CHAPTER 16 – AQUATIC ECOLOGY AND STYGOFAUNA

GULF ALUMINA LTD – SKARDON RIVER BAXITE PROJECT
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16. AQUATIC ECOLOGY AND STYGOFAUNA

16.1 Introduction

This chapter describes the freshwater aquatic ecosystems, fauna and flora within and surrounding the Project area, based on field surveys and desktop reviews, and defines environmental objectives and performance outcomes for freshwater aquatic ecology (hereafter referred to as aquatic ecology). Matters of national environmental significance (MNES) and matters of state environmental significance (MSES) associated with aquatic ecology are described. This chapter identifies potential Project impacts on the aquatic environment, including MNES and MSES, describes measures to mitigate and manage impacts, and provides a risk assessment for residual impacts. The significance of residual impacts on MNES and MSES is assessed and potential biodiversity offsets identified.

Information in this chapter is primarily based on the information provided in Appendix 6 and Appendix 7.

Chapter 15 describes the terrestrial ecology (including MNES and MDSES) of the Project and assesses Project impacts on terrestrial ecology, noting that the terrestrial and aquatic environments are not discrete and elements of terrestrial ecology and freshwater aquatic ecology are described in both chapters.

Chapter 17 describes coastal processes and assesses Project impacts on coastal processes. Chapter 18 describes marine ecology (including MNES and MSES) and assesses Project impacts on marine ecology.

16.2 Environmental Objectives and Performance Outcomes

The environmental objectives and performance outcomes below are based on Schedule 5, Table 2 of the Environmental Protection Regulations 2008 (EP Regulation). The mitigation and management measures presented in this chapter are designed to achieve these environmental objectives and performance outcomes. The environmental management plan (EM Plan) presented in Appendix 13 provides a consolidated description of these mitigation and management measures.

16.2.1 Environmental Objectives

- The activity is operated in a way that protects the environmental values of water, wetlands and associated flora and fauna.
- The activity will be operated in a way that protects the environmental values of groundwater and any associated surface ecosystems, fauna and flora.
- Minimise direct and indirect impacts on fauna and flora.
- Biodiversity offsets are provided for significant residual impacts on fauna and flora.

16.2.2 Performance Outcomes

- Any discharge to water or a watercourse or wetland will be managed so that there will be no adverse effects due to the altering of existing flow regimes for water or a watercourse or wetland.
- Any changes in the hydrology of wetlands or watercourses as a result of mining activities will be prevented or minimised.
- The activity will be managed in a way that prevents or minimises adverse effects on wetlands.
The activity will be managed to prevent or minimise adverse effects on groundwater or any associated surface ecological systems.

Areas of high conservation value and special significance likely to be affected by the proposal are identified and evaluated and any adverse effects on the areas are minimised, including any indirect impacts on the areas.

Biodiversity offset plans will be developed for any significant residual impacts on fauna and flora in accordance with relevant Commonwealth and State policies.

Buffer zones are created around sensitive ecological areas (i.e. wetlands and watercourses) where mining activities are restricted.

Areas of connectivity between mining areas, including wetlands and watercourses are retained.

Weeds and pests are managed to prevent increase in abundance or diversity.

### 16.3 Legislative and Policy Context

MSES are regulated under the Queensland *Environmental Protection Act 1994* (EP Act), the *Nature Conservation Act 1992* (NC Act), and the *Vegetation Management Act 1999* (VM Act), while MNES are regulated under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The NC Act also protects essential habitat of a protected species and an animal breeding place. The *Fisheries Act 1994* regulates the construction of water barriers. Further information on these Acts is provided in Chapter 2. Legislation and policy relevant to water quality is described in Chapter 12.

Schedule 12 Part 1 of the EP Act defines Environmentally Sensitive Areas (ESAs) and Schedule 3A establishes criteria that protects ESAs. Category B ESAs include endangered regional ecosystems (EREs) as identified in the ‘Regional Ecosystem Description Database’ (REDD).

For the purpose of resource activities under the *Mineral Resources Act 1989* (MR Act) that are regulated for environmental compliance under the EP Act, the biodiversity status (BD status) of a regional ecosystem (RE) is used to determine that status of EREs, not the VM Act status (VM status). However, the requirement for biodiversity offsets under the *Environmental Offsets Act 2014* (EO Act) is triggered by VM status not by BD status.

The *Environmental Offsets Regulation 2014* (EO Regulation) can require offsetting for MSES including endangered and of concern remnant regional ecosystems (REs), REs that intersect with wetlands or are within a defined distance of a watercourse, essential habitat for endangered or vulnerable plants or animals, specific protected wildlife habitat, connectivity areas, wetlands and watercourses, protected areas and legally secured offset areas. Endangered, vulnerable, near threatened wildlife and special least concern animals are protected under the NC Act.

MNES regulated under the EPBC Act include listed threatened plants and animals scheduled as critically endangered (CE), endangered (E), or vulnerable (V), and threatened ecological communities (TECs). A requirement for biodiversity offsets for MNES may be triggered by the EPBC Act Environmental Offsets Policy (2012).

The Queensland Government has produced Aqua BAMM which provides an approach for assessment of aquatic ecosystems values.
16.4 Field Surveys

16.4.1 Aquatic Ecology

A field survey for freshwater aquatic flora and fauna was conducted in March 2015. Vegetation and flora surveys, including wetland and watercourse vegetation and flora were completed in mid-April 2010, early June 2010, early April 2011 and February 2015, and are described in Chapter 15.

Local freshwater streams at the commencement of the field survey contained moderate flows, indicating that direct runoff from the previous rainfall events had not yet subsided. Wetlands across the entire Project area were considered expansive and were likely to be at their maximum extent. Further information is provided in Appendix 6.

Monitoring/assessment locations were selected to provide a representative sample of aquatic ecosystems within the Project area and to consider the proposed footprint. Monitoring locations are shown in Figure 16-1. Aquatic ecological sampling and analysis was conducted in accordance with or with close reference to, the following:


Field surveys were undertaken for water quality, sediment, aquatic plants, macroinvertebrates, macrocrustaceans and fish, as described in Table 16-1. Data collected on water quality has been incorporated into water quality data reported in Chapter 12.

### Table 16-1 Field Survey Site Locations and Survey Descriptions

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Coordinates (Datum: GDA94)</th>
<th>Sampling Conducted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Longitude (54k)</td>
<td>Latitude (54k)</td>
</tr>
<tr>
<td>AQ-NA01</td>
<td>611492</td>
<td>8686208</td>
</tr>
<tr>
<td>AQ-NA02</td>
<td>610493</td>
<td>8685825</td>
</tr>
<tr>
<td>AQ-NA03</td>
<td>609600</td>
<td>8686484</td>
</tr>
<tr>
<td>AQ-NA04</td>
<td>609279</td>
<td>8686820</td>
</tr>
<tr>
<td>AQ-LU01</td>
<td>612153</td>
<td>8688641</td>
</tr>
<tr>
<td>AQ-BF01</td>
<td>613740</td>
<td>8694621</td>
</tr>
</tbody>
</table>

All aquatic fauna surveys are subject to inherent limitations in the detection success of target species. These limitations often result in a degree of false-absence records (i.e. a species is present but not detected). Therefore desktop reviews and expert knowledge were considered to determine the value of the Project for supporting aquatic species (i.e. absence of a species was not assumed because it was not detected).

