should comply with minimum standards of these guidelines.</td>
</tr>
<tr>
<td><strong>State Survey Guideline</strong></td>
<td>Provides standards for the ecological survey of flora and fauna species.</td>
<td>Any required future flora or fauna surveys should comply with minimum standards of this guideline.</td>
</tr>
<tr>
<td><strong>Environmental Protection Policy (Water)</strong></td>
<td>The quality of natural waters in Queensland (e.g. water in rivers, creeks, wetlands, lakes, estuaries and coastal areas and ground waters) are protected under the <em>Environmental Protection (Water) Policy 2009</em> (EPP (Water)). The EPP (Water) achieves the object of the <em>Environmental Protection Act 1994</em> to protect Queensland’s waters while supporting ecologically sustainable development.</td>
<td>Table 1 of the Policy and the accompanying plans WQ1302 and WQ1303 outline the EVs for waters in the Nogoa River Sub-basin. These are based on stakeholder consultations undertaken by the Department and the Fitzroy Basin Association to identify EVs and Water Quality Objectives (WQOs) in the Fitzroy Basin. Consultation results are reported in Fitzroy Basin Association Inc. (2011) Environmental values for the Fitzroy: community consultation. Final report. July 2011.</td>
</tr>
<tr>
<td><strong>Wetlands</strong></td>
<td>Natural wetlands including wetlands of high ecological significance and general ecological significance and RES consistent with wetlands. Referable wetlands under the <em>Environmental Protection Regulation 2008</em> were also reviewed.</td>
<td>No wetlands of High Ecological Significance or General Ecological Significance occur on or in the vicinity of the Project area. Riverine wetlands (i.e. RE 11.3.25e) occur within the Project area and within downstream environments of the Nogoa River.</td>
</tr>
<tr>
<td><strong>Central Highlands Regional Council Biosecurity Plan 2017-2022.</strong></td>
<td>The Central Highlands Regional Council local government Biosecurity Plan 2017-2020 has been developed in accordance with the Queensland State Government’s requirements under the <em>Biosecurity Act 2014</em>.</td>
<td>Provides listings of priority weed and pest species known to occur in the local government area within which the Project area occurs.</td>
</tr>
</tbody>
</table>

---

*Note: The table above provides a review of applicable ecological policies and their implications for the Review of Viable Population (RVP) without specific mention of the project area or the Nogoa River Sub-basin.*
6.0 Summary of Other Relevant Stage 3 Technical Findings

The following technical reports prepared for the Stage 3 Preferred Options were reviewed and relevant findings considered in the development of the ecological baseline (provided in Section 7.0) and impact assessment (provided in Section 10.0).

6.1 Stage 3 Catchment Hydrology and Flood Modelling (HEC, 2018b)

This report was prepared by HEC (2018b) to determine the extent of flooding with respect to each Preferred Option. The flood modelling results provided in this report concluded the following:

- Option 1 is considered unlikely to result in any changes to the current flooding regime.
- Option 2 is expected to present a minor drop in flooding downstream of the Project area and will result in a decrease of up to 0.3 m in flood heights upstream when compared to the current flooding regime.
- Option 3 will result in the greatest changes, with a significant reduction in upstream flood heights, and a minor increase in flood heights downstream. There are not expected to be any significant terrestrial or aquatic ecosystem impacts associated with these minor changes in periodic flood heights associated with this option.

With respect to this ecology assessment, the potential for changes in flood heights as presented above are not expected to lead to changes in vegetation distribution within the Project area or more broadly in the locality.

6.2 Stage 3 Material Characterisation for the Ensham Final Void Plan (RGS, 2018)

The report prepared by RGS (2018) assessed the potential for acid and metalliferous mine drainage and also saline drainage potential. The report found that the risk of the Project area experiencing any acid drainage issues, or elevated concentrations of metals/metalloids in surface water and groundwater resources, was considered low. The report did identify that elevated salinity from the groundwater and leachates from the spoils will be a key issue that may require management.

With respect to ecological values, the work undertaken by RGS (2018) suggests that salinity within the voids will be a significant constraint for all three Options. Option 1 and Option 3 will have void waters that will progressively increase in salinity through evapo-concentration and the release of salts from the surrounding rehabilitated overburden. This ingress and concentration of salt may limit aquatic life within these pits to those tolerant and capable of living within highly saline waters, and may limit the use of the pit water by terrestrial species to highly transient fauna such as birds, that may wade within the waterbodies rather than consume the water or biota within. The water management associated with Option 2 suggests that the waterbodies have potential to provide a more diverse array of habitats for both terrestrial and aquatic species, as the water quality will generally be of better quality when compared to the other options as water from the Weemah Channel will be mixed with void waters to manage salinity and toxicant concentrations. Further to this, the capture of flood waters in the voids will primarily dilute levels of salinity and other contaminant levels but will also prevent ingress of groundwater into the voids as the pressure of water in the voids will balance with the groundwater inflow, periodically reducing the saline groundwater inflows into the voids.
6.3 Stage 3 Geomorphic Assessment Ensham Mine Residual Void Study (WRM, 2018)

WRM (2018) prepared a geomorphic assessment of the waterways and floodplains within the Project area. The report noted there would be no material difference in velocities and shear stresses experienced along the river channels or the floodplain between the three options.

WRM (2018) noted for Option 3 that low velocity zones are expected across the surface of the infilled voids, suggesting these landforms will be stable in the short to medium term with potentially some sediment deposition occurring during moderate flood events.

The report concluded that all three options are unlikely to significantly alter the geomorphology of the Nogoa River or its Anabranch. Therefore, with respect to ecological values, the risk of geomorphological changes impacting terrestrial and aquatic habitats is considered low.

6.4 Stage 3 Residual Void Project - Groundwater Assessment (HS, 2018c)

HS (2018c) undertook an assessment of groundwater drawdown potential for each of the three options. HS predicted that drawdown in most riverine alluvium would be negligible, and consequently drawdown would have a negligible effect on river-aquifer interaction in general.

With respect to this ecological assessment, it is anticipated that the eventual groundwater recharge is not expected to have detrimental consequences on ecological EVs.

6.5 Stage 3 Void Water Quantity and Quality Balance Technical Report (HEC, 2018c)

HEC (2018c) undertook an assessment of the predicted void water quality and balance for each of the three options, based on nine model scenarios. For Options 1 and 3, there will be no exchange of water between the voids and the river and consequently no potential for impacts on downstream environmental values. For Option 2: FMBU, there is the potential for some interaction between river water and the voids during a significant flood event, if the flood is large enough to fill the voids over the expected 60 year life of the scheme.

Dilution calculations undertaken by HEC (2018c) for backflow from the voids to the river immediately after a peak flow event show that for between 92% and 95% of the time backflow is occurring, the estimated Nogoa River TDS downstream of the voids would be equal to the adopted background TDS of 115 mg/L as contained within the Environmental Approval for the Mine site. Modelling prepared by HEC (2018c) indicates that TDS does not exceed 250 mg/L in these peak flow events. Therefore, impacts from the released water are expected to be minimal.

An assessment of the quality of void water with respect to aquatic values was therefore undertaken for Option 2 using the data provided by HEC (2018c). The Environmental Protection (Water) Policy 2009 Nogoa River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Nogoa River Sub-basin (Queensland Government, 2013) specifies Water Quality Objectives (WQOs) for each EV for a specific water area and/or type, such as sub-basins.

The potential occurrence of Arsenic (As), Molybdenum (Mo) and Selenium (Se) were modelled by HEC (2018c) to determine their potential concentrations, given these trace elements are known to bioaccumulate if their concentrations are high. It should be noted that Selenium is an important micronutrient for plant and animal cell growth, but only in very small concentrations. The trigger values
within the ANZG (2018) for aquatic ecosystems (i.e. to avoid bioaccumulation, or known toxicity to any organism) are as follows:

- **Arsenic**: A freshwater trigger value of 0.013 mg/L;
- **Molybdenum**: A freshwater trigger value of 0.034 mg/L; and
- **Selenium (total)**: A freshwater trigger value of 0.005 mg/L.

For Option 2, no water will be operationally released back to the Nogoa River. All beneficial use waters will be pumped to irrigation channels for distribution. There is potential during high flow events for some exchange of floodwaters to occur with void waters from Pit B and Pit C via the intake structures if the flood is large enough to fill the voids. Due to the pits holding largely river water from the flood event during the filling period of the high flow event, and the resultant dilution caused by these floodwaters, there is expected to be minimal impact to the water quality of the Nogoa River.

Simulated water quality for Pit B and Pit C indicate that where this exchange could potentially occur, the water quality values for Arsenic, Molybdenum and Selenium are below than the ANZECC Water Quality Guidelines for aquatic ecosystems, further reinforcing that there is unlikely to be impacts on downstream ecosystems during this type of event.

The median simulated values for salinity within Pit B and Pits C/D range between 252 µS/cm and 262 µS/cm over the 129 year model period. This represents the low salinity class as identified within the *Environmental Protection (Water) Policy 2009 Nogoa River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Nogoa River Sub-basin* (Queensland Government, 2013).

The objectives for irrigation water quality for Arsenic, Molybdenum and Selenium are shown in **Table 6.1**. In order to comply with the aquatic ecosystem guidelines, water released for irrigation through implementation of Option 2: FMBU are recommended to be below the values shown in **Table 6.1** for those metals/metalloids. Acceptable salinity levels for irrigation water vary based on irrigation water quality, soil properties, plant salt tolerance, climate, landscape, as well as water and soil management (ANZECC). General salinity classes for irrigation water are shown in **Table 6.2**.

With respect to aquatic ecosystems, a trigger value of 250 (mg/L) Total Dissolved Solids (TDS) has been identified under the *Environmental Protection (Water) Policy 2009 Nogoa River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Nogoa River Sub-basin* (Queensland Government, 2013). As shown in **Table 6.3** and **Table 6.4**, the simulated median TDS levels range between 252 mg/L and 1,093 mg/L. This suggests that the void waters will exceed the trigger value for aquatic systems. It should be noted however that no void waters will be operationally released back to the Nogoa River. There may be some exchange between the Nogoa River and the Pit B and Pit C voids during high flow events, when the voids are full. At this time, it is anticipated that dilution of void water with floodwater will ensure that any impacts from void water entering the Nogoa River are undetectable.

### Table 6.1 Irrigation EV: Water quality objectives for heavy metals and metalloids in agricultural irrigation water (reproduced from Queensland Government 2013)

<table>
<thead>
<tr>
<th>Element</th>
<th>Soil cumulative contaminant loading limit (CCL)(kg/ha)</th>
<th>Long-term trigger value (LTV) in irrigation water (up to 100 years) (mg/L)</th>
<th>Short-term trigger value (STV) in irrigation water (up to 20 years) (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>20</td>
<td>0.1</td>
<td>2.0</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>ND</td>
<td>0.01</td>
<td>0.05</td>
</tr>
<tr>
<td>Selenium</td>
<td>10</td>
<td>0.02</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Table 6.2  Salinity classes for irrigation water (reproduced from Queensland Government 2013)

<table>
<thead>
<tr>
<th>Conductivity (µS/cm)</th>
<th>Salinity class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;650</td>
<td>1 - Low salinity water, suitable for use on all crops except tobacco, with all methods of water application, with little probability of a salinity problem developing.</td>
<td></td>
</tr>
<tr>
<td>650 – 1,300</td>
<td>2 - Medium salinity, suitable for use on all but very low salt tolerance crops. Water can be used if a moderate amount of leaching occurs. Plants with medium salt tolerance can be grown, usually without special practices for salinity control. Sprinkler irrigation with the more saline waters in this group may cause leaf burn on salt-sensitive crops, especially at higher temperatures in the daytime when evaporation may be high.</td>
<td></td>
</tr>
<tr>
<td>1,300 – 3,000</td>
<td>3 - High salinity - suitable for use on medium and high salt tolerant crops only. Water should not be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required.</td>
<td></td>
</tr>
<tr>
<td>3,000 – 5,000</td>
<td>4 - Very high salinity - suitable for use only on high salt tolerant crops. For use soils must be permeable, free draining, and water must be applied in excess to provide considerable leaching.</td>
<td></td>
</tr>
<tr>
<td>5,000 – 8,000</td>
<td>5 - Extremely high salinity generally unsuitable for irrigation unless soils are permeable, well drained and crops are of very high salt tolerance.</td>
<td></td>
</tr>
<tr>
<td>&gt;8,000</td>
<td>6 - Too saline for irrigation</td>
<td></td>
</tr>
</tbody>
</table>

The modelled quality of water in Pit B and Pits C/D is representative of the quality of water that will be distributed for irrigation purposes. The median values of the void waters within Pit B and Pits C/D are presented in Table 6.3 and Table 6.4. Table 6.3 represents the initial development of Option 2 whereby only Pit A and Pit B are utilised for beneficial use. It is expected that Pits C/D and E under this scenario will experience a gradual increase in salinity and metal/metalloid concentrations. Table 6.4 represents the water quality results for the full development of Option 2 (i.e., whereby Pits A, B, C and D are managed and utilised). Generally, the quality of void water to be used for irrigation purposes will not exceed either the short or long term trigger values for irrigation as identified in the Table 6.1 above. This suggests that there should be no impacts on downstream aquatic ecosystems should any irrigation water flow into the Nogoa River or the anabranch.

HEC (2018c) estimates for Option 2 that salinity levels within Pit A will take approximately 7 years (from the commencement of the collection of high flow events) to fall below the irrigation threshold for salinity, and the waters within Pit B will take approximately 1 year to fall below the irrigation salinity threshold. It is anticipated that shandying of water can be undertaken with the Ensham water allocation, and between waters contained within Pits A and B to allow irrigation water to be supplied once the project commences.

Table 6.3  Modelled Water Quality Results for Initial Development of Option 2 (i.e. AB Pits in operation only) for 129 years (Source: HEC, 2018c)

<table>
<thead>
<tr>
<th>Option 2 AB Pits (129 year Model) Run 3</th>
<th>Conductivity (µS/cm)</th>
<th>TDS (mg/L)</th>
<th>As (mg/L)</th>
<th>Mo (mg/L)</th>
<th>Se (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pit A</td>
<td>Max</td>
<td>7,936</td>
<td>5,317</td>
<td>0.035</td>
<td>0.083</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>1,436</td>
<td>962</td>
<td>0.012</td>
<td>0.027</td>
</tr>
<tr>
<td>Pit B</td>
<td>Max</td>
<td>8,090</td>
<td>5,420</td>
<td>0.005</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>391</td>
<td>262</td>
<td>0.004</td>
<td>0.006</td>
</tr>
</tbody>
</table>
### Table 6.4  Modelled Water Quality Results for Full Development of Option 2 (i.e. Pits AB and CD Pits in operation) for 129 Years (Source: HEC, 2018d)

<table>
<thead>
<tr>
<th>Option 2 ABCD Pits (129 year Model) Run 4</th>
<th>Conductivity (µS/cm)</th>
<th>TDS (mg/L)</th>
<th>As (mg/L)</th>
<th>Mo (mg/L)</th>
<th>Se (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pit A</td>
<td>Max</td>
<td>7,903</td>
<td>5,295</td>
<td>0.026</td>
<td>0.067</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>1,631</td>
<td>1,093</td>
<td>0.012</td>
<td>0.024</td>
</tr>
<tr>
<td>Pit B</td>
<td>Max</td>
<td>8,090</td>
<td>5,420</td>
<td>0.005</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>427</td>
<td>286</td>
<td>0.004</td>
<td>0.006</td>
</tr>
<tr>
<td>Pit CD</td>
<td>Max</td>
<td>7,285</td>
<td>4,881</td>
<td>0.004</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>376</td>
<td>252</td>
<td>0.003</td>
<td>0.003</td>
</tr>
<tr>
<td>Pit E</td>
<td>Max</td>
<td>7,591</td>
<td>5,086</td>
<td>0.013</td>
<td>0.043</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>972</td>
<td>651</td>
<td>0.005</td>
<td>0.016</td>
</tr>
</tbody>
</table>
7.0 Ecological Baseline Results

7.1 Vegetation

7.1.1 Protected Matters Search Tool

The Protected Matters Search Tool (PMST) identified four Commonwealth listed Threatened Ecological Communities (TECs) as potentially occurring in the Study Area. These are shown in Table 7.1 below.

Table 7.1 PMST Search Identified Threatened Ecological Communities

<table>
<thead>
<tr>
<th>Name</th>
<th>Status</th>
<th>Type of Presence</th>
<th>Recognised REs consistent with TEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brigalow (<em>Acacia harpophylla</em> dominant and codominant)</td>
<td>Endangered</td>
<td>Community known to occur within area</td>
<td>11.3.1 and 11.4.8</td>
</tr>
<tr>
<td>Natural Grasslands of the Queensland Central Highlands and the northern Fitzroy Basin</td>
<td>Endangered</td>
<td>Community likely to occur within area</td>
<td>None</td>
</tr>
<tr>
<td>Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions</td>
<td>Endangered</td>
<td>Community likely to occur within area</td>
<td>None</td>
</tr>
<tr>
<td>Weeping Myall Woodlands</td>
<td>Endangered</td>
<td>Community likely to occur within area</td>
<td>None</td>
</tr>
</tbody>
</table>

7.1.2 Regional Ecosystem Mapping

A review of the vegetation maps prepared by the Queensland Herbarium (Version 10.1) identified nine Regional Ecosystems as occurring on the Project area with an additional 2 REs occurring adjacent to the Project area. These vegetation units provide a baseline to assess potential disturbance outside of the existing mine footprint. Disturbance areas have been identified as a consequence of the Stage 3 Civil Design (WSP, 2018) investigations.

To create landform stability for the proposed Option 1: LL levees, WSP (2018) has created a landform design that generally extends the levees outwards towards the Nogoa River and the Anabranch for C and D pits respectively to further address the minimisation of erosion. Further to the outward extension of the levee walls, the WSP (2018) landform design also requires levee realignments in two locations where the levees are too close to the void highwalls to achieve long term stability for the levees. Typically, the average outward extension of the levee ranges up to approximately 40 m from the current levee location. Based upon available aerial imagery, this outward extension will result in the clearing of up to 60 ha of non-regulated regrowth/previously disturbed vegetation. The 60 ha disturbance areas comprises extension of levee footprints, and a 10 m buffer from the toe of the proposed levee landforms for construction activities (noting there will be no disturbance to Riparian Regional Ecosystem 11.3.25e) for each levee.

With respect to Option 2, WSP (2018) has also designed two intake structures that will extend from the existing levee walls on Pit B and Pit C to the Nogoa River and the Anabranch respectively. These structures will impact approximately 3 ha of mapped riparian regional ecosystem associated with the Nogoa River and its Anabranch.