All sediment sampling, field testing and quality determinations were undertaken in accordance with the following:

16.4.2 Stygofauna

In accordance with the ‘Pilot Survey’ approach presented in the *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (DSITIA 2014), ten bores were surveyed for stygofauna between 21 and 26 April 2015. As recommended by DSITIA (2014), the survey design included impact and control bores: five bores were in the area where groundwater may be disturbed by the Project (impact bores), and five bores were where groundwater will not be modified by the project (control bores). Further information, including bore locations is provided in Appendix 7. All bores are either within the Project area or within 2 km of the Project area.

16.5 Desktop Review

The desktop review was undertaken to identify potential matters of ecological significance including species and communities, and other ecological features that may occur on or within the vicinity of the Project disturbance area. This review included an assessment of the following information:

- **Aerial Photograph Interpretation (API)** to determine the broad categorisation of vegetation within and surrounding the site and to review the extent of historical clearing and land use, and any other significant environmental features such as watercourses and wetlands.
- **RE and essential habitat mapping** (DNRM, 2013). The most recent version of the EHP regulated vegetation management mapping (2015) including essential habitat mapping was used to provide an indication of the status and position of remnant vegetation and any mapped essential habitat in relation to landforms of the site.
- **Wetland Maps Report Tool**. This mapping tool has access to the Wildlife Online database of flora and fauna which holds records of plants and animals that have either been sighted or collected within a given drainage basin, including any records of conservation significant species. The records held in this database are maintained by EHP (accessed 24th February 2015).
- **Queensland Wetland Mapping**. Mapping was sourced from the EHP wetland database and the Protected Matters Search Tool (accessed 20th January 2015). This includes EHP Referable Wetlands Mapping as well as broader state-wide wetlands mapping (refer Wetland Info).
- **Referable wetlands mapping** (EHP, 2014a). The referable wetlands mapping produced by EHP was reviewed to provide an indication of the occurrence and location of any wetland management areas in relation to proposed Project activities.
- **Wildlife Online database of flora and fauna** (DEHP, 2014b). This database holds records of plants and animals that have either been sighted or collected within a given radius of the site (a search parameter was prescribed limiting the search area to a 10km radius around an approximate central point of the site (-11.82822 142.04341)). The records held in this database are maintained by EHP.
- **HERBRECS database of plant records**. This database provides confirmed records of plant collections made within a specified area, of which voucher specimens are held by the Queensland Herbarium (EHP). Data from this source provides useful information on the location of rare and threatened species and expedites targeted surveys for such plants in the field.
- **Protected matters database of MNES** (DoE, 2015a). This database applies a range of bio-models to predict the presence of species of flora and fauna and other MNES within a given radius of the site (a search parameter was prescribed limiting the search area to a 20 km radius around an approximate central point of the study area (-11.83918 142.0259)).
Review of relevant legislation and associated plans and policies, including but not limited to the NC Act, VM Act, EPBC Act, and the Water Act.

- Literature review. A range of scientific papers, recovery and conservation plans and other literature were reviewed for a number of related matters (such as targeted threatened species).
- Advice from federal and state agency personnel on specific species expected to target during surveys (for example Bare-rumped Sheathtail Bat).
- Other databases containing relevant species information, including BirdData (web version of Birds Australia's New Atlas of Australian Birds) and the International Union for the Conservation of Nature (IUCN) Red List.

Over the course of aquatic ecology studies undertaken for the Project, a number of different searches of publicly available databases (e.g. Wildlife Online and EPBC Act Protected Matter Search) have been generated for the Project area and surrounding buffer zones. Over time, the information provided in these searches has changed including the list and status of threatened species. The most recent publicly available information has been used as a reference point for assessment of aquatic ecology values, although ecosystems or species of conservation significance identified through previous searches may also be described and assessed.

The desktop review for stygofauna used existing information to assess the suitability of local environmental features (e.g. geology, hydrology, water quality) for stygofauna, and the likely nature (e.g. diversity, taxonomic composition and abundance) of stygofauna.

### 16.6 Environmental Values

#### 16.6.1 Catchments and Watercourses

Catchments and watercourses within the Project area and surrounds are described in Chapter 12, Section 12.4, and summarised below.

The Project’s mining leases are primarily drained by two drainages – the Skardon River and Namaleta Creek. The northern end of the Project is bounded by the Skardon River which drains mangrove areas through three primary tributaries to the south and east. The Skardon River is considered a predominantly estuarine system, consisting of freshwater systems within its upper reaches.

Namaleta Creek is a localised drainage with a catchment of 37 km², of which 21 km² lies upstream of the eastern mine boundary. This watercourse is tidally influenced, where mangrove communities begin approximately 1 km west (downstream) of the existing crossing of Namaleta Creek.

#### 16.6.2 Wetlands

A number of different wetland mapping systems exist for wetlands in Queensland. Wetlands within the Project area and surrounds are described in Chapter 12, Section 12.4. Potential wetlands within and surrounding the Project have been mapped by EHP, and are shown in:

- **Figure 16-6** for EHP WetlandInfo mapping which separates wetlands into marine, estuarine, riverine, lacustrine and palustrine
- **Figure 16-7** for EHP’s map of referable wetlands showing high ecological significance wetlands and general high ecological significance wetlands (noting that there are no mapped ‘wetland protection areas’)
- **Figure 16-8** for EHP’s Vegetation Management Act wetlands
For the purpose of describing freshwater wetlands and assessing potential Project impacts, the following wetland groupings have been considered:

- Lunette Swamp
- Bigfoot Swamp
- Namaleta Creek (freshwater sections)
- The HES wetlands bisecting Pits 14 and 15
- Supratidal wetlands to the west of the Skardon River South Arm
- Wetland complexes to the west and north of the Project area.

For the purpose of describing marine and estuarine wetlands and assessing potential Project impacts, the following wetland groupings have been considered:

- Skardon River estuarine areas
- Namaleta Creek estuarine areas.

16.6.3 Wetland Hydrology

As described in Chapter 13, Section 13.5.5, all wetlands in and surrounding the Project area are considered to be dependent on shallow aquifers as well as runoff from rainfall. The wetlands within and surrounding the Project area include several groundwater dependent ecosystems located along drainage lines which comprise valley fill alluvial deposits with underlying shallow aquifer systems. All freshwater wetlands are likely to be recharged by surface water during the wet season and maintained during the dry season by seasonally perched groundwater recharge. All wetlands are considered to be shallow aquifer groundwater dependent ecosystems.

Based on site knowledge, Lunette Swamp and Bigfoot Swamp wetlands dry out during the dry season, except for small ponds at the lower end of Bigfoot Swamp, which can also dry out in some years. Lunette Swamp dries out fairly rapidly, by July 2015 there was no water in Lunette Swamp.

The palustrine wetlands across the Project area are associated with depressions and water course drainage lines. In addition to retaining water they are also a repository of soils and sediments that will retain nutrients to support local biodiversity. The detailed nature of partitioning of the various components of the hydrological cycle – rainfall, runoff, recharge and baseflow, as they affect wetlands, is understood at a conceptual level for the area. These wetlands are dependent on surface water and groundwater interaction. The riverine and estuarine wetlands reaches of Namaleta Creek adjacent to the Project and further downstream are affected by the behaviour of runoff and baseflows entering the Creek.

Freshwater swamps and riverine systems (e.g. Namaleta Creek) are likely to be recharged by surface water during the wet season and maintained for variable durations during the dry season by seasonally perched groundwater recharge. These systems are considered ephemeral, where surface water contracts to small semi-permanent pools during the dry season.

16.6.4 Wetland Ecosystems

Vegetation within wetlands is described in Chapter 15, Section 15.6.2, with a summary provided below.

16.6.4.1 Lunette Swamp

Lunette Swamp is characterised by two distinct inner vegetation patterns, and one less distinct pattern occupying the outermost area of land influenced by the wetland. Consequently, three subunits of
vegetation are mapped for this drainage depression: 7a, 7b and 7c (corresponding with RE 3.3.14 / 3.3.22) – each with unique floristic characteristics. Vegetation unit 7a is under fresh water for long periods, where the deepest water was recorded as 1.5m and marked by a consistent band of moss growing around old *Lophostemon suaveolens* trees at this level. The unit is characterised by low open forest dominated by *Asteromyrtus symphyocarpa* to a height of 4-6 m. The ground layer flora is remarkably simple with diversity limited to more or less two species due to long-term submergence and probably anaerobic conditions.

Vegetation unit 7b forms a distinctive floristic edge of Lunette Swamp that is defined by the presence of a band of dispersed False Casuarina (*Calycopeplus casuarinoides*) trees, bloodwoods and the paperbark *Melaleuca saligna* forming woodland to open woodland to 8-10 m. The vegetation outside of the ‘wetland’ zone reverts to the Darwin Stringybark (*Eucalyptus tetrodonta*) and Melville Island Bloodwood (*Corymbia nesophila*). Vegetation unit 7c occupies the outermost fringe of the wetland and grades subtly into tall grassy woodland of *Eucalyptus tetrodonta* and *Corymbia nesophila* with a mid-dense shrub layer (vegetation unit 6 (RE 3.5.2)).

At the time of the field investigation, the wetland systems within the Project area were near the maximum extent of inundation due to season rain, as shown in Figure 16-2.

**Figure 16-2** Lunette Swamp - Outer Margins, March 2015

### 16.6.4.2 Bigfoot Swamp

The EHP mapped RE for Bigfoot Swamp is mixed polygon RE 3.3.14a / 3.3.22a, as shown in Figure 16-10. An observational survey of Bigfoot Swamp was undertaken in February 2015. A detailed floristic and vegetation description was not made at the time, so variation and different floristic associations are likely
to occur in different sections of the Swamp. The Swamp however, does appear (from the edge) to have floristic and structural similarities to Lunette Swamp, particularly in the development of large-class specimens of *Lophostemon suaveolens* and the density and stem diameters of the dominant tree *Asteromyrtus symphyocarpa*. On this basis the outer margins of the swamp consist of RE 3.3.22a and it is highly likely that the internal sections of the swamp consist of RE 3.3.14a.

RE 3.3.14a vegetation communities are described as:

- Palustrine wetland (e.g. vegetated swamp). *Melaleuca saligna* (paper bark) usually dominates the sparse canopy (10-18m tall). *Lophostemon suaveolens* (swamp mahogany) is frequently a codominant canopy tree. *Melaleuca clarksonii* (hard-barked teatree) is sometimes present as an emergent tree (12-16m tall) in the deepest part of the swamps. *Asteromyrtus symphyocarpa* usually dominates the very sparse to sparse sub-canopy layer (4-10m tall). *Calycopeplus casuarinoides* (false casuarina) occurs on the margins of the wettest areas. The shrub layer (0.5-2.5m tall) is usually very sparse and the very sparse to sparse ground layer consists mainly of graminoids. Occurs in drainage swamps, which generally remain flooded in the wet season for many months.

RE 3.3.2a is described as:

- floodplain (other than floodplain wetlands). *Corymbia clarksoniana* (Clarkson's bloodwood) dominates the sparse canopy (8-25m tall).

At the time of the field investigation, the wetland systems within the Project area were near the maximum extent of inundation due to season rain, as shown in Figure 16-3.
16.6.4.3 Supratidal Wetland along Skardon River

There is an inconspicuous wetland zone between the mangroves and the base of the bauxite plateau, as shown in Figure 16-4. It is too small to assign to a regional ecosystem type, but forms part of vegetation map unit 5 (RE 3.1.1 / 3.1.3 / 3.1.6). This unique semi-aquatic feature is situated on the western banks of the south branch of the Skardon River. It is a narrow, linear wetland approximately 10 m wide at its widest point (often narrower) and is perched marginally higher than the highest tidal water level. The wetland is fed by a shallow seasonal freshwater seepage from what appears to be the aquifer at the base of the bauxite plateau and has an estuarine and tidal influence. A characteristic of this wetland is the permanence of tidal water and the presence of mangrove vegetation.

![Supratidal Wetland, March 2015](image)

16.6.4.4 Namaleta Creek (RE Complex)

Namaleta Creek is predominantly a freshwater system but is also influenced by the seasonal inland extent of saltwater incursion. Downstream sections of Namaleta Creek in ML6025 have a seasonal estuarine influence as indicated by the dominance of mangroves. Consequently, the watercourse supports a diverse range of vegetation types and is a zone of refuge for a range of flora not found elsewhere on leases. A detailed flora investigation of Namaleta Creek and its environs was undertaken in 2015 which identified:

- RE 3.3.12, *Melaleuca quinquenervia* open forest, *Eleocharis dulcis* sedgeland
- RE 3.3.9, Fringing woodland along outer edge of drainage line (edge of floodplain).
- RE 3.3.49, *Melaleuca viridiflora, Asteromyrtus symphyocarpa* low woodland
- RE 3.3.51, *Melaleuca acacioides* tall shrubland
RE 3.3.64, Asteromyrtus lysicephala open heath over sedgeland

Namaleta Creek was observed to consist of a mosaic of wetland systems including riverine system (river and creek channels) which contained deepwater habitats (<2m) and fringing palustrine systems which were dominated by persistent emergent vegetation (refer to Figure 16-5). Dominant trees and shrubs through this corridor comprised of Asteromyrtus spp., Melaleuca acaioides, Melaleuca viridiflora and emergent layer of M. Leucadendra. The sedge Eleocharis dulcis was observed to dominate the central channel where water was present, where the herbs Dapisanthus spathaceus and Fimbristylis insignis were also present on the edges.

Figure 16-5  Namaleta Creek, Sedge Dominated Main Channel, March 2015

16.6.4.5  Mapped Wetland between Pits 14 and 15 (RE 3.3.22a, Unit 9)

The description for map unit 9 (RE 3.3.22a) is based on a desktop assessment of photographs taken from the area in July 2015, which was unable to be accessed in February 2015 (wet season). The conspicuous floristic component of the trees (RE 3.3.22a) differs considerably from the current RE description of RE 3.3.64 / 3.3.9. Additional field surveys may be undertaken to confirm the RE status of this vegetation community. RE 3.3.22a is not associated with wetland habitat, it is classified as “floodplain (other than floodplain wetlands)” by EHP.
Referrable Wetlands - Wetland Management Areas

Legend:
- Port of Skardon River
- Mining Lease Boundaries
- Watercourses
- Existing Disturbance Footprint
- Project Footprint
- Southern Haul Road
- Wetland Buffer
- Wetland Management Area
  - HES Wetland
  - GES Wetland

Figure 16-7
Gulf Alumina Limited

Date: 8/10/2015
Reference: R1
Coordinate System: GDA 1994 MGA Zone 54
Map Scale: 1:80,000

No warranty is given in relation to the data (including accuracy, reliability, completeness or usefulness) and accept no liability (including without limitation, liability in negligence) for any loss, damage or costs (including professional legal costs) suffered or incurred by any person arising out of or in connection with the use of any information or reliance upon the data. Data must not be used for direct marketing or be used in breach of privacy laws. Tenures © Geos Mining (2015). State Boundaries and Towns © Geoscience Australia (2006). Watercourses © Geoscience Australia (imagery sourced from Gulf Alumina, Wetland Management Areas © State of Queensland, Department of Environment and Heritage Protection, 2014. Wetland Buffer provided by RPS.