Using the identified disturbance areas, specific habitats for conservation significant species that may be impacted by the RVP have also been determined for each Option. The distributions of REs as provided by the Queensland Herbarium (Version 10.1) mapping are shown in Figure 7.1. These are described in Table 7.2, including a short description, biodiversity status, VM Act status, and area within the Project area.
Bio-condition surveys of the vegetation present on the Project area by ECOSM (2010) were used to confirm the identification and distribution of the REs.

It should be noted that the accuracy of this RE mapping was assessed based upon review of previous field surveys undertaken across the Project area (ECOSM, 2010) which indicated that the latest RE Mapping as supplied by the Queensland Herbarium (2017) is sufficiently accurate for the purposes of this Stage 3 assessment. Broad habitat/ecosystem types have been extrapolated from this RE mapping to allow site characterisation with respect to available habitats for threatened species later in this report.
<table>
<thead>
<tr>
<th>RE Code</th>
<th>Short Description</th>
<th>VM Act / BD Status</th>
<th>EPBC Act Status</th>
<th>Vegetation Structure</th>
<th>Broad Habitat</th>
<th>Habitat Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.3.1</td>
<td><em>Acacia harpophylla</em> and/or <em>Casuarina cristata</em> open forest on alluvial plain.</td>
<td>E/E</td>
<td>E</td>
<td>Mid-dense Open Forest</td>
<td>Open Forest</td>
<td>This vegetation represents MNES and MSES and should be avoided wherever practicable.</td>
</tr>
<tr>
<td>-</td>
<td>Mosaic of non-remnant vegetation with un-mapped 11.3.1.</td>
<td>-</td>
<td>-</td>
<td>Mixed structure</td>
<td>Disturbed</td>
<td>Unmapped areas of 11.3.1 may provide habitat for threatened flora species, and hollow bearing trees in this area may provide habitat for threatened fauna species.</td>
</tr>
<tr>
<td>11.3.25 (e)</td>
<td><em>Eucalyptus tereticornis</em> or <em>E. camaldulensis</em> woodland fringing drainage lines.</td>
<td>LC/OC</td>
<td>-</td>
<td>Mid-dense Open Forest</td>
<td>Riparian Wetland</td>
<td>This vegetation may provide habitat for koala, greater glider and various MNES (Migratory Species) and is recognised as a State Biodiversity Corridor under the State Planning Policy. This RE is also mapped as Essential habitat for the NC Act listed Ornamental Snake (<em>Denisonia maculata</em>) by DES.</td>
</tr>
<tr>
<td>11.3.25(e)/11.3.3</td>
<td><em>Eucalyptus tereticornis</em> or <em>E. camaldulensis</em> woodland fringing drainage lines and <em>Eucalyptus coolabah</em> woodland on alluvial plains.</td>
<td>LC/OC</td>
<td>-</td>
<td>Mid-dense Open Forest</td>
<td>Riparian Wetland</td>
<td>This vegetation may provide habitat for koala, greater glider and various MNES (Migratory Species) and is recognised as a State Biodiversity Corridor under the State Planning Policy. This RE is also mapped as Essential habitat for the NC Act listed Ornamental Snake (<em>Denisonia maculata</em>) by DES.</td>
</tr>
<tr>
<td>11.3.9</td>
<td><em>Eucalyptus platyphylla</em>, <em>Corymbia</em> spp. woodland on alluvial plains</td>
<td>LC/NC</td>
<td>-</td>
<td>Sparse Woodland</td>
<td>Woodland</td>
<td>May provide habitat for conservation significant flora and fauna.</td>
</tr>
<tr>
<td>11.4.8</td>
<td><em>Eucalyptus cambageana</em> woodland to open forest with <em>Acacia harpophylla</em> or <em>A. argyrodendron</em> on Cainozoic clay plains.</td>
<td>E/E</td>
<td>E</td>
<td>Mid-dense Woodland to Open Forest</td>
<td>Wetland</td>
<td>This vegetation represents a MSES and provides habitat for Ornamental Snake and various MNES (Migratory Species).</td>
</tr>
<tr>
<td>RE Code</td>
<td>Short Description</td>
<td>Conservation Significance</td>
<td>Vegetation Structure</td>
<td>Broad Habitat</td>
<td>Habitat Value</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------------</td>
<td>---------------------------</td>
<td>---------------------</td>
<td>--------------</td>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td>11.5.3</td>
<td><em>Eucalyptus populnea</em> +/- <em>E. melanophloia</em> +/- <em>Corymbia clarksoniana</em> woodland on Cainozoic sand plains and/or remnant surfaces</td>
<td>LC/NC</td>
<td>Sparse Woodland</td>
<td>Woodland</td>
<td>May provide habitat for conservation significant flora and fauna.</td>
<td></td>
</tr>
<tr>
<td>11.5.9b</td>
<td><em>Eucalyptus crebra</em>, <em>E. tenuipes</em>, <em>Lysicarpus angustifolius</em> +/- <em>Corymbia spp.</em> woodland on Cainozoic sand plains and/or remnant surfaces</td>
<td>LC/NC</td>
<td>Sparse Woodland</td>
<td>Woodland</td>
<td>May provide habitat for conservation significant flora and fauna.</td>
<td></td>
</tr>
<tr>
<td>11.7.2</td>
<td><em>Acacia</em> spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone.</td>
<td>LC/NC</td>
<td>Sparse Woodland</td>
<td>Woodland</td>
<td>May provide habitat for conservation significant flora and fauna.</td>
<td></td>
</tr>
<tr>
<td>11.7.4</td>
<td><em>Eucalyptus decorticans</em> and/or <em>Eucalyptus spp.</em>, <em>Corymbia spp.</em>, <em>Acacia spp.</em>, <em>Lysicarpus angustifolius</em> woodland on Cainozoic lateritic duricrust.</td>
<td>LC/NC</td>
<td>Mid-dense Woodland</td>
<td>Woodland</td>
<td>May provide habitat for conservation significant flora and fauna.</td>
<td></td>
</tr>
<tr>
<td>11.7.1/11.7.2</td>
<td><em>Acacia harpophylla</em> and/or <em>Casuarina cristata</em> and <em>Eucalyptus thozetiana</em> or <em>E. microcarpa</em> woodland on lower scarp slopes on Cainozoic lateritic duricrust and <em>Acacia</em> spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone.</td>
<td>LC/OC (d)</td>
<td>Mid-dense Woodland</td>
<td>Woodland</td>
<td>This vegetation represents a MSES and should be avoided where practicable.</td>
<td></td>
</tr>
<tr>
<td>11.7.2/11.7.1</td>
<td><em>Acacia</em> spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone and <em>Acacia harpophylla</em> and/or <em>Casuarina cristata</em> and <em>Eucalyptus thozetiana</em> or <em>E. microcarpa</em> woodland on lower scarp slopes on Cainozoic lateritic duricrust.</td>
<td>LC/OC (sd)</td>
<td>Mid-dense Woodland</td>
<td>Woodland</td>
<td>This vegetation represents a MSES and should be avoided where practicable.</td>
<td></td>
</tr>
</tbody>
</table>

Note: E – Endangered for both EPBC Act and VM Act; OC – Of Concern (Biodiversity Status); LC – Least Concern (VM Status); NC – No Concern (Biodiversity Status) under the VM Act; d – dominant where two or more communities are mapped as one polygon and the OC RE is dominant, sd – subdominant were two or more communities are mapped as one polygon.
7.2 Habitats Present within the Project Area

7.2.1 Terrestrial Habitats

The following broad terrestrial habitats were identified from the RE mapping for the Project area and locality including:

- Riparian wetlands consisting of RE 11.3.25(e), 11.3.3, and 11.4.8;
- Woodland consisting of RE 11.3.9, 11.5.3, 11.5.9, 11.7.1, 11.7.2 and 11.7.4;
- Open Forest of RE 11.3.1; and
- Disturbed Lands/Pasture/Cropping/Rehabilitation.

These areas are shown in Figure 7.2.

7.2.2 Aquatic Habitats

The Project Area is traversed by a number of watercourses that drain from north to south into the Nogoa River (Figure 2.1). The major watercourses within the current receiving environment of the Project Area include:

- Boggy Creek;
- Corkscrew Creek;
- Sandhurst Creek;
- Nogoa River (and its anabranch); and
- Mackenzie River.

A diversion has been built along Boggy Creek to permanently divert flows around the Ensham Mine footprint. Boggy Creek skirts the Ensham Mine to the north, before discharging into the Nogoa River south of the Ensham Mine.

Boggy Creek is considered to be ephemeral; however several waterholes persist throughout much of the year. The portions of the Nogoa and Mackenzie Rivers as shown in Figure 2.1 is are considered perennial, largely as a result of regulated releases from Fairbairn Dam, though contain little flow during the dry season. A number of mine water bodies are present, together with a number of farm dams within the Project area.

The habitats associated with the Nogoa River, the anabranch and the A Pit water body are described in more detail in the following sections.

7.2.2.1 Nogoa River (Main channel)

The aquatic habitat assessments undertaken for the Ensham Central Project area as reported by Hansen Consulting (2006) found that the main channel of the Nogoa River is characterised by muddy banks and silted substrate with no riffle zones. The banks are generally steep with very little macrophyte growth.

At the time of the field surveys for the 2006 assessment, the water was found to be turbid due to the high sediment loads from surrounding land uses. While a number of quiet backwater areas were present adjacent to fallen trees and sediment mounds, the river within the Project area was typified by a fast-flowing current for much of the year due to the regulated releases from the Fairbairn Dam. It was considered that these releases have created an environment which would ordinarily occur much less frequently (e.g. during storm events).
Work undertaken in the initial REMP prepared by 4T Consulting (2012) found the channel diversity is either low or very low in the Comet – Nogoa systems, and runs were the most common habitat type, followed by pools. There are few rapids but a number of riffles exist at Riley’s Crossing which is on the Mackenzie River downstream from Ensham (4T Consulting, 2012). There are few backwaters or glides and substrates were found to consist most typically of sand with some gravelly and/or rocky sections where flow velocities are greater. Hydrobiology (2015) installed a monitoring site in a riffle section at Riley’s Crossing downstream of the Ensham Mine Project site to obtain a representative sample of this riffle.

During the aquatic habitat assessments undertaken for the Ensham Central Project, Hansen Consulting (2006) identified that there were no aquatic flora species recorded in the deeper, free-flowing sections of the Nogoa River. It was considered highly likely however that native Water Ribbonweed species such as Vallisneria spp. and Aponogeton elongatus were present. These aquatic plants would provide important habitat for native invertebrate and fish species and other aquatic fauna such as the identified threatened turtle species.

7.2.2.2 Nogoa River Anabranch

The anabranch was described by Hansen Consulting (2006) as being characterised by muddy banks and a silted substrate. Waterholes generally had steep banks with very little macrophyte growth. Unlike the main channel, the aquatic environment of the anabranch comprised was found to contain a single water hole approximately 100 m long. This water hole was showing signs of eutrophication and was covered by green algae. Hansen Consulting (2006) described these conditions as being typical of a system which is subject to hot dry conditions for much of the year and that no longer receives flood overflows from the Nogoa River on a regular basis due to the presence of Fairbairn Dam.

7.2.2.3 Aquatic Fauna and Habitats of the Pits

With respect to aquatic fauna and habitats, C&R Consulting (2010) undertook an assessment of pit waters on aquatic fauna, specifically fauna present within A Pit. The key findings of this assessment were:

- the water quality encountered within A Pit at the time of survey was impacted by salinity (electrical conductivity measurements ranged between 6,892 µS/cm to 8,131 µS/cm between 0.2 to 3 m depth respectively), but all metal toxicant concentrations were below ANZECC Guidelines (2000) for aquatic ecosystems;
- A Pit, at the time of survey had a relatively species-rich fish population, 11 species from six different families having been observed and/or caught. This compares favourably with the 16 species from nine different families that had been recorded in the Nogoa River adjacent to the mine site at the time of this survey;
- at the time of survey, all fish species caught were in good condition, with some exhibiting breeding potential; and
- the macroinvertebrate assemblage present within A Pit was species poor. According to C&R Consulting (2010), this is commonly encountered in highly disturbed, artificial systems.

This report found that fish species are able to survive in the voids for prolonged periods (approximately three years) following high flow events such as those that occurred in 2008. Based upon the work undertaken by C&R Consulting (2010), it appears that with appropriate ingress of fresh water at suitable ratios, the longevity of fish species can continue for extended periods within voids.
7.3 Biodiversity

7.3.1 Flora of the Study Area

In total 918 species of plant from 111 families have been recorded within the Wildlife Online Database (DES, 2018) within 50 km of the Project area. The dominant families consist of Poaceae (178 species), Asteraceae (51 species), Myrtaceae (47 species), Fabaceae (47 species), Malvaceae (46 species), and Chenopodiaceae (32 species). There are 110 species of introduced flora identified within the Study Area.

Due to the high levels of clearing for agricultural purposes throughout the Nogoa River systems, there has been a substantial decline in the occurrence of native vegetation in much of the floodplain areas. According to Pre-European Regional Ecosystem mapping (Queensland Herbarium, 2017), prior to European settlement, the Study Area would have been dominated by woodland and open forest communities.

7.3.2 Fauna of the Study Area

482 species of fauna have been recorded within the Wildlife Online database (DES, 2018) within 50 km of the Project area. These species consist of 67 species of mammal from 21 families, 99 species of reptile from 12 families, 253 species of bird from 14 families, 14 species of insect from 3 families, 22 species of amphibians from 4 families, and 27 species of ray-finned fish from 16 families. Of these species the following numbers of introduced species have been recorded:

- Amphibians: 1 species;
- Mammals: 10 species;
- Reptiles: 1 species; and
- Birds: 5 species.

7.4 Threatened Species

7.4.1 Terrestrial Flora and Fauna

Results from the review of the Commonwealth’s Protected Matters Search Tool, DES Wildlife Online Database and review of other available sources of data including reports from adjacent mine sites are presented in this section. Table 7.3 and Table 7.4 present the consolidated data of the flora and fauna species of conservation significance respectively known or expected to occur within the Study Area.

The species identified in Table 7.3 and Table 7.4 were then used in the risk assessments prepared in Appendix A and Appendix B to determine the likelihood of occurrence of the threatened flora and fauna species within the Project area, in accordance with the methodology described in Section 4.1.

While the shrub *Cerbera dumicola* is known to occur on the Project area, this species appears confined to the central western sections of the Project area (Figure 7.3), and as such is not considered likely to be impacted by the RVP. Due to the potential presence of the grass *Dichanthium queenslandicum* and the tree *Acacia spania* in proximity to the RVP, and the presence of suitable habitat on the Project area for these species, it is recommended that targeted surveys be undertaken in vegetation communities present on the Project area if potential habitat areas shown in Figure 7.3 are proposed to be disturbed as a result of the RVP. Any disturbance outside of the existing operational footprint would require field surveys to determine if these species will be impacted. Figure 7.3 identifies the location of known habitat for the *Cerbera dumicola* and the potential habitats for *Dichanthium queenslandicum* and *Acacia spania* present within the Project area.
Table 7.5 identifies the threatened fauna species known or expected to occur within the Project area. The Stage 3 Geotechnical investigation has identified that minor changes to the alignment of levees associated with Option 1: LL and Option 2: FMBU will be required. Targeted surveys will be required to be undertaken in accordance with Commonwealth and State Survey Guidelines to ensure impacts on threatened species and their habitats can be avoided where possible. This may involve minor modifications to the alignment or design of levees to potentially reduce the impact on threatened species or their habitats where they are identified. If significant impacts are identified and are unavoidable, appropriate mitigation measures such as relocation of individuals or establishing compensatory habitat components may be considered, and will be determined as part of the Stage 5 regulatory approval process, and prior to any disturbance.

7.4.2 Aquatic Threatened Flora and Fauna

No threatened aquatic flora species were identified during the literature review component of this analysis as occurring on or adjacent to (within 10 km) the Project area.

No threatened insect or fish species were identified during the literature review process as occurring on or adjacent to (within 10 km) the Project area.

Two aquatic reptile species consisting of the Fitzroy River Turtle (*Rheodytes leukops*) and the Southern Snapping Turtle (*Elseya albagula*) were however identified as having potential to occur within the Project area and associated locality (refer to Appendix B).

7.4.2.1 Fitzroy River Turtle

The Fitzroy River Turtle was first described in 1980 and is only found in the Fitzroy River and its tributaries, around Rockhampton in eastern central Queensland. The species occurs within permanent freshwater riverine reaches and large, isolated permanent waterholes. The Fitzroy Turtle River is known to feed on the larvae of aquatic insects, sponges and ribbon weed (Limpus *et al.*, 2011).

The breeding season is from September to November. Females excavate a nest in the sand or gravel riverbank during the night and lay approximately 20 eggs in each of one or more clutches, each egg approximately 29 mm long and 21 mm wide. The eggs take about 47 days to hatch (at 30 degrees Celsius) (Limpus *et al.*, 2011).

The Fitzroy River Turtle is sometimes called a "bottom-breathing turtle" due to its highly unusual ability of absorbing oxygen under water through gills in their cloaca (the single opening under the tail used for passing of waste and reproductive material). This enables them to spend virtually all of their time under water and not surface for days in cool running water (Limpus *et al.*, 2011).

This species is known to occur within the Nogoa River.

7.4.2.2 Southern Snapping Turtle

The Southern Snapping Turtle is only found in the Burnett, Fitzroy, Raglan and Mary River drainages of south-east Queensland. It prefers permanent flowing water habitats where there are suitable shelters and refuges (e.g. fallen trees) (Hamman *et al.*, 2007).

The timing of breeding varies between locations with most breeding occurring during autumn and winter. Most turtles lay one clutch per year (average 13 eggs), digging a shallow nest in a sloping river bank. Hatchlings emerge in December or January after an incubation period of around 24 weeks. These turtles may not breed in a year when food is scarce (Hamman *et al.*, 2007).
The Southern Snapping Turtle is mainly a herbivore, eating a range of aquatic plants. Its diet also includes fallen fruit (e.g. native figs) and occasionally aquatic insects, molluscs (e.g. snails) and even small cane toads (Hamman et al., 2007). This species is known to occur within the Nogoa River with this River system representing Essential habitat for this species downstream of the Project area.
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>King Blue-grass</td>
<td><em>Dichanthium queenslandicum</em></td>
<td>E</td>
<td>V</td>
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<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
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<td>Blue-grass</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td><em>Aristida annua</em></td>
<td>V</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>DD</td>
</tr>
<tr>
<td></td>
<td><em>Bertya opponens</em></td>
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<td></td>
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<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
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<td></td>
<td><em>Solanum elachophyllum</em></td>
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<td>-</td>
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</tr>
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<td>-</td>
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</tr>
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<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td><em>Cerbera dumincola</em></td>
<td>-</td>
<td>NT</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td><em>Acacia spania</em></td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Low</td>
</tr>
</tbody>
</table>

Note: V - Vulnerable under the EPBC Act and the NC Act; E – Endangered under the EPBC Act and the NC Act; NT – Near Threatened under the NC Act; DD – Data Deficient Species
## Table 7.4 Threatened Fauna Recorded from within the Study Area

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>EPBC Act Status</th>
<th>NC Act Status</th>
<th>PMST</th>
<th>Wildlife Online</th>
<th>Enrahm Central EIS 2006</th>
<th>Blackwater Mine Site</th>
<th>Curragh Mine Site</th>
<th>Jellinbah Coal Mine</th>
<th>Kestrel Mine Site</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Curlew Sandpiper</td>
<td><em>Calidris ferruginea</em></td>
<td>CE, MiW</td>
<td>E</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Common Sandpiper</td>
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<td>MiW</td>
<td>SL</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Sharp-tailed Sandpiper</td>
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<td>SL</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>-</td>
<td>-</td>
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</tr>
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<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Marsh Sandpiper</td>
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<td>-</td>
<td>-</td>
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</tr>
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<td>Little Whimbrel</td>
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<td>SL</td>
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<td>-</td>
<td>-</td>
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</tr>
<tr>
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<td>SL</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Red Goshawk</td>
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</tr>
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<td>✓</td>
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<td>Painted Honeyleater</td>
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</tr>
<tr>
<td>Star Finch</td>
<td><em>Neochima ruficauda ruficauda</em></td>
<td>E</td>
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<td>-</td>
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<td>Eastern Curlew</td>
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<td>E</td>
<td>-</td>
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<td>-</td>
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</tr>
<tr>
<td>Southern Black-Throated Finch</td>
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<td>E</td>
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<td>Scientific Name</td>
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<td>NC Act Status</td>
<td>PMST</td>
<td>Wildlife Online</td>
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<td>Coal Mine Site</td>
<td>Mine Site</td>
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<tr>
<td>Australian Painted Snipe</td>
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<td>-</td>
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<td>-</td>
<td>-</td>
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<td>Medium</td>
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</tr>
<tr>
<td>Fork-tailed Swift</td>
<td><em>Apus pacificus</em></td>
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<td>SL</td>
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<td>-</td>
<td>-</td>
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<td>Horsfield’s Cuckoo</td>
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<td>SL</td>
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<tr>
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<td>-</td>
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<td>White-throated Needletail</td>
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<td>-</td>
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<td>Satin Flycatcher</td>
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<td>-</td>
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<td>E</td>
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<td>✓</td>
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</table>

Note: MiT – Migratory Terrestrial under EPBC Act, MiW – Migratory Wetland under EPBC Act, V– Vulnerable under the EPBC Act and the NC Act; CE – Critically Endangered under the EPBC Act; E – Endangered under the EPBC Act and the NC Act; SL – Special Least Concern under the NC Act, DD – Data Deficient Species
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<tr>
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<td>Falco hypoleucis</td>
<td>V (NC Act)</td>
</tr>
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<td>Geophasa scripta scripta</td>
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<td>Large-pied Bat</td>
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<td>Southern Snapping Turtle</td>
<td>Elseya albagula</td>
<td>CE (EPBC Act) and E (NC Act)</td>
</tr>
</tbody>
</table>

Note: M – Migratory under EPBC Act, V - Vulnerable under the EPBC Act and the NC Act; CE – Critically Endangered under the EPBC Act; E – Endangered under the EPBC Act and the NC Act; SL – Special Least Concern under the NC Act.
7.5 Essential Habitat

Essential Habitat mapping (which has recently been updated by DES following state government amendments to the VM Act) indicates that there are some areas of Essential Habitat associated with the Nogoa River and its Anabranch as shown in Figure 7.4.

Essential Habitat has been identified for the Ornamental Snake (*Denisonia maculata*) to the west of the Nogoa River and its Anabranch convergence, and includes the riparian areas, and other lowland vegetation. Essential habitat for the southern snapping turtle (*Elseya albagula*) occurs to the east of the convergence and is associated with the Nogoa River.

Option 2 will result in impacts on Essential Habitat due to the installation of intake structures and reinstallation of a water pipeline across the Nogoa River which intersect with areas of essential habitat. Approximately 3 ha of clearing of this habitat will be required for Option 2 as shown in Figure 7.4. Option 1:LL and Option 3:BTP do not impact upon the essential habitat as no remnant vegetation will be cleared as a consequence of these options.

7.6 State-Wide Biodiversity Corridor

A state-wide biodiversity corridor strategy was developed for the Queensland *State Planning Policy – State Interests Guideline Biodiversity* (2016) requirements. This identified important areas of vegetation providing biodiversity corridors across the Queensland landscape. This strategy also included provision of a buffer area to the corridor, so that development on or adjacent to the corridor (within the buffer area) is adequately assessed to prevent potential impacts of development on the wildlife corridor.

The Project area is traversed by a recognised state-wide biodiversity corridor as shown in Figure 7.5 identified under the State Planning Policy (SPP) for the protection of biodiversity. It should be noted that the provisions of the SPP do not apply to components of this project that occur within the existing mine footprint as these have been assessed under the *Environmental Protection Act (1994)* for mineral activities. The components outside of the mining tenements (i.e. the Option 2: FMBU pipeline to Weemah Channel) may be subject to the SPP. Further assessment will therefore be required with regard to project infrastructure that will need to be constructed on private land outside the MLs.

The state-wide biodiversity corridor is associated with the Nogoa River Anabranch and its major tributaries and includes a buffer area. Option 1: LL and Option 3: BTP do not impact upon the biodiversity corridor as no remnant vegetation will be cleared as a consequence of these options.

Works within the existing Ensham Mine site are not bound by any regulatory requirements associated with this corridor as mining activities are not subject to State Planning Policy provisions. Standard conditions of the existing Ensham EA address impacts on this corridor through the prevention of impacts to riparian vegetation, and mitigation measures addressing noise, sedimentation and erosion control.
FIGURE 7.4
DES Mapped Essential Habitat on and Adjacent to the Project Area
7.7 Queensland Wetland and Riparian Areas

To understand impacts upon wetland areas, this ecological assessment has considered implications of the three Options with the following:

- *Environmental Offsets Act 2014*;
- *Environmental Protection Regulation 2014*;
- *Vegetation Management Act 1999*; and
- Existing conditions under the Ensham Mine Environmental Authority (EPML00732813) relative to riparian areas (Condition D38).

Further to the above, the map of referable wetlands, a state-wide regulatory map under the *Environmental Protection Regulation 2008* was reviewed with respect to the RVP. The map of referable wetlands identifies wetlands of high ecological significance (HES) and general ecological significance (GES) across the state. HES wetlands on the map are identified as matters of state environmental significance (MSES) under the *Environmental Offsets Act* (2014). No referable wetlands were identified on or adjacent to the Project area.

While the provisions of the VM Act do not apply to the project components within the existing approved mine footprints, this Act does however recognise the ecological importance of riparian wetland REs such as RE 11.3.25e, RE 11.3.3 or RE 11.4.8, which occur on the Project area. Riparian wetland vegetation is considered an important component to wetland systems and provisions are incorporated into the VM Act to protect this vegetation. In addition to the VM Act, Condition D38 of the EA, prescribed under the *Environmental Protection Act 1994*, recognises the value of riparian vegetation and requires that flood protection levees not impact on riparian or existing remnant vegetation. Options 2 and 3 are considered compliant with Condition D38 of the EA. Queensland riparian wetlands and watercourses with respect to the Project area and locality are shown in Figure 7.2. Option 1 may be compliant with Condition D38 provided the works associated with the regrading of the levee structures for this option remain outside of remnant areas of riparian vegetation.

7.8 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems have been divided into the following systems for assessment within this report:

- Terrestrial GDEs; and
- Potential GDE Aquifers and Subterranean Fauna.

7.8.1 Terrestrial GDEs

Review of the Queensland Globe mapping for Terrestrial GDEs, identified that the Nogoa River and its Anabranch may represent a GDE as shown in Figure 7.6.

Terrestrial GDEs are ecosystems that are dependent on the sub-surface presence of groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services. Terrestrial GDE area features include riverine wetlands and deep-rooted regional ecosystems that have some sub-surface groundwater dependency.
Recent studies have found that groundwater occurrence in the alluvium at Ensham is highly variable, with thin saturated zones of poor quality water in deeper sections of an otherwise largely unsaturated formation (AGE, 2006). Water level data shows the seasonal variability in groundwater to be limited and coincident with the heterogeneous distribution of these sediments. Shallow silts and clays are anticipated to be partially isolating the Nogoa River, limiting leakage from the river into the basal sands and gravels. It is possible that leakage may occur where these clays are absent or where the basal sands are exposed within the river. However, this is conceptually thought to occur only in localized areas. This hydraulic separation of the alluvium from the Nogoa River means that whilst the water in the river is fresh, the underlying alluvium can be brackish to highly saline (HS, 2018).

Based on the separation of the riparian alluviums from the deeper impacted alluviums associated with the coal seams, there is not expected to be any adverse impacts on terrestrial GDEs in the Project area.

7.8.2 Potential GDE Aquifers

The Project Area has several types of aquifers, with the two main aquifers being the alluvial aquifer (along the river and tributaries) and the coal seam aquifer of the Rewan Group or Rangal Coal Measures, which contain fine grained sandstone and siltstone. These aquifers have the potential to support subterranean fauna (e.g., stygofauna) (refer to Section 7.8.3). The physico-chemical quality of groundwater can indicate the suitability of an aquifer to provide habitat for subterranean fauna. Generally, the aquifers that are inhabited by subterranean fauna exhibit relatively stable water quality, with little variation in temperature, salinity and pH. As such, subterranean fauna are typically highly sensitive to changes in their environment. The Queensland Government has prepared mapping of potential subterranean fauna aquifers as shown in Figure 7.7.
Figure 7.6
Terrestrial GDEs In and Adjacent to the Project area
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<th>Geology</th>
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<th>EC</th>
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<td>120</td>
<td>17</td>
<td>381</td>
<td>8</td>
<td>3700</td>
<td>449</td>
<td>654</td>
<td>0.17</td>
<td>0.03</td>
<td>0.001</td>
<td>0.78</td>
<td>0.25</td>
</tr>
<tr>
<td>Winton Creek Bore</td>
<td>Alluvium</td>
<td>6/5/2018</td>
<td>7530</td>
<td>7.85</td>
<td>170</td>
<td>12</td>
<td>70</td>
<td>7</td>
<td>2630</td>
<td>239</td>
<td>45</td>
<td>0.202</td>
<td>0.03</td>
<td>&lt;0.0005</td>
<td>0.78</td>
<td>0.28</td>
</tr>
<tr>
<td>Railway Bore</td>
<td>Undiff Coal Measures</td>
<td>5/5/2018</td>
<td>6370</td>
<td>7.32</td>
<td>170</td>
<td>104</td>
<td>174</td>
<td>25</td>
<td>1000</td>
<td>1070</td>
<td>577</td>
<td>0.01</td>
<td>&lt;0.005</td>
<td>&lt;0.0005</td>
<td>0.78</td>
<td>0.66</td>
</tr>
<tr>
<td>RB 1</td>
<td>Rewan, Rangal</td>
<td>5/5/2018</td>
<td>3430</td>
<td>8.16</td>
<td>677</td>
<td>14</td>
<td>13</td>
<td>3</td>
<td>938</td>
<td>405</td>
<td>4</td>
<td>0.014</td>
<td>0.02</td>
<td>&lt;0.0005</td>
<td>0.78</td>
<td>0.14</td>
</tr>
<tr>
<td>RB 2</td>
<td>Rewan, Rangal</td>
<td>5/5/2018</td>
<td>11 700</td>
<td>7.69</td>
<td>170</td>
<td>13</td>
<td>31</td>
<td>7</td>
<td>4030</td>
<td>126</td>
<td>&lt;0.5</td>
<td>0.069</td>
<td>0.01</td>
<td>0.002</td>
<td>0.78</td>
<td>0.65</td>
</tr>
<tr>
<td>RB 3</td>
<td>Rewan, Rangal</td>
<td>4/5/2018</td>
<td>9840</td>
<td>7.91</td>
<td>100</td>
<td>64</td>
<td>12</td>
<td>6</td>
<td>3650</td>
<td>174</td>
<td>1</td>
<td>0.032</td>
<td>&lt;0.005</td>
<td>&lt;0.0005</td>
<td>0.78</td>
<td>0.34</td>
</tr>
<tr>
<td>RB 4</td>
<td>Rewan</td>
<td>6/5/2018</td>
<td>7580</td>
<td>7.96</td>
<td>130</td>
<td>63</td>
<td>9</td>
<td>8</td>
<td>2670</td>
<td>166</td>
<td>6</td>
<td>0.015</td>
<td>0.05</td>
<td>0.001</td>
<td>0.78</td>
<td>0.3</td>
</tr>
<tr>
<td>RB 6</td>
<td>Rangal coal</td>
<td>6/5/2018</td>
<td>6940</td>
<td>7.48</td>
<td>80</td>
<td>86</td>
<td>269</td>
<td>9</td>
<td>2280</td>
<td>446</td>
<td>14</td>
<td>0.132</td>
<td>2.32</td>
<td>0.001</td>
<td>0.78</td>
<td>4.54</td>
</tr>
<tr>
<td>WSM B2D</td>
<td>Emerald Formation</td>
<td>4/5/2018</td>
<td>12 100</td>
<td>7.16</td>
<td>160</td>
<td>274</td>
<td>248</td>
<td>14</td>
<td>4100</td>
<td>548</td>
<td>618</td>
<td>0.096</td>
<td>0.03</td>
<td>&lt;0.0005</td>
<td>0.78</td>
<td>1.71</td>
</tr>
<tr>
<td>WSM B3D</td>
<td>Emerald Formation</td>
<td>3/5/2018</td>
<td>6150</td>
<td>7.67</td>
<td>970</td>
<td>10</td>
<td>76</td>
<td>7</td>
<td>1860</td>
<td>123</td>
<td>&lt;0.5</td>
<td>0.101</td>
<td>0.02</td>
<td>&lt;0.0005</td>
<td>0.78</td>
<td>0.57</td>
</tr>
</tbody>
</table>
7.8.3 Subterranean Fauna

Subterranean fauna are defined as fauna that live their entire lives below the ground surface. They are divided into two groups - aquatic and non-aquatic. Organisms that are restricted to aquatic systems below ground are termed stygofauna, and those that inhabit air filled voids and fractures below the surface are classed as troglofauna. Within these two groups there are varying levels of dependence upon the subterranean habitat. Those that spend their entire life cycle below ground are considered to be truly subterranean.

7.8.3.1 Troglofauna

The nature and structure of cavity development is important in determining potential habitat for troglofauna. Cavities must not be filled with sediment, isolated or sealed, with troglofauna requiring interconnected voids that allow for circulation of water, gases and nutrients, as well as animal movement (Eberhard, 2007). By inhabiting environments that have 100% relative humidity, or by reducing surface area available for water loss, the problem of water loss faced by invertebrates can be overcome (Villani et al., 1999). Troglofauna, while humidity is essential to their existence, do not inhabit spaces that are regularly inundated.

In Queensland, Troglofauna are poorly documented with studies generally restricted to caves and karst systems (Thurgate et al., 2001) such as Chillagoe Karst and Undara lava tubes (Hoch and Hosfeld, 1999). Additionally, unlike Western Australia (EPA, 2012), no troglofauna have been yielded as bycatch in surveys completed as part of Queensland EIAs which may indicate their habitat is restricted to karstic cave systems (Thurgate et al., 2001).

Stage 2 of the RVP did not identify troglofauna habitat in the Project area. Further to this, the Stage 3 Groundwater Report (HS, 2018c) identified that there will be no groundwater drawdown in areas above the floodplain, as a result of the RVP. This finding supports the Stage 2 assessment that there will be no impacts upon troglofauna in and adjacent to the Project area as a result of the RVP. The majority of the Project area, as defined in the ToR, is dominated by floodplain. Floodplains exclude troglofauna due to the periodic inundation of air filled cavities during flood events.

Due to the lack of suitable habitat within the Project area, troglofauna are not considered further in this report.

7.8.3.2 Stygofauna

Stygofauna in Queensland

A review on the status of knowledge regarding stygofauna diversity, ecology and biogeography within Australia was commissioned by ACARP (Hose et al., 2015). Queensland is known to host at least 24 described stygofauna families and 23 described genera across nine of the 17 major stygofauna taxonomic groups. Additionally, undescribed families have been recorded across a further three major stygofauna taxonomic groups. The composition of stygofauna is consistent with communities found in other regions in Australia and globally. However, Queensland assemblages appear to be unusually rich in Oligochaetes and Syncarids (Glanville et al., 2016).

Stygofauna in Queensland have been recorded as inhabiting a wide range of lithologies. These include unconsolidated and consolidated sedimentary material and fractured rocks. Variation in stygofauna yields indicated differences in habitat suitability based on lithology, however there were exceptions to this and given the stygofauna in Queensland still are largely undocumented, groundwater systems cannot be excluded from the possibility of stygofauna being present.

Review of the data in the Queensland Subterranean Aquatic Fauna Database selected data from projects within the Bowen Basin from Projects with similar geologies (Table 7.7). Only sites with stygobites were selected from the database and the EIA reports corresponding with the data were reviewed. In general, the alluvial systems were considered depauperate. The Crustacea were the only true stygobites and included the...
syncarids and copepods (harpacticoids and cyclopoids) (Table 7.7). The highest yields were from the alluvium aquifers. The syncarid family Parabathynellidae occurs across the greatest number of IBRA sub-regions in Queensland, followed by the Bathynellidae and Cyclopidae (copepods). The majority of the stygal families in Queensland occur in alluvium followed by Basalt and Coal aquifers. Sandstone and Silt aquifers had the lowest diversity. The syncarids and copepods also exist in a greater diversity of lithologies than other taxa (Glanville et al., 2016).