By enacting the provisions of the above disclaimer entirely, you are agreeing to no liability, whether for damages, injuries, or any other matter resulting from the use of this data.
Figure 16-8
Gulf Alumina Limited

Legend
- Port of Skardon River
- VMA Watercourses
- Mining Lease Boundaries
- Existing Disturbance Footprint
- Project Footprint
- Southern Haul Road
- Wetland Buffer

Vegetation Management Act Wetlands and Watercourses

Date: 8/10/2015
Revision: 7

North

Port of Skardon River
ML 40082
ML 40089
Bigfoot Swamp
ML 6025
Lunette Swamp
ML 6025
Pit #15
Pit #14
Pit #15

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16.6.5 Aquatic Flora Species

The EPBC Act Search for MNES did not identify any threatened freshwater aquatic flora species listed under the EPBC Act that could potentially occur within the site.

The WetlandMaps Report Tool identified the threatened wetland indicator species *Lycopodiella limosa* as having been recorded within Ducie drainage basin. *Lycopodiella limosa* is listed as near threatened under the NC Act.

The Queensland Herbarium ‘HERBRECS’ search did not identify any records of threatened or near threatened species (wetland indicators) having been previously recorded within 20 km of the site.

Within the Ducie drainage basin, EHP WildNet database included data for a total of 531 flora species recorded, 72 are considered wetland indicator species (including *Lycopodiella limosa*).

No listed threatened freshwater aquatic flora species under the EPBC Act or NC Act were encountered during the field surveys.

Habitat for *Lycopodiella limosa* includes wetlands and swamps on soft organic mud /organic sands substrate. *Lycopodiella limosa* was considered to have a moderate likelihood of occurrence. There is suitable habitat for this species within wetland areas of the Project area, but within the Project footprint. Although the species has been identified in the Ducie drainage basin, the species has not been recorded within 50 km of the Project area.

16.6.6 Aquatic Fauna

The WetlandMaps Report Tool identified one threatened aquatic fauna species as having been recorded within Project area drainage basins, the estuarine crocodile (*Crocodylus porosus*). This species is described in Chapter 18.

The EPBC Act Search identified four threatened fauna species that are partially dependent on freshwater aquatic ecosystems that could potentially occur or have suitable habitat that could occur within and surrounding the Project area. The species identified and their status under the EPBC Act are:

- Speartooth Shark (*Glyphis glyphis*) – listed as critically endangered.
- Dwarf Sawfish (*Pristis clavata*) – listed as vulnerable.
- Freshwater Sawfish (*Pritis pritis*) – listed as vulnerable.
- Green Sawfish (*Pritis ziisron*) – listed as vulnerable.

All of these species are typically associated with the marine or estuarine environment and have therefore been assessed in Chapter 18 and Appendix 8. However, relevant information about the potential freshwater aquatic habitat within Namaleta Creek is provided below, noting that the Project will not impact freshwater habitat within the Skardon River.

The likelihood of occurrence of these species within freshwater habitat in Namaleta Creek is considered low for the following reasons:

- Speartooth Shark (*Glyphis glyphis*) - Due to Namaleta Creek’s limited freshwater extent (small system) and ephemeral nature, the system is not considered to contain its preferred habitat features.
- Dwarf Sawfish (*Pristis clavata*) and Green Sawfish (*Pritis ziisron*) - Due to Namaleta Creek’s limited freshwater extent (small system), ephemeral nature and low conductivity waters present within its upper reaches, the system is not considered to contain its preferred habitat features.
- Large tooth or Freshwater Sawfish (*Pritis pritis*) – Due to Namaleta Creek’s limited freshwater extent (small system) and ephemeral nature, the system would not provide a constant freshwater habitat for the species to inhabit in the first few years of its lifecycle.
16.6.7 Aquatic Macroinvertebrates

Aquatic macroinvertebrates were assessed based on taxonomic richness, PET taxa richness, aquatic community condition and the Signal 2 Index (refer Appendix 6 for further detail).

PET taxa richness is based on the number of aquatic macroinvertebrate families collected from three orders of aquatic insects: Plecoptera (stoneflies), Ephemeroptera (mayflies) and Trichoptera (caddisflies).

The Signal 2 Index provides an objective method to assess the condition of macroinvertebrate communities based on the ‘type’ and ‘presence’ of individual taxonomic groups.

At the time of the wet season survey, taxonomic richness in edge habitat collected from the lotic environment of Namaleta Creek was higher in comparison to the edge/pool composite habitats sampled from the palustrine systems of Bigfoot Swamp and Lunette Swamp.

PET taxa richness for the lotic environment of Namaleta Creek sites were higher compared to the palustrine systems of Bigfoot Swamp and Lunette Swamp.

Mean Signal 2 scores of macroinvertebrate samples collected from the edge habitat of the Namaleta Creek survey locations was 3.3; however, the mean signal scores for the Lunette Swamp and Bigfoot swamp were 2.8 and 3.8 respectively. Bigfoot swamp shows a lower tolerance to disturbance in comparison to the Namaleta Creek and Lunette Swamp.

Although the low macroinvertebrate taxonomic richness within the lotic environment of Namaleta Creek was not expected due to the relatively undisturbed nature of the catchment, the result is likely to be associated with the timing of sampling (within the monsoon season). Notwithstanding, the macroinvertebrate communities present at the time of the survey, are likely to be representative of undisturbed systems within the catchment, sampled at that particularly time of the year (monsoon season).

The low macroinvertebrate taxonomic richness which was also observed in the wetland systems Lunette Swamp and Bigfoot Swamp was expected to an extent, due to the non-flowing conditions and the lack of preferred edge sub-habitats tree roots, trailing vegetation, under overhanging banks and along logs), which is representative of wetland systems.

16.6.8 Macro-Crustaceans

Only one macro-crustacean was captured in a baited trap from Namaleta Creek, which was sent to the Queensland Museum for formal identification. The crab was identified as a juvenile Austrothelphusa sp., species unknown. The Museum informed that preliminary genetic work on these crabs indicate significant divergence between populations in different catchments. The results of this work may eventually indicate that there are a suite of narrow endemic species of Austrothelphusa.

16.6.9 Fish

Native fish are an important biological indicator of aquatic ecosystem health. Fish communities reflect a range of natural and human-induced disturbances through changes in abundance and species composition.

A total of seven species of fish were captured and/or observed within the wet season survey, including barramundi which require connectivity with the sea. Eastern rainbowfish and sailfin glassfish were the most abundant. None of the fish species identified are listed as threatened under the NC Act or EPBC Act.

No fish species were recorded in the wetland systems of Lunette Swamp and Bigfoot Swamp, which may indicate a lack of connectivity with other systems within the region, a condition that may differ seasonally.