Table 7.7  Stygofauna yielded from Queensland coal projects. Data sourced from DESI

<table>
<thead>
<tr>
<th>Project</th>
<th>Site ID</th>
<th>Lithology</th>
<th>Drainage Basin</th>
<th>Stygofauna yielded</th>
</tr>
</thead>
<tbody>
<tr>
<td>East End No. 5</td>
<td>160</td>
<td>Sedimentary Rock</td>
<td>Calliope</td>
<td>Bathynellidae (Syncarid)</td>
</tr>
<tr>
<td></td>
<td>161</td>
<td></td>
<td></td>
<td>Bathynellidae</td>
</tr>
<tr>
<td></td>
<td>175</td>
<td>Alluvium</td>
<td></td>
<td>Bathynellidae, Parabathynellidae (Syncarid)</td>
</tr>
<tr>
<td>Rolleston Coal</td>
<td>192</td>
<td>Basalt</td>
<td>Fitzroy</td>
<td>Notobathynella sp. (Syncarid)</td>
</tr>
<tr>
<td></td>
<td>91</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elimatta</td>
<td>230</td>
<td>Alluvium</td>
<td></td>
<td>Parastenocaris spp. (Harpacticoid), Dussartcyclops sp. ELIM (Cyclopoid)</td>
</tr>
<tr>
<td></td>
<td>246</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>262</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>266</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teresa</td>
<td>360</td>
<td>Alluvium</td>
<td></td>
<td>Notobathynella sp.</td>
</tr>
<tr>
<td>Ravenswood</td>
<td>288</td>
<td>Granitoid</td>
<td>Burdekin</td>
<td>Parabathynellidae</td>
</tr>
<tr>
<td></td>
<td>342</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>343</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>344</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Byerwen</td>
<td>351</td>
<td>Basalt</td>
<td></td>
<td>Notobathynella sp.</td>
</tr>
<tr>
<td>Kevin’s Corner Project</td>
<td>10</td>
<td>Sandstone-Mudrock</td>
<td></td>
<td>Notobathynella sp.</td>
</tr>
<tr>
<td>Carmichael Coal</td>
<td>133</td>
<td>Coal</td>
<td></td>
<td>Notobathynella sp.</td>
</tr>
</tbody>
</table>

Stygofauna Habitat in the Project Area

Biological distribution in groundwater is influenced by various properties which include geology, hydrology, physico-chemical and biological (Strayer, 1994). Not all aquifers are suitable for groundwater invertebrates. While stygofauna have been collected from many aquifer types including fractured basalt, fractured sandstone and pesolithic, karstic and alluvial aquifers often have the highest yields and greatest diversity (Hancock et al., 2005; Humphreys, 2008). Endemic stygofauna are not distributed randomly; rather they are concentrated in regions that support diverse communities such as surficial aquifers, with diversity decreasing with increasing depth.

Central sections of the Project area are associated with the Nogoa River and its Anabranch and contain potential GDE aquifers (refer Section 7.8.2). Mapping prepared by DEHP indicates that unconsolidated sediments are extensively distributed throughout the Project area along the Nogoa River floodplain channels. Further to this, a sandstone outcrop is also known to occur (Figure 7.7). These areas represent suitable habitat for stygofauna.
Based on similar geologies in the Fitzroy Basin, the likelihood of a high stygofauna diversity in the Project area appears low given that similar alluvium with lower salinities does not appear to support diverse communities. Additionally, the alluvium aquifer that follows the Nogoa River and the Anabranch in the Project area is continuous and hydraulically connected to features that are important in maintaining the integrity of subterranean ecosystems as they promote recharge and allow taxa to disperse (Stayer, 1994).

It was also noted within the Groundwater Report (HS, 2018c) that drawdown associated with current approved mining operations has and will occur along the length of the Nogoa River floodplain adjacent to the mine site. According to HS (2018c), the alluvial aquifers do not appear to be connected to the residual voids or the deeper Rangal or Rowan Coal Measure aquifers. As a consequence, drawdown associated with on-going mining operations appears to be restricted to the deeper coal aquifers in and adjacent to the Project area. Given the depth and high salinity of the groundwater within these deeper coals measures, there is not anticipated to be any impacts on subterranean fauna.

Impacts associated with increasing salinity levels as well as metals/metalloid concentrations associated with Option 1 are not expected to impact the alluvial aquifer as the alluvial aquifer is not connected to the residual voids. Further to this, Options 1 and 3 will predominantly act as groundwater sinks until groundwater equilibrium is achieved. As a consequence, there is not expected to be any adverse impacts on the deeper groundwater aquifers present in and adjacent to the Project area.

Option 2 will predominantly act as a groundwater sink, however periodically this may alter under expected management operations. The water quality of Option 2 waters will be maintained with respect to salinity, and potential contaminants, at levels suitable for irrigation purposes. Therefore any water outflow to the deeper aquifers will be of lower salinity, and better quality than the current groundwater quality.
8.0 Biosecurity

Biosecurity at the Ensham Mine Site is carried out in accordance with Weed and Pest Animal Management Policy under the Ensham Mine Environmental Management System. This policy outlines the accepted measures to remove, control and limit the spread of pests, weeds, and disease pathogens on site.

With respect to the RVP, an assessment of the known disease pathogens, weeds, and pests present in the Study Area has been undertaken and compared to the existing Weed and Pest Animal Policy, to ensure all restricted species are addressed. This Policy was prepared with the assistance of the Central Highlands Regional Council.

Further to the above, measures specific to the RVP have been proposed below to ensure the removal, control of disease pathogens, weeds, and pests are controlled and the potential for spread is limited. This includes the development of a monitoring program that will allow the audit of the success of measures, and will assist in determining the success of the Ensham Weed and Pest Management Policy in the longer term.

8.1 Pathogens

Review of the Department of Agriculture and Fisheries plant pests and disease web page\(^1\) indicates there are no pathogens that are likely to affect the Ensham Mine Site. Proposed control methods are proposed in Table 8.2 below to minimise this risk.

8.2 Weeds

Table 8.1 below identifies the weed species or restricted matters that are known to occur within 10 km of the Project area. Species that are listed as Weeds of National Significance (WoNS) or listed under the Biosecurity Act 2014 and identified under the Central Highlands Regional Council Biosecurity Plan 2017-2022 (Central Highlands Regional Council, 2017) are included in this table.

It is of note that Buffel Grass (*Cenchrus ciliaris*) is recognised as a weed of national significance due to its invasive nature into ecosystems. This species is also recognised as an important pasture species in Queensland. The listing of Buffel Grass as a Weed of National Significance provides mechanisms for the control of this species within important conservation significant ecosystems, and also provides recognition of the impact of this species on these systems. This species should be avoided where rehabilitation of native vegetation is proposed.

---

### Table 8.1  Weed Species Known or Expected to Occur within 10 km of the Project area

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>PMST Type of Presence</th>
<th>Recorded on Wildlife Online (10 km Radius)</th>
<th>Presence on Project area</th>
<th>Biosecurity Act Priority Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acacia nilotica</em> subsp. <em>indica</em></td>
<td>Prickly Acacia</td>
<td>Species or species habitat may occur within area</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Verbesina encelioides</td>
<td>Crownbeard</td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td><em>Symphyotrichum subulatum</em></td>
<td></td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Xanthium occidentale</td>
<td></td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td><em>Eclipta prostrata</em></td>
<td>White Eclipta</td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Melochia pyramidata</td>
<td></td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Euphorbia hyssopifolia</td>
<td></td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td><em>Stylosanthes scabra</em></td>
<td></td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Malvastrum americanum var. americanum</td>
<td></td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Gossypium hirsutum</td>
<td></td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td><em>Sida spinosa</em></td>
<td>Spiny Sida</td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Sida cordifolia</td>
<td></td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Malvastrum coromandelianum subsp. coromandelianum</td>
<td></td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Oxalis corniculata</td>
<td></td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Antigonon leptopus</td>
<td></td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td><em>Harrisia martinii</em></td>
<td>Harrisia Cactus</td>
<td></td>
<td>-</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Portulaca oleracea</td>
<td>Pigweed</td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td><em>Argemone ochroleuca subsp. ochroleuca</em></td>
<td>Mexican Poppy</td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td><em>Setaria verticillata</em></td>
<td>Whorled Pigeon Grass</td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td><em>Urochloa mosambicensis</em></td>
<td>Sabi Grass</td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Melinis repens</td>
<td>Red Natal Grass</td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Cenchrus ciliaris</td>
<td>Buffel Grass</td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Echinochloa colona</td>
<td>Awnless Barnyard Grass</td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td><em>Megathyrsus maximus</em></td>
<td></td>
<td></td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
</tbody>
</table>

8.2.1 Management Recommendations

A Weed and Pest Animal Management Policy (Ensham EMS EP 8.1) has been developed for the Ensham Mine site under the sites Environmental Management System. Restricted matters, including Parthenium Weed, Parkinsonia, *Opuntia* spp. and Harrisia Cactus, are currently controlled in accordance with this plan. It is anticipated that these control measures will be carried forward by the ultimate land manager of the Project area.

The residual voids are likely to create waterbodies which may result in the proliferation of aquatic weeds. The Ensham Weed and Pest Animal Management Policy (Ensham EMS EP 8.1) will need to be amended to incorporate monitoring and control procedures to manage potential occurrences of aquatic weed species for all residual voids. It is anticipated that these control measures will be carried forward by the ultimate land manager of the Project area.

### Table 8.2 Management Recommendations to Control Weeds

<table>
<thead>
<tr>
<th>Period</th>
<th>Issue</th>
<th>Management Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ongoing Land Management</td>
<td>Inspection vehicles carrying weeds or pathogens.</td>
<td>Vehicles used for any inspections or monitoring activities on site are to be cleaned and inspected prior to entry and exit of the site.</td>
</tr>
<tr>
<td></td>
<td>Vegetated areas to be monitored following significant rainfall events.</td>
<td>Inspections to be undertaken to identify any outbreaks of restricted species. Where restricted species are identified, the owner or operator should control outbreaks in accordance with the control measures identified in the Weed and Pest Animal Management Policy.</td>
</tr>
</tbody>
</table>
Residual voids may encourage proliferation of aquatic weed species. Annual inspections for presence of priority aquatic weed species. Outbreaks to be controlled using the measures identified in the Weed and Pest Animal Management Policy.

### 8.3 Feral Species

**Table 8.3** below identifies the feral animal species that may occur or are known to occur within 50 km of the Project area that are listed as having National Significance or listed under the Biosecurity Act 2014 and identified under the Central Highlands Regional Council Biosecurity Plan 2017-2022 (Central Highlands Regional Council, 2017).

**Table 8.3 Feral Fauna Species Known to Occur within 50 km of the Project area**

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>PMST Type of Presence</th>
<th>Presence on Project area</th>
<th>Central Highlands BioSecurity Plan Priority Status</th>
<th>Ensham Mine Site Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemidactylus frenatus*</td>
<td>Asian House Gecko</td>
<td>Species or species habitat likely to occur within area</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Columba livia*</td>
<td>Rock Pigeon</td>
<td>Species or species habitat likely to occur within area</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sturnus vulgaris*</td>
<td>Common Starling</td>
<td>Species or species habitat likely to occur within area</td>
<td>-</td>
<td>5</td>
<td>✓</td>
</tr>
<tr>
<td>Acridotheres tristis</td>
<td>Indian Myna</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>✓</td>
</tr>
<tr>
<td>Anas platyrhynchos*</td>
<td>Mallard</td>
<td>Species or species habitat likely to occur within area</td>
<td>-</td>
<td>1</td>
<td>✓</td>
</tr>
<tr>
<td>Streptopelia chinensis*</td>
<td>Spotted Turtle- Dove</td>
<td>Species or species habitat likely to occur within area</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Passer domesticus*</td>
<td>House Sparrow</td>
<td>Species or species habitat likely to occur within area</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rhinella marina*</td>
<td>Cane Toad</td>
<td>Species or species habitat likely to occur within area</td>
<td>✓</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Canis lupus familiaris*</td>
<td>Domestic Dog</td>
<td>Species or species habitat likely to occur within area</td>
<td>-</td>
<td>1</td>
<td>✓</td>
</tr>
<tr>
<td>Felis catus*</td>
<td>Cat</td>
<td>Species or species habitat likely to occur within area</td>
<td>✓</td>
<td>3</td>
<td>✓</td>
</tr>
<tr>
<td>Lepus capensis*</td>
<td>Brown Hare</td>
<td>Species or species habitat likely to occur within area</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>Mus musculus*</td>
<td>House Mouse</td>
<td>Species or species habitat likely to occur within area</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
</tr>
</tbody>
</table>

### Scientific Name | Common Name | PMST Type of Presence | Presence on Project area | Central Highlands BioSecurity Plan Priority Status | Ensham Mine Site Status
--- | --- | --- | --- | --- | ---
*Oryctolagus cuniculus* | Rabbit | Species or species habitat likely to occur within area | ✓ | 3 | ✓
*Rattus rattus* | Black Rat | Species or species habitat likely to occur within area | ✓ | - | ✓
*Sus scrofa* | Pig | Species or species habitat likely to occur within area | ✓ | 1 | ✓
*Vulpes vulpes* | Red Fox | Species or species habitat likely to occur within area | ✓ | 3 | ✓
Various species | Feral Deer | - | - | 1 | ✓

Note: * - Commonwealth Identified Feral Species; 1 - Pest Fauna Identified under the Biosecurity Act 2014 and incorporated in the Central Highlands Regional Council Biosecurity Plan 2017-2022.

### 8.3.1 Management Recommendations

A Weed and Pest Animal Management Policy has been developed for the Ensham Mine site under the site’s Environmental Management System. Restricted matters, including Red Fox, Pig, Black Rat, Rabbit, Cat, Dog and House Mouse are currently controlled in accordance with this plan. It is recommended that this existing plan be amended to ensure adequate controls are put in place for the appropriate control of restricted pest species for areas to be disturbed prior to implementation of the selected RVP Option. It is anticipated that this plan will form the basis for on-going pest management following mine relinquishment.

**Table 8.4 Proposed Management Recommendation to Control Feral Animals**

<table>
<thead>
<tr>
<th>Period</th>
<th>Issue</th>
<th>Management Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ongoing Land Management</td>
<td>Presence of pest species.</td>
<td>Annual inspections of RVP areas for presence of restricted pest species. Outbreaks to be controlled using the measures identified in the Weed and Pest Animal Management Policy.</td>
</tr>
</tbody>
</table>
9.0 Gap Analysis

The known biophysical (hydrological, geotechnical, water quality and environmental) aspects of the Project area, were assessed for gaps in information that may have consequences for later stages of the ecological assessment of the RVP. Where any gaps were found, the particular gap was then identified, so it may be addressed in later stages of the project. This analysis has also considered the known processes or activities proposed for each Option that may have the potential to impact the identified ecological values, including threatened flora, fauna, and ecosystems.

The analysis for gaps in ecological data consisted of a review of the ecological policies, Commonwealth and State Government databases, technical reports undertaken for Stage 3, previous ecological reports for the Project area and ecological reports for the locality as identified in Section 2.2.

9.1 Biophysical Gap Analysis

9.1.1 Overburden Geochemistry

Stage 3 Geochemical (RGS, 2018) investigations of the surface spoil have found that the spoil is likely to produce relatively benign, slightly alkaline seepage and will result in non-saline runoff occurring. Acid generation from the overburden has been deemed low and no evidence of acid mine drainage has been observed in the groundwater or surface water in the last 10 years (RGS, 2018). The majority of the spoil has very low sulphur content and metal concentrations were also found to present a low risk. Therefore, no gaps in available information are considered to occur for overburden geochemistry.

9.1.2 Water

9.1.2.1 Surface Water

Option 2 relies on harvesting water during high flow events from the Nogoa River and pumping water from the relevant pits to the Weemah Channel pits for beneficial use as required. The gap identified in the Stage 2 Ecology Report centred on the need for an option specific assessment of hydrology, geochemistry and associated water quality, as the surface water must be suitable for both irrigation and aquatic ecosystem purposes to meet water quality objectives for the lower Nogoa River.

The Stage 3 Geochemistry technical report shows that the overburden material presents a low risk of producing acid mine drainage and accordingly low potential to leach heavy metals or metalloids. There is however, the possibility for salt to leach from spoil material.

Low levels of bioaccumulation of metals may occur over the very long term within mine voids, where internal surface flows are directed. Most of Ensham Mine’s spoil material is dispersive to highly dispersive (RGS 2018) and thus presents an erosion risk if not managed in accordance with the geotechnical assessment. Dispersive material eroded from the landform levees associated with Option 1 have the potential to impact the nature and quality of downstream watercourses and floodplains if not appropriately managed. The eventual land manager for Option 1: LL will be responsible for monitoring erosion of the landform levees over time. It should be noted that if significant landform levee erosion occurs in the post-relinquishment phase there is the potential that over time, this may contribute to a compromising of the integrity of the landform levees, which may have impacts upon downstream ecosystems should they fail, allowing void water to enter the Nogoa River.
9.1.2.2 River Stability

The Geomorphological Assessment (WSP, 2018) prepared in Stage 3 of this project indicates that the resultant landforms for each Option will remain stable from the short to medium term. This indicates that impacts on downstream ecosystems from the RVP will be minimal over this timeframe.

Armouring will be required along some sections of the landform levees associated within Option 1, where higher flow velocities from the Nogoa River and the Anabranch make initial contact with the levees along their western edges in proximity to the Nogoa River to prevent erosion, and the movement of sediment downstream.

Removal of the levees for Option 3, together with the surcharging of the backfilled floodplain is also expected to result in a stable landform. This is attributed to the slowing of floodwaters through the widened floodplain. This slower moving water is therefore less likely to cause erosion of the backfilled material which would otherwise cause a potential impact on aquatic values downstream of the Project area. WSP (2018) however identified a low risk of differential settling for this option. This may generate holes/cracks within the backfilled spoil, allowing water ingress, resulting in erosion and piping. The land manager responsible for the ongoing management of the Option 3 landscape will be responsible for monitoring and addressing potential erosion issues in this resultant landscape.

9.1.2.3 Groundwater

Determination of any long-term impacts, which are likely to occur following the relinquishment of the mine, have been addressed within the Stage 3 groundwater modelling (HS, 2018c). Stage 3 investigations into the potential impacts of Option 3: BTP found that the backfilled void ‘aquifer’ level does not approach its ultimate rest point until approximately 100 years after commencement of the simulation (HS, 2018c). Current models predict that after reaching rest, water levels in C Pit, D Pit and E Pit will become groundwater sources, whereas Y Pit will act as a groundwater sink (HS, 2018c). This data suggests that the RVP will not impact upon potential habitat for subterranean fauna with potential to occur in the vicinity of the Project area.

9.2 Ecological Data Gaps

9.2.1 Weemah Channel Pipeline

The proposed pipeline to the Weemah Channel has been briefly assessed within this report. A more detailed ecological assessment for this pipeline is expected to be undertaken should Option 2 be selected as the final option. The assessment will address aquatic, terrestrial, and subterranean impacts on the environment, as a consequence of construction and operation of the pipeline.

9.2.2 Regional Ecosystems/TECs

There have been a number of detailed investigations of the Regional Ecosystems present on the Project area including:

- Ensham Central Project EIS (Hansen Consulting, 2006), and Ensham Central Project Supplementary EIS (Hansen Bailey, 2009) where a detailed ecological assessment was presented by ECOSM; and


These assessments provided a rigorous investigation of the Regional Ecosystems as required at the time of their production. For the purposes of this assessment, the Queensland Herbarium (Version 10.1) RE mapping has been utilised, as this is the most recent known available mapping. The findings of the
previous surveys undertaken in 2010 (ECOSM, 2010) support the current Herbarium RE mapping (Version 10.1) however, it appears that some regrowth of vegetation communities fringing 11.3.25e has occurred.

This change in vegetation distribution may be a result of subject analysis, or due to the time difference between the ECOSM (2010) survey and the latest 2018 update of the Regional Ecosystem data. As a consequence it will be necessary to accurately map the distribution of REs in any areas that may be impacted outside of the existing mine disturbance areas (e.g. Option 1 regrading of outward slopes of levees and realignment of levees in two locations, Option 2 construction of intake structures, and replacement of a water pipeline are expected to require some clearance of predominantly non-regulated regrowth/disturbed areas and some minor clearance of RE 11.3.25e).

The occurrence of RE, and the quantities of remnant vegetation to be removed will need to be confirmed during field surveys in later stages of the project.

**Distribution of Regional Ecosystems (Option 1 and Option 2)**

Based on the WSP (2018) landform levee design and associated construction footprint, approximately 60 ha of non-regulated regrowth/previously disturbed vegetation will be impacted as a result of Option 1. Option 2 will impact 3 ha of RE 11.3.25e vegetation during construction of the intake structures.

It is recommended that should either Option 1 or Option 2 be selected, a survey to delineate any REs within the design footprints be undertaken prior to construction works. Field survey should be undertaken in accordance with the standards provided in Nelder et al (2017). There are no seasonal requirements for this vegetation survey. It is recommended that quaternary sites are sampled in throughout the expansion areas, to allow formal identification of any Regional Ecosystems. A secondary quadrat should be established where it is believed REs are identified in this area. Depending upon the results of the quaternary level of survey, should any potential Threatened Ecological Communities be identified, it will be necessary to determine condition thresholds or size limits contained within Commonwealth conservation advice statements for potentially occurring TECs known to occur in the locality of the Project area.

### 9.2.3 Threatened Flora

It is recommended that targeted surveys for threatened flora known and with potential to occur in the Project area be undertaken should any clearing associated with Option 1: LL or Option 2 be proposed to occur outside of the existing mine footprint in areas. This will ensure threatened species are identified in potential impact areas and that appropriate mitigation measures such as avoidance, or offsetting can be incorporated in these early stages of the Project.

Surveys should be undertaken in any potential additional disturbance areas (outside of existing approved disturbance areas), so that the distribution of these species can be determined, as well as the density of any individuals present.

**Threatened Flora Survey Requirements**

Table 9.1 provides the optimal season for the survey of known and potentially occurring threatened flora in the Project area. Table 9.1 also provides the recommended survey techniques. Cerbera dumicola is known to occur within the Project area, and Dichanthium queenslandicum is known to occur in RE 11.3.25 and Acacia spania is known to occur in REs 11.7.1 and 11.7.2. As Option 1 and Option 2 have potential to impact RE 11.3.25e, targeted surveys for Dichanthium queenslandicum are recommended in accordance with Table 9.1.
### Table 9.1 Threatened Flora Survey Requirements

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Survey effort required</th>
<th>Seasons of Survey</th>
<th>Survey Guideline</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Dichanthium queenslandicum</em></td>
<td>King Blue-grass</td>
<td>Targeted survey to be undertaken during RE verification process.</td>
<td>Flowers are recorded throughout the year, particularly in March (following sufficient rainfall)</td>
<td>Flora Survey Guidelines – Protected Plants</td>
<td>This species should be detectable over the summer months. One survey should be undertaken to determine if this species is present in any impact areas.</td>
</tr>
<tr>
<td><em>Cerbera dumicola</em></td>
<td>Native Frangipani</td>
<td>Targeted survey of potential habitats areas.</td>
<td>Flowers in October, but readily identifiable throughout the year</td>
<td>Flora Survey Guidelines – Protected Plants</td>
<td>This species should be detectable over the summer months. One survey should be undertaken to determine if this species is present in any impact areas.</td>
</tr>
<tr>
<td><em>Acacia spania</em></td>
<td>-</td>
<td>Targeted survey to be undertaken during RE verification process</td>
<td>Flowers in August-September period. Readily identifiable throughout the year</td>
<td>Flora Survey Guidelines – Protected Plants</td>
<td>This species should be detectable over the summer months. One survey should be undertaken to determine if this species is present in any impact areas.</td>
</tr>
</tbody>
</table>

### 9.2.4 Threatened Fauna Gaps

Updated fauna surveys (targeted on preferred habitats and occurrence of threatened species) would be required should disturbance of riparian areas be required as a component of Option 1: LL.

#### Threatened Fauna Survey Requirements

*Table 9.2* provides the optimal season for the survey of known and potentially occurring threatened fauna in the Project area. *Table 9.2* also provides the recommended survey techniques for those threatened species with potential to occur within the cleared/disturbed areas adjacent to the existing levee banks, or within riparian habitats associated with the Nogoa River. It is anticipated that during the RE ground verification works should Option 1 or Option 2 be selected, that the habitats these species occur in will be targeted for the respective threatened species. It should be noted that the following surveys can be undertaken simultaneously or can be combined so that a discrete survey period can be undertaken to sample all threatened fauna taxa.

#### Table 9.2 Threatened Terrestrial Fauna Survey Requirements

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Survey effort required</th>
<th>Seasons of Survey</th>
<th>Survey Guideline</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Erythrotriorchis radiatus</em></td>
<td>Red Goshawk</td>
<td>Targeted survey of riparian areas to be impacted.</td>
<td>Spring, summer and autumn periods</td>
<td>Survey Guidelines for Australia’s Threatened Birds (DEWHA, 2010)</td>
<td>No additional considerations.</td>
</tr>
<tr>
<td>Scientific Name</td>
<td>Common Name</td>
<td>Survey effort required</td>
<td>Seasons of Survey</td>
<td>Survey Guideline</td>
<td>Comments</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>--------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Falco hypoleucus</td>
<td>Grey Falcon</td>
<td>Targeted survey of riparian areas to be impacted targeting nest sites.</td>
<td>Spring, summer and autumn periods</td>
<td>Not covered in guideline, but principles for Red Goshawk are appropriate for this species. Survey Guidelines for Australia’s Threatened Birds (DEWHA, 2010)</td>
<td>No additional considerations.</td>
</tr>
<tr>
<td>Geophaps scripta scripta</td>
<td>Squatter Pigeon</td>
<td>Opportunistic surveys during RE field verification of riparian areas. 3 days of field survey recommended.</td>
<td>Spring, summer and autumn periods</td>
<td>Survey Guidelines for Australia’s Threatened Birds (DEWHA, 2010)</td>
<td>No additional considerations.</td>
</tr>
<tr>
<td>Numenius madagascariensis</td>
<td>Eastern Curlew</td>
<td>Opportunistic surveys during RE field verification of riparian areas. 3 days of field survey recommended.</td>
<td>Spring, summer and autumn periods</td>
<td>Not covered in guideline, but principles for Australian Painted Snipe are appropriate for this species. Survey Guidelines for Australia’s Threatened Birds (DEWHA, 2010)</td>
<td>No additional considerations.</td>
</tr>
<tr>
<td>Rostratula australis</td>
<td>Australian Painted Snipe</td>
<td>Quantification of potential habitat to be impacted for this species. Opportunistic surveys during RE field verification. 3 days of field survey recommended.</td>
<td>Spring, summer and autumn periods</td>
<td>Survey Guidelines for Australia’s Threatened Birds (DEWHA, 2010)</td>
<td>No additional considerations.</td>
</tr>
<tr>
<td>Chalinolobus dwyeri</td>
<td>Large-pied Bat</td>
<td>Targeted survey of potential roost trees. These are to be marked and call detectors used to determine utilisation. 3 days of field survey with 6 detector hours per night recommended.</td>
<td>October through to March</td>
<td>Survey Guidelines for Australia’s Threatened Bats (DEWHA, 2010)</td>
<td>No additional considerations.</td>
</tr>
<tr>
<td>Scientific Name</td>
<td>Common Name</td>
<td>Survey effort required</td>
<td>Seasons of Survey</td>
<td>Survey Guideline</td>
<td>Comments</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td><em>Nyctophilis corbeni</em></td>
<td>Corbens Long-eared Bat</td>
<td>Targeted survey of potential roost trees. These are to be marked and call detectors used to determine utilisation. 3 days of field survey with 6 detector hours per night recommended.</td>
<td>October through to March</td>
<td>Survey Guidelines for Australia’s Threatened Bats (DEWHA, 2010)</td>
<td>No additional considerations.</td>
</tr>
<tr>
<td><em>Phascolarctos cinereus</em></td>
<td>Koala</td>
<td>Targeted survey of known koala food trees in areas to be impacted. 3 days of field survey recommended. Spotlight surveys over 3 nights.</td>
<td>Throughout the year</td>
<td>SPOT Assessment Technique (Phillips and Callaghan, 2011)</td>
<td>No additional considerations.</td>
</tr>
<tr>
<td><em>Tachyglossus aculeatus</em></td>
<td>Short-beaked Echidna</td>
<td>Fauna spotter catcher to undertake pre-clear inspection of all habitat areas prior to construction activities.</td>
<td>Spring, summer and autumn periods</td>
<td>-</td>
<td>No additional considerations.</td>
</tr>
<tr>
<td><em>Denisonia maculata</em></td>
<td>Ornamental Snake</td>
<td>Targeted survey of riparian areas to be impacted immediately prior to construction activities by Fauna Spotter Catcher.</td>
<td>Presumably active late spring through summer to early autumn</td>
<td>Survey Guidelines for Australia’s Threatened Reptiles (DSEWPaC, 2011).</td>
<td></td>
</tr>
<tr>
<td><em>Egernia rugosa</em></td>
<td>Yakka Skink</td>
<td>Habitat assessment and targeted survey for burrows and communal defecation sites. Should be undertaken in in riparian areas to be impacted.</td>
<td>Presumably active late spring through summer to early autumn</td>
<td>Survey Guidelines for Australia’s Threatened Reptiles (DSEWPaC, 2011).</td>
<td>Should be undertaken during the warmer months of the year to identify presence.</td>
</tr>
</tbody>
</table>
### Gap Analysis

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Survey effort required</th>
<th>Seasons of Survey</th>
<th>Survey Guideline</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemiaspis damelii</td>
<td>Grey Snake</td>
<td>Targeted active searching under large objects such as rocks, logs etc. Survey of riparian areas to be impacted. 3 days of field survey recommended</td>
<td>Presumably active late spring through summer to early autumn following rainfall when primary prey Cyclorana species are active</td>
<td>Survey Guidelines for Australia’s Threatened Reptiles (DSEWPaC, 2011).</td>
<td>Should be undertaken during the warmer months of the year to identify presence.</td>
</tr>
<tr>
<td>Furina dunmalli</td>
<td>Dunmall’s Snake</td>
<td>Targeted active searching under large objects such as rocks, logs etc. Survey of riparian areas to be impacted including spotlighting surveys. 3 days of field survey recommended</td>
<td>Presumably active late spring through summer to early autumn following rainfall when primary prey amphibian species are active</td>
<td>Survey Guidelines for Australia’s Threatened Reptiles (DSEWPaC, 2011).</td>
<td>Should be undertaken during the warmer months of the year to identify presence.</td>
</tr>
</tbody>
</table>

#### 9.2.5 Aquatic Ecosystems

##### 9.2.5.1 Aquatic Flora

No threatened aquatic flora has been identified within 50 km of the Project area. No gaps have been identified for threatened aquatic flora within the Project area or its locality.

##### 9.2.5.2 Aquatic Fauna

As works associated with Option 3 will predominantly be restricted to historically disturbed areas or the existing approved mine footprint, there are no anticipated gaps in the existing information available for the Project area with respect to aquatic fauna for this Option.

Option 1 will require regrading of the outward levee walls extending outward up to 40 m. Provided appropriate mitigation measures, including delineation of remnant riparian vegetation, implementation of sediment and erosion control measures (including mitigation structures and on-going monitoring) are undertaken to address construction and operational phases of the project, no impacts are expected to result on aquatic fauna.

In additional to the impacts and mitigation measures identified for Option 1 above, Option 2 is expected to require the trenching of a replacement water pipeline across the Nogoa River as well as the installation of two intake structures, potentially impacting the riparian vegetation of the Nogoa River. This process has potential to involve the disturbance of the habitat of threatened aquatic fauna species.

Ground verification of the location and extent of the Option 2 structures will need to be undertaken to determine the extent of impact upon aquatic fauna. It is anticipated that this will be undertaken at a later stage of the project should Option 2 be selected as the final Option. Based upon available information it is anticipated that Option 2 will not require additional surveys as mitigation measures are expected to be able
to address potential impacts upon these species. These mitigation measures are expected to be outlined in an Aquatic Fauna Management Plan for the proposed construction activities and is expected to include the following requirements:

- Minimising the pipelines or intake structures footprint in habitat areas,
- Minimising the disturbance time to flow regimes as much as possible. This may also include avoidance of fish migration periods along the Nogoa River;
- During dewatering of pipeline or intake structure work areas, a spotter/catcher is on site to collect any turtle species or other aquatic fauna contained in the dewatered construction areas, and
- Appropriate sedimentation and erosion controls are implemented during and following construction to protect aquatic ecosystems downstream of any construction.

**Subterranean Fauna**

Stage 3 involved the preparation of a desktop assessment in accordance with the Queensland Subterranean fauna survey guidelines as contained within this report. The desktop assessment was structured according to the Western Australian Environmental Protection Authority’s (EPA) Environmental Assessment Guideline 12 (EAG 12) (EPA, 2013). The EAG 12 provides information that considers the conservation of subterranean fauna species and ecological communities as listed by the EPBC Act. The Department of Science, Information Technology and Innovation’s (Qld Govt) guideline (DSITI, 2015) for the environmental assessment of subterranean aquatic fauna adheres to the EPA’s Guidance Statement 54a (EPA, 2007) which provides technical support for the EAG 12.

The desktop assessment found that no subterranean fauna are expected to be impacted by any of the preferred options.

The basis for this conclusion is:

- None of the Preferred Options will result in the loss of habitat as the groundwater table will not be affected as water will not be abstracted or diverted from the Nogoa River.
- The Nogoa River continues to receive recharge from the Fairbairn Dam, this will be beneficial to any groundwater biota which rely on good hydraulic conductivity to replenish food reserves in a normally depleted environment.
- Groundwater quality in the Alluvial aquifer in the Project area and surrounds is typically within the ranges considered acceptable for stygofauna.
- Connectivity along the aquifer remains intact and not obstructed causes isolated areas, allowing taxa to disperse.

While the Project area may support stygofauna in two aquifer types as would be expected compared to areas of similar geology in the Fitzroy and Bowen Basins as shown in the literature. The stygofauna community that may be present within the Ensham Project area would therefore consist of taxa dominated by the syncarid and copepod crustaceans. Dispersal would occur within the Alluvial Aquifer along the river channels. The likelihood of the three Preferred Options impacting any potential stygofauna communities present is therefore considered to be very low.

**9.2.6 Migratory Avian Fauna**

No information/data gaps were identified with respect to migratory bird species. It is therefore recommended that no additional surveys be undertaken for migratory bird species.
## 9.3 Summary of Gaps

Table 9.3 provides a summary of the identified ecological and biophysical gaps for the RVP.

### Table 9.3 Summary of the Identified Ecological and Biophysical Stage 3 RVP Gaps

<table>
<thead>
<tr>
<th>Ecological Gaps</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aquatic Ecosystems</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquatic Flora</td>
<td>No identified Gaps</td>
<td>No identified Gaps</td>
<td>No identified Gaps</td>
</tr>
<tr>
<td>Aquatic Fauna</td>
<td>No identified Gaps</td>
<td>Works within Nogoa River and its Anabranch (pipeline and intake structures) will require additional survey should Option 2 be selected.</td>
<td>No identified Gaps</td>
</tr>
<tr>
<td>Subterranean Fauna</td>
<td>No identified Gaps</td>
<td>No identified Gaps</td>
<td>No identified Gaps</td>
</tr>
<tr>
<td><strong>Terrestrial Ecosystems</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terrestrial Flora</td>
<td>Works outside of mine footprint (levee footprint) will require additional survey should Option 1 be selected</td>
<td>Works within Nogoa River and its Anabranch (pipeline and intake structures) will require additional survey should Option 2 be selected. Further detailed assessment will be required for any off lease infrastructure.</td>
<td>No identified Gaps</td>
</tr>
<tr>
<td>Terrestrial Fauna</td>
<td>Works outside of mine footprint (levee footprint) will require additional survey should Option 1 be selected</td>
<td>Works within Nogoa River and its Anabranch (pipeline and intake structures) will require additional survey should Option 2 be selected. Further detailed assessment will be required for any off lease infrastructure.</td>
<td>No identified Gaps</td>
</tr>
<tr>
<td>Migratory Fauna</td>
<td>No identified Gaps</td>
<td>No identified Gaps</td>
<td>No identified Gaps</td>
</tr>
</tbody>
</table>
10.0 Impact Assessment

A risk based approach has been undertaken for this Stage 3 impact assessment of preferred Options 1 to 3 to identify the potential impacts of each Option, outlined in this section. In Stage 4 of the RVP, the Commonwealth Significant Impact Criteria (DEE, 2013) will be used for an impact assessment based upon a detailed design once the preferred option has been selected. These criteria provide a scientifically rigorous process to determine the significance of impacts upon various aspects of threatened species and community ecological requirements.

As outlined within the Introduction, this Stage 3 report has been prepared under the assumption that the impact assessment is based upon a safe, stable and non-polluting landforms post relinquishment for each Option. Once the final Option is selected, a more detailed Ecological Impact Assessment will ultimately be prepared to address construction and on-going impacts for the Final Option, including any potential biosecurity impacts.