The low number and diversity of fish species recorded during the March 2015 survey in Namaleta Creek was unexpected; this is taking into consideration the relatively undisturbed catchment however, general
observations (high water clarity) confirmed the lack of fish present. The lack of fish present may be representative of the timing of the survey, where fish populations had limited time to allow for recruitment. The survey coincided with the wet season of the region, where streams within the area contained moderate flows, indicating that direct runoff from previous and recent rainfall events had not yet subsided. Another factor that may have contributed to the low fish numbers observed during the survey maybe the ephemeral nature of Namaleta Creek. Notwithstanding, the low number and diversity of fish species recorded is likely to be representative of undisturbed systems within the catchment, when sampled at that particularly time (monsoon season) as the catchment above the Project area appears to be in very good condition.

16.6.10 Sediment Quality

The ANZECC/ARMCANZ (2000) interim sediment quality guideline (ISQG) values were used as the regional guidelines to compare and interpret collected data for the Project area. Results from sediment sampling are presented in Appendix 6. Sediment samples collected were analysed for total metal concentrations. The total metal concentrations for whole sediment fractions did not exceed the available ANZECC (2000) ISQG-Low guideline values. The low total metal concentrations recorded from the monitoring locations are a reflection of the catchment’s low mineralisation and undisturbed nature.

16.6.11 Stygofauna

Of the ten bores surveyed, six bores (three impact bores and three control bores) each contained an individual stygofaunal specimen (refer Appendix 7). A total of two stygofaunal taxa were found:

- Oligocheates (segmented worms), which are commonly found in a range of aquatic (surface freshwater, groundwater and marine) and terrestrial habitats. Freshwater oligocheates can live in pristine to highly degraded habitats, and are so tolerant of many types of pollution (e.g. nutrients, low dissolved oxygen) and habitat degradation that they make poor indicators of aquatic ecosystem condition.
- Acarina (freshwater mites), which are commonly found in a range of aquatic (surface freshwater, groundwater and marine) and terrestrial habitats. Freshwater mites are parasitic as juveniles, and become free-living and predatory as adults. The distribution of freshwater mites is generally patchy, and many have relatively limited geographical distributions.

No stygofaunal taxon was restricted to impact bores, with both oligocheates and mites recorded from control bores. Therefore, no recorded stygofaunal taxon is endemic to the Project footprint.

The diversity and abundance of stygofauna in eastern Australia is relatively high in alluvial and sand-dominated groundwater ecosystems. Clay-dominated geological units provide relatively poor habitat for stygofauna.

Surveys identified very low diversity and abundance of tolerant stygofauna taxa (i.e. worms and mites) within clay-dominated geological units. It is unlikely that diverse and abundant stygofaunal communities, or more environmentally sensitive stygofaunal taxa, would occur in such clay-dominated geological units. While the Project area is dominated by clay and otherwise unsuitable geological units for stygofauna, there are several small geological units within the Project area that may have greater suitability for diverse, endemic and abundant stygofaunal communities, including:

- Namaleta shallow aquifer system, which is a palaeochannel alluvium and sand aquifer
- Lunette shallow aquifer system, which is a shallow alluvium and sand aquifer, and
- the Bulimba formation, which contains shallow aquifers that consist of coarse sand.
In alluvial aquifers in eastern Australia, the average number of stygofauna taxa was higher when the samples were collected from less than 6 m from the water table, and where the water table was less than 10 m below ground. The Project area contains shallow groundwater ecosystems, with all surveyed bores having a depth to water table of less than 10 m. The hydrological characteristics of the Project area would support stygofaunal communities.

The electrical conductivity of groundwater within and near the Project area is very low and suitable for stygofauna. Stygofauna can tolerate a pH range of 4.3 to 7.5, but diversity is highest between 6.5 and 7.5. The pH of water at all bores surveyed within and near the Project study area was approximately 5 pH units, which is considerably lower than the range known to support diverse and abundant stygofauna communities (refer Chapter 12 for bore water quality). While the reported stygofaunal taxa (i.e. worms and mites) appear to tolerate these low pH conditions, more sensitive stygofaunal taxa may not be tolerant of low pH of the groundwater within and adjacent to the Project study area.

16.7 Potential Impacts and Mitigation Measures

16.7.1 Project Footprint and Regional Ecosystems / Vegetation Map Units

The impact of the Project footprint on regional ecosystem / vegetation map units is described in Chapter 15, including that there will be no direct impact in watercourses or wetlands other than Namaleta Creek crossing and the crossing of the EHP mapped HES wetland between Pits 14 and 15 (although this is considered to be a drainage feature and not a wetland).

16.7.2 Buffer Zones

In order to protect wetlands and wetland associated ecosystems from direct Project disturbance, the buffers zones listed in Table 16-2 have been proposed. Direct impacts within wetland and watercourse regional ecosystems / vegetation communities are limited to the haul road crossing of Namaleta Creek and the EHP mapped HES wetland between Pits 14 and 15. Buffer zones will also contribute to maintaining connectivity across the landscape and assist in reducing edge effects resulting from fire or spread of weeds.

These vegetation surveys described in Chapter 15, and shown on Figure 16-10, were used to delineate on mapping unique and important vegetation communities, including wetland ecosystems. The regional ecosystems associated with wetlands are shown in Figure 16-11. These vegetation maps are considered a more accurate representation of potential wetland areas than State mapped wetland areas provided in Figure 16-6 to Figure 16-9.

An effectively managed wetland buffer helps to maintain and protect the wetland itself, but also serves to maintain and protect ecological functions and processes and potentially significant species. With the exception of the 50 m buffer to the mapped HES wetlands bisecting Pits 14 and 15, a minimum 100 m buffer has been proposed for all other wetlands. The 100 m buffer distance has been developed with consideration of buffer distances required for specific wetland environmental values and stressor stated in the Queensland Wetland Buffer Planning Guideline – March 2011. Further information is provided in Appendix 6, justifying the selection of the buffer distances to protect environmental values in accordance with other published studies.

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1 DERM (2011) Queensland Wetland Definition and Delineation Guideline – Part A: A guide to existing wetland definitions and the application of the Queensland Wetlands Program definition, Department of Environment and Resource Management
Table 16-2 Buffer Zones

<table>
<thead>
<tr>
<th>Wetland</th>
<th>Map Units</th>
<th>Equivalent RE</th>
<th>Proposed Buffer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lunette Swamp</td>
<td>7a, 7b</td>
<td>RE 3.3.14/ 3.3.22</td>
<td>Will be protected from direct impacts by a buffer of at least 100m from mining activities.</td>
</tr>
<tr>
<td>Bigfoot Swamp</td>
<td>n/a</td>
<td>RE 3.3.14/ 3.3.22</td>
<td>Not located on the mining lease and at least 500m from the nearest mining activity.</td>
</tr>
<tr>
<td>Namaleta Creek</td>
<td>3, 5a, 5b, 5c, 5d, 5e, 5f</td>
<td>RE 3.3.50, RE 3.3.49, RE 3.3.64, RE 3.3.9, RE 3.3.12, RE 3.3.51</td>
<td>Will be protected from direct impacts by a buffer of at least 100m from mining activities, except where the southern haul road will necessitate further clearing.</td>
</tr>
<tr>
<td>Supratidal wetlands to the west of the Skardon River South Arm</td>
<td>5</td>
<td>RE 3.1.1 / 3.1.3/ 3.1.6</td>
<td>Will be protected from direct impacts by a buffer of at least 100m from mining activities.</td>
</tr>
<tr>
<td>The HES wetlands bisecting Pits 14 and 15</td>
<td>9</td>
<td>RE 3.3.22a</td>
<td>Will be protected from direct impacts by a buffer of at least 50m from mining activities, except where the southern haul road transects the HES wetland.</td>
</tr>
<tr>
<td>Wetland complexes to the west and north of the Project area</td>
<td>n/a</td>
<td>Multiple REs</td>
<td>Will be protected from direct impacts by a separation of at least 500m from the mining activities.</td>
</tr>
</tbody>
</table>

The only direct impact on wetlands and watercourses will be the upgraded crossing of Namaleta Creek and the extension of the haul road across the RE 3.3.22a (vegetation map unit 9 - the mapped HES wetland), resulting in approximately 2 ha of disturbance within mapped wetlands.

The overlap of buffer zones with the government mapped wetlands is shown Figure 16-6, Figure 16-7, Figure 16-8, and Figure 16-9. The overlap of field mapped regional ecosystems (derived from vegetation map units, including those associated with wetlands) with buffer zones is shown in Figure 16-10. The field mapped regional ecosystems associated with wetlands are shown in Figure 16-11, along with the proposed buffer zones, including overlaps. These overlaps are described in Table 16-3, with an explanation of the potential mapping issues giving rise to the overlap.

Table 16-3 Buffer Zones and Mining Overlaps

<table>
<thead>
<tr>
<th>Description of Buffer Overlap</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A small part of the eastern edge of Pit 1 near, but not within, the supratidal wetland of the Skardon River</td>
<td>This overlap is due to either the coarse scale of resource mapping or low accuracy of wetland mapping. Mining will not occur in the buffer zones. Inspections will be undertaken prior to mining to accurately delineate wetland boundaries and a 100m buffer zone.</td>
</tr>
<tr>
<td>Description of Buffer Overlap</td>
<td>Explanation</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>A very small portion at the north eastern extent of Pit 3 near, but not within the supratidal wetland of the Skardon River</td>
<td>This overlap is due to either the coarse scale of resource mapping or low accuracy of wetland mapping. Mining will not occur in the buffer zones. Inspections will be undertaken prior to mining to accurately delineate wetland boundaries and a 100m buffer zone.</td>
</tr>
<tr>
<td>Fragments of the southern end of Pit 12, near, but not within the Namaleta Creek wetlands</td>
<td>Figure 16-10 and Figure 16-11 show that vegetation in this area is RE 3.5.22 (map unit 2), which is not a wetland associated RE. This overlap is likely to due to the low accuracy of wetland mapping, although the coarse scale of resource modelling may also give rise to the overlap. Mining will not occur in the buffer zones. Inspections will be undertaken prior to mining to accurately delineate wetland boundaries and a 100m buffer zone.</td>
</tr>
<tr>
<td>Small parts of the northern extent of Pits 14 and 15 including the extension of the Southern Haul Road through the HES wetland to the south of Namaleta Creek</td>
<td>Figure 16-10 and Figure 16-11 show that vegetation in this area is map RE 3.3.2a (unit 9), which is not a wetland associated RE. This overlap is likely to due to the low accuracy of wetland mapping, although the coarse scale of resource modelling may also give rise to the overlap. Mining will not occur in the buffer zones. Inspections will be undertaken prior to mining to accurately delineate wetland boundaries and a 50m buffer zone.</td>
</tr>
</tbody>
</table>
Legend
- Port of Skardon River
- Mining Lease Boundaries
- Existing Disturbance Footprint
- Project Footprint
- Southern Haul Road
- Watercourses

Field Mapped Regional Ecosystems
VM Status (v8.0)
- Port of Skardon River
- Mining Lease Boundaries
- Existing Disturbance Footprint
- Project Footprint
- Southern Haul Road
- Watercourses

Vegetation Map Unit
- 3.5.2
- 3.5.22
- 3.3.50
- non-rem
- 3.1.1 / 3.1.3 / 3.1.6
- 3.3.49
- 3.3.64
- 3.3.9
- 3.3.12
- 3.3.51
- 3.3.49
- 3.5.2
- 3.3.14 / 3.3.22
- 3.2.10
- 3.3.22a

Project Footprint and Field Mapped Regional Ecosystems

Figure 16-10
Gulf Alumina Limited

Date: 9/10/2015

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Legend

- Port of Skardon River
- Mining Lease Boundaries
- Existing Disturbance Footprint
- Project Footprint
- Southern Haul Road
- Watercourses

Field Mapped REs Associated with Wetlands

Figure 16-11
Gulf Alumina Limited

Date: 9/10/2015

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16.7.3 Crossings

Two watercourse / drainage feature crossings are proposed for the Project:

- Namaleta Creek crossing (upgrade to the existing crossing)
- southern haul road crossing of a drainage feature between Pits 14 and 15.

The crossings will facilitate access to the two pits areas (Pit 14 and Pit 15) to the south of Namaleta Creek (scheduled for Year 7, 8 and 9 of the mine life). The southern haul road crossing of the drainage feature links Pit 14 and Pit 15.

These crossings and the environmental features of the crossing locations are shown in following figures:

- **Figure 16-12** shows waterways for waterway barrier works risk levels and referable wetlands (wetland management areas). Waterways for waterway barrier works are mapped by State government. Namaleta Creek and the ‘wetland / watercourse’ between Pits 14 and 15 are mapped as having a ‘moderate’ risk of impact. EHP’s map of referable wetlands shows high ecological significance wetlands and general high ecological significance wetlands.

- **Figure 16-13** shows aerial imagery and contours. As demonstrated the southern haul road crossing occurs approximately 2 km upstream on the junction with Namaleta Creek, at a location where the elevation is similar to that of the surrounding bauxite mining areas (i.e. 7.5 m AHD to 8.5 m AHD), where *Eucalyptus tetrodonta* woodland dominates.

- **Figure 16-14** shows Project mapped regional ecosystems as described in Chapter 15. These are considered to represent the most accurate delineation of vegetation including at the southern haul road crossing locations which is mapped as RE 3.3.22a (woodland of *Corymbia novoguineensis* over *Livistona muelleri* classified as “floodplain (other than floodplain wetlands)” by EHP)
Crossing Locations, Waterways Barrier Works and Referrable Wetlands

Legend
- Port of Skardon River
- Mining Lease Boundaries
- Watercourses
- Existing Disturbance Footprint
- Project Footprint
- Haul Road
- Crossing

Queensland Waterways for Waterway Barrier Works
Risk of Impact
- 2 - Moderate (Streams)
- 5 - Major (Estuaries)

Pit #14
Pit #15
Namaleta Creek Crossing
Drainage Feature Crossing
Wetland Buffer
Wetland Management Area
HES Wetland
GES Wetland

Figure 16-12
Gulf Alumina Limited

Date: 8/10/2015
Revision: 17

Legend

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Namaleta Creek Crossing

Drainage Feature Crossing

FIELD MAPPED REGIONAL ECOSYSTEM

VEGETATION MAP UNIT

3.5.2 1
3.5.22 2
3.3.50 3
non-rem 4
3.1.1 / 3.1.3 / 3.1.6 5
3.3.49 5a
3.3.64 5b
3.3.9 5c
3.3.12 5d
3.3.51 5e
3.3.49 5f
3.3.49 5g
3.5.2 6
3.3.14 / 3.3.22 7a, 7b, 7c
3.2.10 8
3.3.22a 9

Gulf Alumina Limited

Crossing Locations and Field Mapped Regional Ecosystems

Figure 16-14

Gulf Alumina Limited

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16.7.3.1 Namaleta Creek Crossing

The existing crossing of Namaleta Creek crossing consists of an earthen crossing (10 – 15 m wide), where two cylindrical pipes connect the upstream and downstream reaches of Namaleta Creek. These existing pipe culverts may be impacting flows and fish passage.