10.1 Option 1: LL

10.1.1 Identified Impacts

10.1.1.1 Vegetation

With respect to the RVP and Option 1: LL, it is anticipated that approximately 60 ha of non-regulated regrowth/disturbed vegetation adjacent to the existing levee walls will be cleared to allow for the realignment and regrading of the outward levee batters associated with this Option. This clearing has potential to impact upon non-regulated regrowth habitats associated with the Nogoa River, some of which may provide habitat for threatened terrestrial species. A review of the available RE mapping indicates that no REs will be cleared as a result of this Option.

Should this Option be selected as the final option, a detailed field survey for listed terrestrial threatened species and communities known to be present in or adjacent to the area proposed for clearing should be undertaken. An Impact Assessment should then be prepared in accordance within the Commonwealth Impact Assessment Guideline.

The riparian vegetation associated with the Nogoa River and Anabranch is recognised as a potential Terrestrial GDE habitat in DES mapping. The Stage 3 Hydrology Study (HEC, 2018b) found that the shallow aquifers associated with the river are not connected to the deeper alluvium, or the aquifers associated with the coal measures. Based upon this finding, there is not expected to be any impacts upon the riparian vegetation present within the Project area or in its vicinity due to Option 1.

10.1.1.2 Terrestrial Flora

Based upon the Stage 3 Civil Design (WSP, 2018) as outlined in Section 10.1.1.1, impacts on terrestrial flora species are expected to be minimal. Realignment and regrading of sections of the levee walls, where they occur in proximity to void highwalls or where the footprint of the levees will be increased to reduce batter slopes, will result in the clearing of up to 60 ha of non-regulated regrowth/previously disturbed vegetation. No areas of known or potential habitat for threatened flora will be directly impacted by the realignment/regrading of sections of levee associated with this Option.

There are not expected to be any additional indirect impacts on terrestrial flora as a result of Option 1: LL as a result of the RVP.
10.1.1.3 Terrestrial Fauna

Commonwealth and State listed ‘Endangered’ species with potential to occur in the Project area include Eastern Curlew (Numenius madagascariensis) and Australian Painted Snipe (Rostratula australis). Habitat of Eastern Curlew and Australian Painted Snipe is predominantly associated with the Nogoa River and its Anabranch. As no clearing of REs will occur as a result of this option, and as clearing will be restricted to approximately 60 ha of previously disturbed land, there is not expected to be any material impacts upon these species.

Commonwealth and State listed ‘Vulnerable’ species known or with potential to occur in the Project area include Red Goshawk (Erythrotriorchis radiatus), Squatter Pigeon (Geophaps scripta scripta), Grey Falcon (Falco hypoleucos), Large Pied Bat (Chalinolobus dwyeri), Corbens Long-eared Bat (Nyctophilus corbeni), Koala (Phascolarctos cinereus), Ornamental Snake (Denisonia maculata), and Yakka Skink (Egernia rugosa). These species are known to utilise RE 11.3.25e habitats. Based upon available RE mapping (Version 10.1), Option 1: LL will not result in the removal of any REs. Clearing of disturbed land will occur adjacent to the existing mine levees.

Should Option 1: LL be selected as the final option, it is recommended that a field survey be undertaken to accurately delineate any REs that may occur within or adjacent to the disturbance area. Further to this an assessment for threatened fauna that may occur within the disturbance area should be undertaken. A detailed Impact Assessment can then be prepared in accordance with the Commonwealth Impact Assessment Guideline to more accurately determine the ecological level of impact.

No material indirect impacts (i.e. noise, dust, excess light) are expected to occur on any terrestrial fauna species known to utilise the Project area as a result of the RVP at the post relinquishment phase of the project.

10.1.1.4 Aquatic Flora

No threatened aquatic flora species were identified as having potential to occur within 50 km of the Project area. Aquatic flora are known to occur within the Nogoa River. Option 1: LL of the RVP is not expected to have any direct impact upon the Nogoa River or its Anabranch. No water will be actively returned to the Nogoa River or its Anabranch, therefore there will be no opportunity for water within the RVP to cause indirect impacts such as poor water quality to impact this group of species.

The Stage 3 Material Characterisation for the Ensham Coal Mine Final Void Plan (RGS, 2018) technical report indicates that no acid mine drainage occurs within the Ensham Mine. As a consequence, there is expected to be a low potential for metals or metalloids to impact downstream environments. The implementation of appropriate rehabilitation and ongoing monitoring for erosion and sedimentation will minimise any impacts on aquatic flora due to sedimentation.

10.1.1.5 Aquatic Fauna

Two threatened reptile species were identified as having potential to occur within the Project area. These species are known to occur within the Nogoa River. As no REs will be cleared as a result of this Option, no direct impacts are anticipated on these species.

10.1.1.6 Terrestrial Groundwater Dependent Ecosystems

Mapping prepared by the Queensland Government (2018) indicates that the riparian corridor associated with the Nogoa River is considered a potential terrestrial GDE. Groundwater assessment prepared by HEC (2018) indicates that there are no linkages between the shallow Nogoa River aquifer, and the deeper alluvium or Rangal coal seam aquifers. Therefore, it is considered unlikely that there will be any impacts on terrestrial GDEs should Option 1 be selected.
10.1.1.7 Subterranean Fauna

Troglofauna

Option 1: LL is not expected to result in any impacts on Troglofauna as no suitable habitat for this group of species is expected to occur within the Project area.

Stygofauna

The Project area may support stygofauna in the two aquifer types present (alluvium and the deeper coal measures).

With respect to stygofauna, Option 1 is unlikely to impact any potential stygofauna habitat, namely the alluvium aquifer that extends along the Nogoa River and its Anabranch. The basis for this conclusion is:

- This Option will not result in the loss of habitat as the groundwater table will not be affected as water will not be abstracted or diverted from the Nogoa River.
- As the Nogoa River continues to receive recharge from the Fairbairn Dam, this will be beneficial to any groundwater biota which rely on good hydraulic conductivity to replenish food reserves in a normally depleted environment.
- Groundwater quality in the Alluvial aquifer in the Project area and surrounds is typically within the ranges considered acceptable for stygofauna.
- Connectivity along the aquifer remains intact and no obstructions are planned that would cause the isolation of areas, thereby allowing taxa to disperse.

10.1.1.8 Migratory Species

No migratory species are considered to be significantly impacted by potential measures associated with Option 1: LL. The RVP occurs in a historically operated coal mine area, and this group of highly mobile species can actively avoid operational activities as needed. This option will ultimately result in the presence of residual waterbodies (specifically pits A-E) which are likely to become brackish over time, and where contaminants such as Arsenic, Molybdenum and Selenium will concentrate through evapo-concentration. It is anticipated that aquatic organisms, including fish, will become depauperate in these residual voids over time. This will limit the utilisation of the voids by migratory species to a wading area, rather than a foraging area. As a consequence, due to these species high mobility, and due to the expected resulting depauperate aquatic diversity within the voids, impacts upon migratory species are expected to be minimal.

Analysis of the HEC (2018c) Void Water Quantity and Quality Balance Modelling report indicates that there is potential for metals/metalloids to bioaccumulate within void waters. They may therefore exceed aquatic guidelines to various aquatic life forms over time when compared to the trigger values contained in the ANZECC (2000) Water Quality Guidelines. Nevertheless, it is anticipated that the water bodies are likely to provide some wading resources for transitory bird species. It is anticipated that due to the gradually increasing salinity and contaminant levels, the diversity of aquatic species within the resultant water bodies will decline over time. This will mean that this option could result in a waterbody only suitable for wading/resting for these species. It should be noted that the residual voids associated with Option 1 are not designed to create aquatic habitats, but rather as a mechanism to contain void waters so that they cannot impact downstream environments.

10.1.2 Management and Mitigation Measures

As part of the rehabilitation process, following construction of the landform levees, Ensham proposes to establish a corridor using native tree species along the western (highwall) side of the rehabilitated A and B pits. This corridor will be approximately 50 to 100 m in width and will provide a linkage approximately 6.7 km long, linking the vegetation associated with Corkscrew Creek with the Nogoa River (refer Figure 3.1).
In addition to creating this linkage, this measure will also augment the available habitats for flora and fauna species on the Project area. This measure is anticipated to be beneficial for a variety of native fauna species increasing the available vegetation cover and associated foraging opportunities in the locality, as well as increasing fauna movement opportunities in this landscape. Ecological values of this treed corridor could be further enhanced through appropriate fencing to restrict stock movement into the corridor, and the placement of habitat features such as nest boxes.

Where practicable, avoidance of impacts on the riparian vegetation due to clearing and regrading of the outside levee batters that occur for Option 1: LL is recommended. To ensure this is achieved, it is recommended that a survey be undertaken to delineate the boundaries of the riparian REs to inform the detailed design. This will provide a current representation of the riparian REs, so that detailed design can be undertaken to avoid/minimise loss wherever practicable. Where any loss of this community is unavoidable, it will be necessary to update the assessment in the later phases of the RVP to identify appropriate mitigation measures.

A field survey is also recommended targeting nesting sites for Red Goshawk (*Erythrotriorchis radiatus*), Squatter Pigeon (*Geophaps scripta scripta*), Grey Falcon (*Falco hypoleucos*), Large Pied Bat (*Chalinolobus dwyeri*), Corben’s Long-eared Bat (*Nyctophilus corbeni*). This assessment should also target Koala (*Phascolarctos cinereus*), Ornamental Snake (*Denisonia maculata*), and Yakka Skink (*Egernia rugosa*). A detailed Impact Assessment would then be prepared in accordance with the Commonwealth Impact Assessment Guideline to more accurately determine the ecological level of impacts of this Option. This will guide the determination of appropriate management and mitigation measures specific to the identified impacts of this Option.

### 10.2 Option 2: FMBU

#### 10.2.1 Identified Impacts

Option 2: FMBU has potential to result in the following ecological impacts.

##### 10.2.1.1 Vegetation

Review of the available Version 10.1 Regional Ecosystem mapping indicates that approximately 3 ha of RE 11.3.25e will be cleared as a result of the required water intake structures. There is also potential for the re-installation of the Ensham Mine pipeline across the Nogoa River, which may result in approximately 0.1 ha of disturbance to RE 11.3.25e adjacent to the existing alignment. The areas proposed for clearing for this Option are shown in Figure 10.1.

This clearing of approximately 3 ha of land has potential to impact upon riparian habitats associated with the Nogoa River, some of which are recognised as habitat for threatened species. Should this Option be selected as the final option, a detailed Impact Assessment would be prepared in accordance with the Commonwealth Impact Assessment Guideline to more accurately determine the ecological level of impact.
10.2.1.2 Terrestrial Flora

Based upon the Stage 3 Civil Design (WSP, 2018) as outlined in Section 3.2, impacts on terrestrial flora species are expected to be minimal. No areas of known or potential habitat for threatened flora will be impacted by this Option.

Two intake structures, as well as the reconstruction of the Ensham Mine internal water pipeline will be constructed across a section of the 11.3.25e RE. This community may provide habitat for threatened flora species including *Dichanthium queenslandicum*. A targeted flora survey would be required should Option 2 become the selected option. This survey will target potential habitat areas of these species, where construction activities will be required. This will allow for minor alignment changes to occur to avoid or minimise potential impacts should it be determined that these species occur.

No material indirect impacts are expected to occur with respect to threatened terrestrial flora species.

10.2.1.3 Terrestrial Fauna

Commonwealth and State listed ‘Endangered’ species with potential to occur in the Project area include Eastern Curlew (*Numenius madagascariensis*) and Australian Painted Snipe (*Rostratula australis*). Habitat of Eastern Curlew and Australian Painted Snipe is predominantly associated with the Nogoa River and its Anabranch. As there is some limited clearing of approximately 3 ha of 11.3.25e RE as a result of this option, there are not expected to be any significant impacts upon these species as they are highly mobile species that do not breed within Australia.

Commonwealth and State listed ‘Vulnerable’ species known or with potential to occur in the Project area include Red Goshawk (*Erythrotriorchis radiatus*), Squatter Pigeon (*Geophaps scripta scripta*), Grey Falcon (*Falco hypoleucos*), Large Pied Bat (*Chalinolobus dwyeri*), Corbens Long-eared Bat (*Nyctophilus corbeni*), Koala (*Phascolarctos cinereus*), Ornamental Snake (*Denisonia maculata*), and Yakka Skink (*Egernia rugosa*). These species are known to utilise RE 11.3.25e habitats. Option 2 will result in the removal of approximately 3 ha of 11.3.25e RE. Further assessment will be required based upon a targeted field survey of available habitats for these species in proposed disturbance areas to accurately determine level of impact, and appropriate mitigation measures.

No material indirect impacts on any fauna species known to utilise the Project area is expected to occur.

10.2.1.4 Aquatic Flora

No threatened aquatic flora species were identified as having potential to occur within 50 km of the Project area. Aquatic flora are known to occur within the Nogoa River. Option 2 of the RVP is expected to have minor impacts on the aquatic habitats of the Nogoa River or its Anabranch due to the construction of intake structures as well as the potential installation of a new pipeline across the Nogoa River. The Stage 3 Material Characterisation for the Ensham Coal Mine Final Void Plan (RGS, 2018) report indicates that no acid drainage occurs, and as a consequence there is low potential for metals or metalloids to impact downstream environments.

10.2.1.5 Aquatic Fauna

Two threatened reptile (turtle) species were identified as having potential to occur within the Project area. These species are known to occur within the Nogoa River. Approximately 3 ha of RE 11.3.25e which may provide riparian habitat for these species will be cleared as a result of this Option. This disturbance is expected to have minimal direct impacts on these species.

On the basis that pits A&E are managed to ensure toxicant levels remain below bio-accumulation values (as specified in the water quality guidelines (ANZG, 2018), bio-accumulation is not expected to occur.
Additionally, as pit F&Y will not be capable of receiving groundwater, bio-accumulation will not present as an issue at these pits.

10.2.1.6 Subterranean Fauna

*Troglofauna*

Option 2 is not expected to have any impacts on Troglofauna as no suitable habitat was identified as occurring within the Project area.

*Stygofauna*

The Project area may support stygofauna in the two aquifer types present (alluvial and the deeper coal measures) as would be expected compared to areas of similar geology in the Fitzroy and Bowen Basins as shown in the literature.

In regards to stygofauna, Option 2 appears unlikely to significantly impact any potential stygofauna habitat, namely the Alluvial Aquifer that extends along the Nogoa River and the Anabranch. The basis for this are:

- This Option will not result in the loss of habitat as the groundwater table will not be affected as water will not be abstracted or diverted from the Nogoa River except under high flow conditions.
- The Nogoa River continues to receive recharge from the Fairbairn Dam, this will be beneficial to any groundwater biota which rely on good hydraulic conductivity to replenish food reserves in a normally depleted environment.
- Groundwater quality in the Alluvial aquifer in the Project area and surrounds is typically within the ranges considered acceptable for stygofauna.
- Connectivity along the alluvial aquifer remains intact and will not be obstructed. Therefore there will be no isolation of the aquifer areas, allowing taxa to disperse freely.

10.2.1.7 Migratory Species

No migratory species are considered to be significantly impacted by potential measures associated with Option 2: FMBU. The RVP occurs in a historically operated coal mine area, and this group of highly mobile species can actively avoid operational activities as needed. This option will ultimately result in the presence of residual waterbodies some of which are likely to become brackish over time. Nevertheless, it is anticipated that the water bodies are likely to provide some foraging and wading resources for these species.

10.2.2 Management and Mitigation Measures

Where practicable, avoidance of clearing riparian vegetation for the construction of the intake channels and structures adjacent to the Pit B and Pit C levees is recommended. Further to this, delineation of the boundaries of the riparian remnant vegetation should be undertaken to provide a current representation of this vegetation, so that detailed design can be undertaken to avoid or minimise loss where practicable. Where any loss of this community is unavoidable, it will be necessary to update the assessment in the later phases of the RVP to identify appropriate mitigation measures.

As part of the rehabilitation process, following construction of the structures associated with Option 2, Ensham proposes to establish a treed corridor along the western (highwall) side of the rehabilitated A and B pits. This corridor will be approximately 50 to 100 m in width and will provide a linkage approximately 6.7 km long, linking the vegetation associated with Corkscrew Creek with the Nogoa River (refer Figure 3.2). In addition to creating this further linkage, this measure will also augment the available habitats for flora.
and fauna species on the Project area. This measure is anticipated to be beneficial for a variety of native fauna species.

10.3  **Option 3: BTP**

10.3.1  **Identified Impacts**

Option 3: BTP has little potential to result in ecological impacts as outlined below.

10.3.1.1  **Vegetation**

There are not expected to be any significant impacts on remnant vegetation associated with Option 3. All construction impacts will be restricted to the existing mine footprint.

10.3.1.2  **Terrestrial Flora**

As no remnant vegetation is proposed to be cleared for this option, there are not expected to be any significant impacts on native terrestrial flora, other than removal of regrowth species associated with rehabilitated areas. This assessment has assumed that disturbance of existing rehabilitated areas for the relocation of spoil to back fill voids can be done in accordance with the current mine approval.

10.3.1.3  **Terrestrial Fauna**

Commonwealth listed ‘Endangered’ species with potential to occur in the Project area include the Eastern Curlew (*Numenius madagascariensis*), Australian Painted Snipe (*Rostratula australis*), and the Southern Snapping Turtle (*Elseya albagula*). Based upon the Stage 3 Geomorphological technical report, it would appear that as the width of the floodplain will be substantially increased from the current situation, Option 3: BTP is considered unlikely to have deleterious impacts upon the habitats of these species downstream of the RVP as the potential for erosion of the re-created floodplain was considered low.

Commonwealth listed ‘Vulnerable’ species known or with potential to occur on the site include Red Goshawk (*Erythrotriorchis radiatus*), Squatter Pigeon (*Geophaps scripta scripta*), Large Pied Bat (*Chalinolobus dwyeri*), Corbens Long-eared Bat (*Nyctophilus corbeni*), Koala (*Phascolarctos cinereus*), Ornamental Snake (*Denisonia maculata*), and Yakka Skink (*Egernia rugosa*). Impacts upon the habitats of these terrestrial species are considered very minor given the high mobility of the bird species, and the high levels of disturbance already present in the mine areas for bat and reptile species. There will be no additional disturbance of remnant habitats beyond that already approved for the mine and no downstream impacts are anticipated to occur.

10.3.1.4  **Aquatic Flora**

No threatened aquatic flora species were identified as having potential to occur within 50 km of the Project area. Aquatic flora are known to occur within the Nogoa River. Option 3 of the RVP is not expected to have any impacts on the aquatic habitats of the Nogoa River or its Anabranch. The Stage 3 Material Characterisation for the Ensham Coal Mine Final Void Plan (HS, 2018c) report indicates that no acid drainage occurs, and as a consequence there is low potential for metals or metalloids to impact downstream environments. Provided erosion and sedimentation controls are implemented during construction and stabilisation phases of the backfill and rehabilitation works, there are not expected to be any impacts upon aquatic flora species.

10.3.1.5  **Aquatic Fauna**

Two reptile species consisting of the Fitzroy River Turtle (*Rheodytes leukops*) and the Southern Snapping Turtle (*Elseya albagula*) were identified as having potential to occur within the Project area. Option 3: BTP
will have no direct impacts upon these species as all works will be restricted to the approved mine footprint. Based upon anticipated water quality it is anticipated that no indirect impacts will occur to these species.

However, these species are known to occur within the broader Nogoa River, and as such Option 3 has potential to indirectly impact upon these species through sedimentation should differential settling be followed by poor land management in the future.

Under this Option the only remaining pits are Pits F and Y. Bio-accumulation is unlikely to present as an issue for these pits as they are not capable of receiving groundwater inflows.

### 10.3.1.6 Terrestrial Groundwater Dependent Ecosystems

Terrestrial GDE mapping prepared by the Queensland Government and presented in Section 7.8 shows that the riparian corridor of the Nogoa River represents a terrestrial GDE. Studies undertaken in Stage 3 indicate that there is low potential for impacts on terrestrial GDEs.

### 10.3.1.7 Subterranean Fauna

**Troglofauna**

Option 3 is not expected to have any impacts on Troglofauna no suitable habitat was identified as occurring within the Project area.

**Stygofauna**

In regards to stygofauna, Option 3 appears unlikely to impact any potential stygofauna habitat, namely the Alluvium Aquifer that extends along the Nogoa River and the Anabranch. The basis for this are:

- This Option will not result in the loss of habitat as the groundwater table will not be affected as water will not be abstracted or diverted from the Nogoa River.
- As the Nogoa River continues to receive recharge from the Fairbairn Dam, this will be beneficial to any groundwater biota which rely on good hydraulic conductivity to replenish food reserves in a normally depleted environment.
- Groundwater quality in the Alluvial aquifer in the Project area and surrounds is typically within the ranges considered acceptable for stygofauna.
- Connectivity along the alluvium aquifer remains intact and will not be obstructed. Therefore there will be no isolation of aquifer areas, allowing taxa to disperse freely.

### 10.3.1.8 Migratory Species

No migratory species are considered to be significantly impacted by potential measures associated with Option 3: BTB. The RVP occurs in a historically operated coal mine, and this group of highly mobile species can actively avoid operational activities as needed. Option 3: BTP will ultimately result in the presence of a number of saline waterbodies with median salinities modelled to range from 8,495 µS/cm to 19,675 µS/cm in the residual water bodies associated with E Pit, F Pit and the Yongala Pits (HEC, 2018c). These pits are however expected to provide some additional wading habitat for this group of species.

### 10.3.2 Management and Mitigation Measures

As part of the rehabilitation process, following backfilling of pits for Option 3, Ensham proposes to establish a corridor using native tree species along the western (highwall) side of the rehabilitated A and B pits. This corridor will be approximately 50 to 100 m in width and will provide a linkage approximately 6.7 km long,
linking the vegetation associated with Corkscrew Creek with the Nogoa River (refer Figure 3.4). In addition to creating this linkage, this measure will also augment the available habitats for flora and fauna species on the Project area. This measure is anticipated to be beneficial for a variety of native fauna species increasing the available vegetation cover and associated foraging opportunities in the locality, as well as increasing fauna movement opportunities in this landscape. Ecological values of this treed corridor could be further enhanced through appropriate fencing to restrict stock movement into the corridor, and the placement of habitat features such as nest boxes.

In addition, appropriate land management practices will need to be adopted for this Option to reduce impacts to vegetation and erosion potential following flood events in areas that experience large degrees of differential settlement.
11.0 Summary of Impacts on Environmental Values

11.1 Assessment of potential impacts on environmental values

An assessment of the potential impacts of each of the three preferred options on relevant environmental values (EVs) has been undertaken based on the outcomes of this study. The EVs are described in the Stage 2 environmental values report (Ensham, 2017b) and the criteria relevant to each of the EVs for the Stage 3 studies have been determined by Ensham Resources Pty Ltd.

The assessment of impacts on EVs has been undertaken by assigning a ranking for each of the preferred options to each EV. The adopted scoring criteria are shown in Table 11.1. A ranking value of zero represents no impact to an EV. Negative rankings represent likely adverse impacts on the EV, while positive rankings reflect likely benefits to the EV. The definitions used within Table 11.1 are contained within Table 11.2.

Table 11.1 Adopted Scoring Criteria for Assessment of EVs

<table>
<thead>
<tr>
<th>Scoring Criteria</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant negative impact for this criterion</td>
<td>-3</td>
</tr>
<tr>
<td>Medium negative impact for this criterion</td>
<td>-2</td>
</tr>
<tr>
<td>Minor negative impact for this criterion</td>
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</tr>
<tr>
<td>No impact for this criterion</td>
<td>0</td>
</tr>
<tr>
<td>Minor benefit for this criterion</td>
<td>+1</td>
</tr>
<tr>
<td>Medium benefit for this criterion</td>
<td>+2</td>
</tr>
<tr>
<td>Significant benefit for this criterion</td>
<td>+3</td>
</tr>
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Table 11.2 Adopted Definitions of Scoring Criteria for Assessment of EVs

<table>
<thead>
<tr>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant impact/benefit - results in a change which is important, notable or of consequence to the EV having regard to its intensity/frequency. For an impact the change will result in not being able to meet published standards (if there are any). For a benefit the change should meet best practice standards (if there are any published)</td>
</tr>
<tr>
<td>Medium impact/benefit - results in a change which is potentially important, notable or of consequence to the EV having regard to its intensity/frequency. For an impact, the change will result in occasions where the criterion will not meet published standards (if there are any). For a benefit the change should meet good practice standards (if there are any published)</td>
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<tr>
<td>Minor impact/benefit - results in a change which is identifiable but is not important, notable or of consequence to the EV having regard to its intensity</td>
</tr>
</tbody>
</table>

Note: The definition of significant impact has been based on the Federal Government's definition of significant impact contained within its "Matters of National Environmental Significance, Significant Impact Guidelines 1.1, Environment Protection and Biodiversity Conservation Act 1999"
### Table 11.3 Summary of Impacts on Option 1 Environmental Values

<table>
<thead>
<tr>
<th>Environmental Aspect</th>
<th>Environmental Value</th>
<th>Criteria</th>
<th>Impacts</th>
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</thead>
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<tr>
<td><strong>Water</strong></td>
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<tr>
<td></td>
<td>Aquatic Ecosystems</td>
<td>Downstream River Quality</td>
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<tr>
<td></td>
<td>(Biodiversity &amp; Habitat)</td>
<td>Aquatic GDEs (Stygofauna)</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Impact on run off quality</td>
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<tr>
<td><strong>Ecology (Flora and Fauna)</strong></td>
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<td>Habitat/Wetlands/Riparian Areas</td>
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<tr>
<td></td>
<td>Terrestrial Ecosystems</td>
<td>Terrestrial Subterranean Fauna Habitat</td>
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<td><strong>Biosecurity</strong></td>
<td>Ecosystem Vulnerability</td>
<td>Pests</td>
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<td>Weeds</td>
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<td></td>
<td>Over Abundant Native Species</td>
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### Table 11.4 Summary of Impacts on Option 2 Environmental Values

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<th>Environmental Aspect</th>
<th>Environmental Value</th>
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<td><strong>Water</strong></td>
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<td>Impact on run off quality</td>
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<td><strong>Ecology (Flora and Fauna)</strong></td>
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<td></td>
<td>Terrestrial Ecosystems</td>
<td>Terrestrial Subterranean Fauna Habitat</td>
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<td><strong>Biosecurity</strong></td>
<td>Ecosystem Vulnerability</td>
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<td>Weeds</td>
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<td>Over Abundant Native Species</td>
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<td></td>
<td>Bioaccumulation</td>
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### Table 11.5 Summary of Impacts on Option 3 Environmental Values

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<th>Criteria</th>
<th>Impacts</th>
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<tbody>
<tr>
<td><strong>Water</strong></td>
<td></td>
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</tr>
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<td></td>
<td>Aquatic Ecosystems</td>
<td>Downstream River Quality</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>(Biodiversity &amp; Habitat)</td>
<td>Aquatic GDE’s (Stygofauna)</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Impact on run off quality</td>
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</tr>
<tr>
<td><strong>Ecology (Flora and Fauna)</strong></td>
<td></td>
<td>Habitat/Wetlands/Riparian Areas</td>
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<tr>
<td></td>
<td>Terrestrial Ecosystems</td>
<td>Terrestrial Subterranean Fauna Habitat</td>
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</tr>
<tr>
<td><strong>Biosecurity</strong></td>
<td>Ecosystem Vulnerability</td>
<td>Pests</td>
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<td></td>
<td>Weeds</td>
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<td></td>
<td></td>
<td>Over Abundant Native Species</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Bioaccumulation</td>
<td>Void Water Quality</td>
<td>0</td>
</tr>
</tbody>
</table>
12.0 Conclusions and Recommendations

12.1 Option 1: LL Impact Assessment Conclusion

Option 1: LL will require construction activities on the existing levees for a distance up to 40 m on the outside surfaces of the existing levees. There is anticipated to be some loss of non-regulated regrowth vegetation in disturbed areas adjacent to the Nogoa River and the Anabranch. As this option would be restricted to historically disturbed areas totalling approximately 60 ha, impacts on ecological values in the Project area are anticipated to be minimal.

Under this option, there is also proposed to be a treed corridor between Corkscrew Creek and the Nogoa River, which has potential to augment the terrestrial wildlife corridors in this area resulting in a beneficial ecological outcome.

12.2 Option 2: FMBU Impact Assessment Conclusion

There will be a loss of approximately 3.0 ha of 11.3.25e regional ecosystems, which represents potential habitat for a number of threatened terrestrial and aquatic species.

There is also expected to be two beneficial outcomes as a result of this Option as the resultant water bodies in Pits A, B, C, and D are expected to provide foraging and wading habitats for various migratory wader species and fringing habitats for terrestrial species. Further to this, a treed corridor is also proposed. This corridor will increase fauna linkages between Corkscrew Creek and the Nogoa River and may also augment existing habitats for flora and fauna species.

The pipeline to the Weemah Channel will involve trenching of the pipeline through predominantly cleared agricultural lands.

12.3 Option 3: BTP Impact Assessment Conclusion

This option will result in large scale disturbance to already rehabilitated sections of the Project area, but is not expected to result in additional direct disturbance of ecological communities outside the existing and approved mine footprint.

On the basis that the backfilling of voids on the floodplain will be safe, stable and non-polluting, there should be no greater risk of erosion and sediment issues from the voids. Where rehabilitation success criteria are not maintained post relinquishment, there is the potential for impacts to vegetation and an increase in erosion and piping risks associated with flood events, particularly from areas subject to differential settlement of the backfill. This may have a consequential impact on downstream ecological values.

12.4 Recommendations

12.4.1 Vegetation

Targeted surveys of any areas to be potentially impacted by Option 1: LL or Option 2: FMBU should be undertaken to accurately determine the RE type, its condition, and its precise distribution. These surveys will be an important component for approval requirements under current regulatory controls.
12.4.2 Terrestrial Flora

Due to the known occurrence of *Cerbera dumicola* and the potential presence of *Dichanthium queenslandicum* and *Acacia spania* in proximity (within 50 km) to the site and the presence of suitable habitat for these species on the Project area, it is recommended that targeted surveys be undertaken in communities present in the Project area if potential habitat areas for these species is proposed to be disturbed. Potential disturbance outside of the existing mine footprint associated with infrastructure associated with Option 1: LL or Option 2: FMBU is likely to require the survey of disturbance to RE11.3.25e along the Nogoa River and its Anabranch targeting *Dichanthium queenslandicum*. Should additional infrastructure be identified in later stages of the RVP, it is recommended that assessment against the preferred habitat of threatened flora known or with potential to occur be undertaken to identify additional survey areas as required.

To survey these species, it is recommended that surveys be undertaken during the summer months following rainfall events, as the positive identification of *Dichanthium queenslandicum* relies on observing the inflorescence. Surveys for the *Acacia spania* can also be undertaken at this time, as flowers or seed pods should be visible.

12.4.3 Terrestrial Fauna

Any works associated with Option 1: LL and Option 2: FMBU outside of the existing mine footprint including the pipeline to Weemah Channel will require targeted fauna surveys. This should be undertaken in the summer or early autumn period to ensure all species are active. If potential habitat areas for threatened species may be disturbed, as a result of any works, targeted surveys will need to be undertaken in regional ecosystems and within disturbed/regrowth areas proposed for disturbance. Fauna surveys should be undertaken in accordance with Commonwealth and State survey guidelines for the target species identified in the habitat areas to be impacted. Surveys should target important habitat components for the target species to quantify any impacts, which will allow appropriate mitigation measures to be determined.

No additional fauna surveys will be required for Option 3: BTP assuming disturbance will be restricted to existing approved mine areas.

12.4.4 Aquatic Flora

As Option 2: FMBU is expected to require some potential disturbance of the Nogoa River and the vegetation associated with it surveys should be undertaken to determine the presence of aquatic flora adjacent to potential disturbance areas. Surveys for aquatic flora should be undertaken during the summer or early autumn period to ensure most aquatic flora species known in this area will be actively growing. No additional aquatic flora surveys will be required for Option 1: LL and Option 3: BTP assuming disturbance will be restricted to existing approved mine areas or areas immediately adjacent to these existing disturbed areas.

12.4.5 Aquatic Fauna

Option 1: LL and Option 2: FMBU will require some potential disturbance of the Nogoa River and the vegetation associated with it. Provided effective erosion and sedimentation erosion control is provided during and following construction activities, there is not expected to be impacts upon aquatic fauna. Therefore, no additional aquatic fauna surveys are recommended.
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APPENDIX A

Assessment of Potential Occurrence of Conservation Significant Flora
## Table A1 Assessment of Potential Occurrence of Conservation Significant Flora Identified During Literature Review

<table>
<thead>
<tr>
<th>Family</th>
<th>Scientific Name</th>
<th>EPBC Act Status</th>
<th>PMST Type of Presence</th>
<th>Wildlife Online Database</th>
<th>Atlas of Living Aust.</th>
<th>AVH</th>
<th>NC Act Status</th>
<th>Likelihood of Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mimosaceae</td>
<td>Acacia spania</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>NT</td>
<td>Suitable habitat present on the Project area. Species recorded within 10 km of the Project area. Potential to Occur.</td>
</tr>
<tr>
<td>Poaceae</td>
<td>Aristida annua</td>
<td>V</td>
<td>Species or species habitat likely to occur within area</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>V</td>
<td>Suitable habitat present on the Project area. Species not recorded within 10 km of the Project area following various flora surveys. Unlikely to Occur.</td>
</tr>
<tr>
<td>Euphorbiaceae</td>
<td>Bertya opponens</td>
<td>V</td>
<td>Species or species habitat likely to occur within area</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>Suitable habitat present on the Project area. Species not recorded within 10 km of the Project area following various flora surveys. Unlikely to Occur.</td>
</tr>
<tr>
<td>Surianaceae</td>
<td>Cadellia pentastylis</td>
<td>Ooline</td>
<td>Species or species habitat likely to occur within area</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>V</td>
<td>No suitable habitat present on the Project area. Species not recorded within 10 km of the Project area following various flora surveys. Unlikely to Occur.</td>
</tr>
<tr>
<td>Apocynaceae</td>
<td>Cerbera dumicola</td>
<td>Native Frangipani</td>
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<td>2</td>
<td>2</td>
<td>2</td>
<td>NT</td>
<td>Recorded in the north-eastern portion of MDL 217 where active dumping has encroached on remnant vegetation. Known to Occur.</td>
</tr>
<tr>
<td>Poaceae</td>
<td>Dichanthium queenslandicum</td>
<td>King Blue Grass</td>
<td>E</td>
<td>Species or species habitat known to occur within area</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>Suitable habitat present in the Project area. Species has been recorded with 10 km of the Project area. Potential to Occur.</td>
</tr>
<tr>
<td>Family</td>
<td>Scientific Name</td>
<td>Common Name</td>
<td>EPBC Act Status</td>
<td>PMST Type of Presence</td>
<td>Wildlife Online Database</td>
<td>Atlas of Living Aust.</td>
<td>AVH</td>
<td>NC Act Status</td>
</tr>
<tr>
<td>--------------</td>
<td>----------------------</td>
<td>-------------</td>
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<td>------------------------</td>
<td>--------------------------</td>
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<td>-----</td>
<td>---------------</td>
</tr>
<tr>
<td>Poaceae</td>
<td>Dichanthium setosum</td>
<td>Blue-grass</td>
<td>V</td>
<td>Species or species</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>Myrtaceae</td>
<td>Eucalyptus raveretiana</td>
<td>Black-box</td>
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<td>Species or species</td>
<td>0</td>
<td>0</td>
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<td>-</td>
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<tr>
<td>Apocynaceae</td>
<td>Marsdenia brevifolia</td>
<td>V</td>
<td>Species or species</td>
<td>Habitat may occur within area.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Rhamnaceae</td>
<td>Polianthion minutiflorum</td>
<td>V</td>
<td>Species or species</td>
<td>Habitat likely to occur within area.</td>
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<td>0</td>
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<td>Solanaceae</td>
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<td>-</td>
<td>-</td>
<td>0</td>
<td>✓</td>
<td>✓</td>
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</tr>
</tbody>
</table>

Note: E – Endangered (EPBC Act and NC Act), V – Vulnerable (EPBC Act and NC Act), SL – Special Least Concern (NC Act), NT – Near Threatened (NC Act)
APPENDIX B

Assessment of Potential Occurrence of Conservation Significant Fauna
Table B1: Assessment of Potential Occurrence of Conservation Significant Fauna Identified During Literature Review