The crossing will be upgraded to support haul truck movements between mining areas to the south of Namaleta Creek and the Port. The corridor associated with the proposed upgrade of the crossing will be 40m requiring an additional 25m of clearing. The design of the crossing will be in accordance with the Department of Agriculture and Fisheries Code for Self-assessable Development – Minor Waterway Barrier Works, Part 3 Culvert Crossings, Code Number: WWBW01 April 2013. This Code is designed to minimise impacts to fish passage. In this respect the upgraded crossing will result in the hydrology of the area more closely resembling its pre-disturbance condition.

Drainage from the crossing section of the road will be directed away from the Creek by raising the crossing above the elevation of the surrounding topography so that runoff from the crossing drains into natural vegetation (or kaolin mine water storages) approximately 50 m to 100 m from the Creek bank.

The design of the crossing of the mapped HES wetland will be determined following inspection of the area, including drainage, and extent and width of the wetland (if wetland is found to be associated with this area).

To prevent any instream impacts including sedimentation to Namaleta Creek and the mapped HES wetland during the construction of haul road crossing, construction activities will be scheduled for the dry season, when the potential for impact is minimised due to low or no flow conditions when temporary impoundments are not expected to be required when working within the in-stream environments. It is unlikely that the construction of the proposed crossing will result in temporary changes to the drainage and flow regimes, if earthworks are completed during the dry season.

All works required within Namaleta Creek and the mapped HES wetland will ensure that all surfaces are adequately stabilised following the completion of the haul roads construction. This will include revegetation of exposed embankment areas and temporary erosion and sediment control until construction is completed or stream banks have been stabilised.

A significant level of vegetation clearing and landform modification has occurred on the northern side of Namaleta Creek as a consequence of the former kaolin clay mine operation. The resilience of the *Melaleuca*-dominated vegetation of this wetland has the capacity to regenerate rapidly, and form a functional and protective vegetation cover within a relatively short period, and this would be expected for the crossing upgrade.

16.7.3.2 Southern Haul Road Crossing of Drainage Feature

The mapped HES wetland between Pit 14 and 15 (vegetation map unit 9) is likely to contain RE 3.3.22a (woodland of *Corymbia novoguineensis* over *Livistona muelleri*, occasionally with *Eucalyptus tetrodonta*). RE 3.3.22a is not associated with wetland habitat, it is classified as “floodplain (other than floodplain wetlands)” by EHP.

This crossing is shown in Figure 16-12, Figure 16-13 and Figure 16-14. Field surveys will be undertaken to confirm that that this area is not wetland habitat, and to select a crossing location that avoids or minimises impacts to wetland vegetation and wetland function, if any. The crossing timing, design and construction methodology will be selected to minimise impacts, taking in account the ecological values of the crossing location. Crossing timing and construction will follow the methodology described for the Namaleta Creek crossing.

The design of the crossing will be in accordance with the Department of Agriculture and Fisheries Code for Self-assessable Development – Minor Waterway Barrier Works, Part 3 Culvert Crossings, Code Number:
WWBW01 April 2013. The design will take into account the potential for wet season runoff to flow along this drainage feature and the operational requirements for access during various rainfall events.

16.7.4 Hydrological Impacts on Wetlands

16.7.4.1 Hydrological Changes

The potential impacts to surface water hydrology are a result of changes to runoff and baseflow stemming from mining. The potential impacts on groundwater hydrology are result of use of shallow aquifer water for mine water supply and changes in the hydrogeological regime resulting from clearing and mining activities.

Potential hydrological impacts on wetlands and watercourses are described in detail in Chapter 13. A summary is provided below.

Modelling of altered surface water and groundwater flows in response to changes in the catchments affected by mining demonstrates that small net increases can be expected to dry season flows as a consequence of increased recharge. There is also likely to be a reduction of wet season peak runoff - particularly in areas where a significant component of the upstream catchment has been recently mined - because of the effect of clearing and mining in promoting recharge of the groundwater store.

Modelling of the hydrology of Bigfoot Swamp and Lunette Swamp was undertaken by considering runoff, baseflow, seepage, rainfall, evaporation and surface outflow. The model was used to predict water levels in wetlands for ‘natural’, ‘mined’ and ‘rehabilitated’ periods over a wet and dry season period. Very minor drawdowns in level are evident as a result of the reduction in overland runoff for mined and rehabilitated conditions during the wet season months from January to March, with the maxima as 3.5 cm (Bigfoot Swamp) and 4.2 cm (Lunette Swamp). There is minimal impact to wetland levels during mined and rehabilitation conditions in comparison to the natural or pre-disturbance condition. Wetland levels for ‘natural’ and ‘rehabilitated’ conditions are almost identical, demonstrating the following rehabilitation, modelling predicts there is insignificant impact on these wetland levels.

The direct impact of mining on each of the local catchments is relatively small (1% to 10%), with natural flow behaviour retained for the majority of the catchment. Therefore, despite the potential for mining to temporarily alter runoff and baseflow characteristics at the top of these catchments, this impact will be moderated by the continuing, natural flows downstream.

Groundwater modelling demonstrates that there are a number of complex interactions of Project impacts on groundwater hydrology that may result in either increases or decreases to groundwater levels.

Modelling predicts that the water supply bores to the north of the Project area will have little or no effect on surrounding surface water bodies. The southern water supply bores could have an effect on the reach of Namaleta Creek adjacent to existing kaolin mine where levels are shown to be drawn down to between 0.1 and 0.2 m.

Modelled impacts from mining on groundwater levels at Namaleta Creek, Lunette Swamp, Bigfoot Swamp and Skardon River demonstrates the following potential changes in groundwater levels during mining operations:

- between 0.4 m drawdown and 0.2 m elevation along Namaleta Creek
- between 0.1 m drawdown and 0.1 m elevation at Lunette Swamp
- between 0.1 m drawdown and 0.3 m elevation at Bigfoot Swamp
- between 0.2 m and 0.3 m drawdown along Skardon River South Arm supratidal wetland
- no modelled changes in groundwater levels at the wetland complexes to the west.
As mining progresses it is predicted to result in short term, local drawdown in groundwater levels near mining areas, however once rehabilitation has commenced it is expected that recovery (elevation) in groundwater levels will occur. As both active mining areas and progressive rehabilitation areas will exist in close proximity simultaneously, the modelled impacts on groundwater levels vary between drawdown and increased elevation. Following mining and progressive rehabilitation, it is expected that groundwater will be elevated at Namaleta Creek, Lunette Swamp, Bigfoot Swamp and Skardon River by between 0.1 m and 0.3 m. This demonstrates the dominance of increased recharge during the rehabilitation phase in comparison to the mining phase, resulting in elevated groundwater levels.

Groundwater levels and associated flow behaviour in the areas under rehabilitation have been observed to stabilise after a decade, once rehabilitation is mature. Progressive and final rehabilitation of mined areas will be important to promote the re-establishment of recharge to groundwater system to restore pre-mining seasonal behaviour.