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>EPBC Act Status</th>
<th>PMAI Type of Presence</th>
<th>WODM Database</th>
<th>Atlas of Living Aust.</th>
<th>Atlas of Endangered Species</th>
<th>Literature Review other Studies</th>
<th>NC Act Status</th>
<th>Preferred Habitat</th>
<th>Likelihood of Occurrence</th>
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<tr>
<td>Curlew Sandpiper</td>
<td>Calidris ferruginea</td>
<td>CE, MI</td>
<td>Species or species habitat may occur within area</td>
<td>0 0 0</td>
<td>Low</td>
<td>-</td>
<td>E</td>
<td>Suitable wetland habitats present on the Project area. Species not recorded within 10 km of the Project area, but this is a highly mobile species. Potential to Occur.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common Sandpiper</td>
<td>Actitis hypoleucus</td>
<td>MI, W</td>
<td>Species or species habitat may occur within area</td>
<td>0 0 0</td>
<td>Low</td>
<td>-</td>
<td>SL</td>
<td>Suitable wetland habitats present on the Project area. Species not recorded within 10 km of the Project area. Unlikely to Occur.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharp-tailed Sandpiper</td>
<td>Calidris acuminata</td>
<td>MI, W</td>
<td>Species or species habitat likely to occur within area</td>
<td>9 9 9</td>
<td>Low</td>
<td>-</td>
<td>SL</td>
<td>Suitable habitat present on the Project area. Species recorded on and within 10 km of the Project area. Known to Occur.</td>
<td></td>
<td></td>
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<tr>
<td>Pectoral Sandpiper</td>
<td>Calidris melanotos</td>
<td>MI, W</td>
<td>Species or species habitat may occur within area</td>
<td>0 2 2</td>
<td>Low</td>
<td>-</td>
<td>SL</td>
<td>Suitable wetland habitats present on the Project area. Species recorded within 10 km of the Project area. Known to Occur.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marsh Sandpiper</td>
<td>Tringa stagnatilis</td>
<td>MI</td>
<td>-</td>
<td>4 3 3</td>
<td>Low</td>
<td>-</td>
<td>SL</td>
<td>Suitable habitat present on the Project area. Species recorded on and within 10 km of the Project area. Known to Occur.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glossy Ibis</td>
<td>Plegadis falcinellus</td>
<td>MIT</td>
<td>-</td>
<td>6 4 4</td>
<td>Low</td>
<td>-</td>
<td>SL</td>
<td>Suitable habitat present on the Project area. Species recorded within 10 km of the Project area. Potential to Occur.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red Goshawk</td>
<td>Erythrorhynchus radiatus</td>
<td>V</td>
<td>Species or species habitat likely to occur within area</td>
<td>1 1 [Historical]</td>
<td>1</td>
<td>High</td>
<td>- E</td>
<td>Coastal and sub-coastal tall open forests and woodlands, preferring areas with a mosaic of vegetation types, permanent water and abundant small birds. Associated with gorse and escarpment country in partially cleared country in eastern Queensland. In eastern Australia, birds seem to move from inland nest sites to coastal plains in winter. Requires large areas of suitable habitat, occupying home ranges of 50-220km². Suitable habitat present on the Project area. Recorded within 10 km of the Project area. Potential to Occur.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common Name</td>
<td>Scientific Name</td>
<td>EPBC Act Status</td>
<td>PMST Type of Presence</td>
<td>Wildlife Online Database</td>
<td>Bird Atlas Database</td>
<td>Atlas of Living Aust.</td>
<td>QDWC Back on Track Species</td>
<td>QDWC Other Studies</td>
<td>Literature Review</td>
<td>NC Act Status</td>
</tr>
<tr>
<td>-----------------------</td>
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</tr>
<tr>
<td>Grey Falcon</td>
<td>Falco hypoleucus</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Squatter Pigeon</td>
<td>Geophaps scripta scripta</td>
<td>V</td>
<td>Species or species habitat likely to occur within area</td>
<td>7</td>
<td>1 (Historical)</td>
<td>1</td>
<td>Medium</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Painted Honeyeater</td>
<td>Grantiella picta</td>
<td>V</td>
<td>Species or species habitat may occur within area</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>High</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Star Finch (eastern)</td>
<td>Neochmia ruficauda ruficauda</td>
<td>E</td>
<td>Species or species habitat likely to occur within area.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>E</td>
</tr>
<tr>
<td>Eastern Curlew</td>
<td>Numenius madagascariensis</td>
<td>CE, MIW</td>
<td>-</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>Low</td>
<td>1</td>
<td>-</td>
<td>E</td>
</tr>
<tr>
<td>Southern Black-Throated Finch</td>
<td>Poephila cincta cincta</td>
<td>CE</td>
<td>Species or species habitat may occur within area.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>High</td>
<td>-</td>
<td>-</td>
<td>E</td>
</tr>
<tr>
<td>Australian Painted Snipe</td>
<td>Rostratula australis</td>
<td>E</td>
<td>Species or species habitat likely to occur within area.</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>Medium</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Fork-tailed Swift</td>
<td>Apus pacificus</td>
<td>MI, MIW</td>
<td>Species or species habitat likely to occur within area</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>SL</td>
</tr>
<tr>
<td>Common Name</td>
<td>Scientific Name</td>
<td>EPBC Act Status</td>
<td>PMATT Type of Presence</td>
<td>Wildlife Online Database</td>
<td>Bird Atlas Database</td>
<td>Atlas of Living Aust.</td>
<td>Biolink on Track Species</td>
<td>NC Act Status</td>
<td>Likelihood of Occurrence</td>
<td></td>
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<tr>
<td>---------------------</td>
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<td>------------------------</td>
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<td>--------------------------</td>
<td></td>
</tr>
<tr>
<td>Horsfields Cuckoo</td>
<td>Cuculus optatus</td>
<td>MI</td>
<td>Species or species habitat may occur within area</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Low</td>
<td>-</td>
<td>SL</td>
<td></td>
</tr>
<tr>
<td>Yellow Wagtail</td>
<td>Motacilla flava</td>
<td>MIT</td>
<td>Species or species habitat may occur within area</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Low</td>
<td>-</td>
<td>SL</td>
<td></td>
</tr>
<tr>
<td>White-throated Needle-tail</td>
<td>Hirundapus caudacutus</td>
<td>MIT</td>
<td></td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>Low</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Satin Flycatcher</td>
<td>Myiagra cyanoleuca</td>
<td>MIT</td>
<td>Species or species habitat known to occur within area</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>Low</td>
<td>-</td>
<td>SL</td>
<td></td>
</tr>
<tr>
<td>Rufous Fantail</td>
<td>Rhipidura rufifrons</td>
<td>MI</td>
<td>Species or species habitat known to occur within area</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caspian Tern</td>
<td>Hydroprogne caspia</td>
<td>MIT</td>
<td></td>
<td>9</td>
<td>7</td>
<td>7</td>
<td>Low</td>
<td>-</td>
<td>SL</td>
<td></td>
</tr>
</tbody>
</table>

The species uses a range of vegetated habitats such as monsoon rainforest, wet sclerophyll forest, open woodlands and appears quite often along edges of forests, or ecotones between forest types. This cuckoo feeds arboreally, foraging for invertebrates on loose bark on the trunks and branches of trees, and among the foliage, including in mistletoes. It will forage from the ground, but requires shrubs or trees from which it sallies and returns to consume prey items. Caterpillars are a favoured food.

Habitat requirements for the Yellow Wagtail are highly variable, but typically include open grassy flats near water. Habitats include open areas with low vegetation such as grasslands, airstrips, pastures, sports fields; damp open areas such as muddy or grassy edges of wetlands, rivers, irrigated farmland, dams, waterholes; sewage farms, sometimes utilise tidal mudflats and edges of mangroves.

The species is found across a range of habitats, more often over wooded areas, where it is almost exclusively aerial, though does roost in tree hollows and the foliage canopy. It forages for insects on the wing; flying anywhere between "cloud level" and "ground level" and readily forms mixed feeding flocks with other aerial insectivores. The species roosts at night in the crowns of tall trees, mainly in forest habitats. The species moves gradually southward in eastern Australia, and in the south it is most common late in the summer (Feb-Mar or early April), and has become increasingly rare at all times but especially in the Oct-Dec period.

Satiny Flycatchers inhabit heavily vegetated gullies in eucalypt-dominated forests and taller woodlands, and on migration, occur in coastal forests, woodlands, mangroves and drier woodlands and open forests.

In east and south-east Australia, the Rufous Fantail mainly inhabits wet sclerophyll forests, often in gullies dominated by eucalypts such as Tallow-wood (Eucalyptus microcarpa), Mountain Grey Gum (E. cypellocarpa), Narrow-leaved Peppermint (E. radiata), Mountain Ash (E. regnans), Alpine Ash (E. delegatensis), Blackbutt (E. pilularis) or Red Mahogany (E. resinifera); usually with a dense shrubby understorey often including ferns. They also occur in subtropical and temperate rainforests.

Mostly found in sheltered coastal embayment's (harbours, lagoons, inlets, bays, estuaries and river deltas) and those with sandy or muddy margins are preferred. They also occur on near-coastal or inland terrestrial wetlands that are either fresh or saline, especially lakes (including ephemeral lakes), waterholes, reservoirs, rivers and creeks. They also use artificial wetlands, including reservoirs, sewage ponds and saltworks. In offshore areas the species prefers sheltered situations, particularly near islands, and is rarely seen beyond reefs.

Suitable habitat is present on the Project area. Species has been recorded within 10 km of the Project area. Potential to Occur.

Suitable habitat is present on the Project area. Species has been recorded within 10 km of the Project area. Potential to Occur.

Limited suitable habitat present on the Project area. Not recorded within 10 km of the Project area. Unlikely to Occur.
<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>EPI Act Status</th>
<th>MAP1 Type of Presence Level of Concern</th>
<th>Wildlife Online Database</th>
<th>Bird Atlas Database</th>
<th>Atlas of Living Aust.</th>
<th>Qld Back on Track Species</th>
<th>Literature Review other Studies</th>
<th>EPBC Act Status</th>
<th>Likelihood of Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latham's Snipe</td>
<td>Gallinago hardwickeii</td>
<td>MIW</td>
<td>Species or species habitat may occur within area</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>Low</td>
<td>-</td>
<td>SL</td>
<td>Suitable habitats present on the Project area. Potential to Occur.</td>
</tr>
<tr>
<td>Osprey</td>
<td>Pandion haliaetus</td>
<td>MIW</td>
<td>Species or species habitat known to occur within area</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Low</td>
<td>-</td>
<td>SL</td>
<td>Suitable habitats present on the Project area. Not recorded within 10 km of the Project area. Unlikely to Occur.</td>
</tr>
</tbody>
</table>

**MAMMALS**

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>EPI Act Status</th>
<th>MAP1 Type of Presence Level of Concern</th>
<th>Wildlife Online Database</th>
<th>Bird Atlas Database</th>
<th>Atlas of Living Aust.</th>
<th>Qld Back on Track Species</th>
<th>Literature Review other Studies</th>
<th>EPBC Act Status</th>
<th>Likelihood of Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Pied Bat</td>
<td>Chalinolobus dwyeri</td>
<td>V</td>
<td>Species or species habitat likely to occur within area</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>Medium</td>
<td>✓</td>
<td>V</td>
<td>Suitable habitats present on the Project area. Potential to Occur.</td>
</tr>
<tr>
<td>Corbens long-eared bat</td>
<td>Nyctophilus corbeni</td>
<td>V</td>
<td>Species or species habitat may occur within area</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>Medium</td>
<td>✓</td>
<td>V</td>
<td>Suitable habitats present on Project area. Occurs within Expert Maybe area. Potential to Occur.</td>
</tr>
<tr>
<td>Ghost Bat</td>
<td>Macraderma gigas</td>
<td>V</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>Critical</td>
<td>-</td>
<td>V</td>
<td>Suitable habitats present on the Project area. Not recorded within 10 km of the Project area. Unlikely to Occur.</td>
</tr>
<tr>
<td>Grey-headed Flying Fox</td>
<td>Pteropus poliocephalus</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>Critical</td>
<td>0</td>
<td>LC</td>
<td>Suitable habitats present on the Project area. Not recorded within 10 km of the Project area. Unlikely to Occur.</td>
</tr>
<tr>
<td>Koala (combined populations of QLD, NSW and the ACT)</td>
<td>Phascolarctus cinereus</td>
<td>V</td>
<td>Species or species habitat known to occur within area</td>
<td>6</td>
<td>-</td>
<td>6</td>
<td>Low</td>
<td>V</td>
<td>V</td>
<td>Suitable habitat present on the Project area. Not recorded within 10 km of the Project area. Unlikely to Occur.</td>
</tr>
<tr>
<td>Bridled nail-tail wallaby</td>
<td>Onychogale fraenata</td>
<td>E</td>
<td>Species or species habitat known to occur within area</td>
<td>0</td>
<td>-</td>
<td>1 (1881)</td>
<td>Critical</td>
<td>E</td>
<td>V</td>
<td>Inhabited a wide range of vegetation types, generally characterized as dry woodlands, thickets and grassland. In its current limited distribution it shows a preference for transitional vegetation between dense Acacia scrub and eucalyptus open woodlands with grassy understory, and between pasture and young regrowth of Brigalow Acacia harpophylla. Not recorded within 10 km of the Project area. Suitable habitat present on the Project area, but species has never been detected on the Project area. Unlikely to Occur.</td>
</tr>
<tr>
<td>Common Name</td>
<td>Scientific Name</td>
<td>EPBC Act Status</td>
<td>PMST Type of Presence</td>
<td>Wildlife Online Database</td>
<td>Bird Atlas Database</td>
<td>Atlas of Living Aust.</td>
<td>Qld Back on Track Species</td>
<td>Literature Review other Studies</td>
<td>NC Act Status</td>
<td>Preferred Habitat</td>
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<tr>
<td>Greater Glider</td>
<td>Petauroides volans</td>
<td>V</td>
<td>Species or species habitat known to occur within area</td>
<td>0 - 0 0 Low - LC</td>
<td>Species largely restricted to wet eucalypt forests and woodlands. It is typically found in highest abundance in taller, montane, moist eucalypt forests with relatively old trees and abundant hollows.</td>
<td>Limited suitable habitat present on the Project area. Predominantly a Coastal species. Not recorded within 10 km of the Project area. Unlikely to Occur.</td>
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</tr>
<tr>
<td>Northern Quoll</td>
<td>Dasyurus hallucatus</td>
<td>E</td>
<td>Species or species habitat likely to occur within area</td>
<td>0 - 0 Medium - LC</td>
<td>Occupies a diversity of habitats across its range which includes rocky areas, eucalypt forest and woodlands, rainforests, sandy lowlands and beaches, shrubland, grasslands and desert. Northern Quoll is also known to occupy non rocky lowland habitats such as beach scrub communities in central Queensland. Northern Quoll habitat generally encompasses some form of rocky area for denning purposes with surrounding vegetated habitats used for foraging and dispersal. Rocky habitats are usually of high relief, often rugged and dissected but can also include tor fields or caves in low lying areas such as in Western Australia.</td>
<td>Suitable habitat present on the Project area. Not recorded within 10 km of the Project area. Unlikely to Occur.</td>
<td></td>
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</tr>
<tr>
<td>Short-beaked Echidna</td>
<td>Tachyglossus aculeatus</td>
<td>- -</td>
<td>5 - 6 Low - SL</td>
<td>Includes forests, woodlands, shrublands and Grasslands, rocky outcrops and agricultural lands. Echidnas are usually found among rocks, in hollow logs, under vegetation or piles of debris, under tree roots or sometimes in wombat or rabbit burrows.</td>
<td>Suitable habitat present on the Project area. Recorded within 10 km of the Project area. Potential to Occur.</td>
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<tr>
<td>REPTILES</td>
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</tr>
<tr>
<td>Collared Delma</td>
<td>Delma torquata</td>
<td>V</td>
<td>Species or species habitat may occur within area</td>
<td>0 - 0 High - V</td>
<td>Open eucalypt forest with a shrub and tussock grass understorey. Soil type is usually shallow and deep-cracking or stony; prefers areas with loose surface, rocks, including rocky slopes and ridge tops. Shelters under weathered loose rocks, flatish bedrock outcappings, logs or mats of leaf, litter, or in soil cracks and crevices among tussock grasses</td>
<td>Suitable habitat present on the Project area. Not recorded within 10 km of the Project area. Unlikely to Occur.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ornamental Snake</td>
<td>Denisonia maculata</td>
<td>V</td>
<td>Species or species habitat known to occur within area</td>
<td>0 - 5 Medium - V</td>
<td>Lower-lying subtropical areas with deep-cracking clay soils and adjacent slightly elevated ground of clayey and sandy loams, is the preferred habitat for this species. The species is also found in vegetation of woodland and shrub land, including some Brigalow Acacia harpophylla, and also riverside woodland and open forest, particularly on natural levees.</td>
<td>Suitable habitat present on the Project area. Species has been recorded within 10 km of the Project area. Potential to Occur.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Yakka Skink</td>
<td>Egernia rugosa</td>
<td>V</td>
<td>Species or species habitat likely to occur within area</td>
<td>1 - 1 Medium - V</td>
<td>Variety of drier forests and woodlands, usually on well-drained, gritty soils, including Poplar Box Eucalyptus populnea on alluvial soils, White Cypress Pine Calitro glaucophylla on sands, Bull Oak Allocasuarina leuehmannii, Brigalow Acacia harpophylla, Bendee Acacia catenulata and Mulga Acacia aneura. Lives in burrows, abandoned rabbit warrens, and hollow logs or in deep rock crevices. An extremely secretive species; its presence is often indicated by scats near its shelter sites</td>
<td>Recorded within 10 km of the Project area. Occurs within Expert &quot;maybe&quot; area. Suitable habitat present on the Project area. Potential to Occur.</td>
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</tr>
</tbody>
</table>
### FISH

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>EPBC Act Status</th>
<th>HABITAT Type of Presence</th>
<th>Wildlife Online Database</th>
<th>Bird Atlas Database</th>
<th>Atlas of Living Aust.</th>
<th>Qld Back on Track Species</th>
<th>NC Act Status</th>
<th>Likelihood of Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Murray Cod</td>
<td>Macquaria australasica</td>
<td>V</td>
<td>Species or species habitat may occur within area</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>V</td>
<td>Suitable habitat present on the Project area. Potential to Occur.</td>
</tr>
</tbody>
</table>

Note: CE: Critically Endangered; E: Endangered (EPBC Act and NC Act), V: Vulnerable (EPBC Act and NC Act), SL: Special Least Concern (NC Act), LC: Least Concern (NC Act), MiW: Migratory Wetland (EPBC Act); MiT: Migratory Terrestrial (EPBC Act); MiM: Migratory Marine (EPBC Act); MiM: Migratory (EPBC Act)

The distribution of this species overlaps with the following EPBC Act-listed threatened ecological communities: Brigalow (Acacia harpophylla dominant and co-dominant) and Bluegrass (Dichanthium spp.) dominant grasslands of the Brigalow Belt Bioregions (North and South).