16.7.4.2 Aquatic Ecology Changes

Vegetation monitoring has occurred in bauxite mining areas around Weipa and Andoom and the surrounding mosaic of drainage depressions and wetland features with similar characteristics to those found around the Project mining leases. Monitoring of these areas, such as floristic composition, plant mortality and weed presence, did not indicate that intensive bauxite mining has a significant modifying effect on wetlands and natural drainage features, even when investigating some of the oldest mining areas (>30 years). Subsequently, it was found that the ecological function, at least visually, of these features remained at near natural levels, with the only discernible detractor being the introduction of weeds and altered fire regimes.

The ecological function of wetlands and streams that depend on seasonal surface and groundwater flows must, of necessity, be tolerant of large variations in annual inputs produced through climatic variations such as La Nina/El Nino in order to persist. It is considered probable that the quantum of long term mining induced changes to water regimes of these systems will be within that of natural cycles and hence the ecological function of these systems will not be significantly impacted.

Groundwater drawdown along Namaleta Creek could potentially result in a change in in-stream aquatic flora species (i.e. reduction in the loss of patches of the freshwater-dependent bulkuru sedge Eleocharis dulcis), where this species is a dominant emergent feature. Fringing vegetation could also be modified in the longer term. Some Melaleuca trees are quite tolerant of a range of ground moisture statuses; however, it is possible that as drier soil conditions prevail, M. viridiflora could, over time replace trees such as M. quinquenervia and M. saligna.

Modelling indicates that there will be negligible impact on Lunette Swamp and Bigfoot Swamp water levels, hence impact on wetland function and aquatic and fringing vegetation health is expected to be negligible.

At Bigfoot Swamp, higher groundwater levels may result in maintenance of higher soil moisture in soils fringing the swamp for longer periods and should maintain the existing wetland assemblages which are resilient to such conditions. Fringing vegetation may experience a short term increase in sedge populations in the ground layer and perhaps a longer term increase in higher soil moisture tolerant canopy species such as C. novoguineensis.

Potential lowering of groundwater levels along the supratidal wetland area, may change floristic composition. Some Melaleuca trees are quite tolerant of a range of ground moisture statuses; however, it is possible that as drier soil conditions prevail, M. viridiflora could, over time replace trees such as M. quinquenervia and M. Saligna. Gradual reductions in ground water availability is unlikely to cause conspicuous dieback of trees in the short to medium-term; and any dieback if it were to occur in this

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2 Monitoring undertaken by ecologists who prepared the report provided in Appendix 6.
situation, is expected to be slow and coincide with the gradual species replacement of canopy species. The present sedge-dominant ground layer could give way to woodland grasses typically found on the adjacent lower slopes of the plateau.

Groundwater levels in the wetland complexes to the west and north of the Project (and west of Bigfoot Swamp and Lunette Swamp) are unlikely to be impacted. Given the large size of contributing catchments to these wetland complexes, changes to inflows will be minimal; hence wetland function will not be impacted.

Notwithstanding the above assessment, any changes to vegetation assemblages are likely to be slow given their resilience to natural water balance variation, whereas impacts on water quality and aquatic fauna may comparatively be more reactive and detectable by a rigorous monitoring regime (refer to Section 16.7.11) which in turn can inform early adaptive management.

Should monitoring demonstrate changes in the hydrology of wetlands as a result of mining, with the potential for significant impacts on the ecology of the wetland, the following mitigation measures will be adopted:

- Local groundwater usage for mine water supply will be reduced in areas where groundwater supply is one of the factors impacting on wetland levels.
- Mining activities may be reduced in areas with potential for impact until such time as wetland hydrology is restored.
- Buffer zones around wetlands (refer to Section 16.7.2) may be increased if it is found that the proposed buffer zones provide insufficient protection.
- Early rehabilitation of mined areas that potentially impact wetland levels will be promoted.

### 16.7.5 Rehabilitation

The proposed rehabilitation plan for the Project is provided in Chapter 7. The proposed final land use (except for infrastructure retained by the Traditional Owners) is native vegetation, similar to that prior to mining. Rehabilitation will occur progressively. Additional discussion on the potential plant species suitable for rehabilitation, seed collection, fire management and monitoring of rehabilitation is provided in Appendix 5.

It is expected that over the much of the Project mining areas will be rehabilitated during the mine life (10 years) and that the remainder will be rehabilitated within a few years following completion of mining.

### 16.7.6 Surface Water and Groundwater Quality Impacts

The water management plan for the Project’s mining activities is described in Chapter 6. Potential impacts on surface water and groundwater quality, measures to mitigate impacts, derivation of water quality objectives and the proposed water quality monitoring program are described in Chapter 12. A summary is provided below.

Mining will not occur during the wet season, thereby minimising the potential for sedimentation and erosion from operations during this period.

During operational periods, it is intended that rainfall runoff entering mine pits will be drained internally and contained within the pit, to be lost as evaporation and as recharge to local aquifers. Due to the nature of bauxite mining (shallow pits to approximately 6 m depth, located at the top of localised catchments and hydrogeology of pit areas allowing seepage from pits) there is no requirement for external storage and release of water captured within pits. Surface water runoff does not occur as long as the mine floor lies below the surrounding terrain. Stormwater drains through the groundwater system. To prevent surface water runoff from mining areas, or to minimise runoff, in the unlikely event of it occurring, the erosion and sediment control measures will be implemented. Prior to mining, detailed resource surveys
will be undertaken to inform the precise location of economic bauxite resources. This is expected to result in accurate delineation of pits areas which avoid wetland and watercourse buffer zones.

The proposed vegetation buffer zones around wetlands will act to reduce potential impacts from sediment laden runoff.

One or more sediment ponds will be located at the Port infrastructure area to capture runoff from disturbance areas, including the bauxite stockpile, paved areas, workshops and haul roads. Port area sediment ponds will be designed by an appropriately qualified person. On the basis that Port sediment ponds are not expected to be regulated structures, the nominal design is for a 1:10 year annual exceedance probability (AEP), 24 hour rainfall event, subject to refinement during detailed design. Port area sediment ponds will have a spillway that is designed, constructed and effectively armoured to convey anticipated flows. Should the Port area sediment pond(s) overtop, water will drain through an area of vegetation prior to entering the Skardon River estuary. Sediment traps will be installed around the bauxite stockpile before releasing water to sediment ponds. Releases from Port sediment ponds will be monitored against proposed release criteria.

An erosion and sediment control plan (ESCP) will be developed for the Project prior to commencement of construction and mining activities and will cover all aspects of the Project including clearing, construction, operations, rehabilitation and decommissioning.

Measures to prevent contamination of surface water and groundwater from hydrocarbons, chemicals in infrastructure areas, and from the bio-remediation pad, including bunding, storage and handling and water monitoring are described Chapter 11. The proposed measures will minimise the risk of release of contaminants to water bodies.

Design and management of the landfill, waste storage areas and treated effluent irrigation areas are described in Chapter 8. The proposed measures will minimise the risk of release of contaminants to water bodies.

Surface water and groundwater monitoring programs are described in Chapter 12 and are designed to detect changes in water quality in wetlands and watercourses as a result of Project activities.

The proposed mitigation measures will minimise the potential water quality impacts to aquatic ecology, wetlands and watercourses from Project activities. Therefore impacts to aquatic ecology as a result of changes in water quality are not expected to be significant.

16.7.7 Acid Sulphate Soils
The potential to encounter and / or disturb acid sulphate soils (ASS), and measures to manage ASS if required, are described in Chapter 10.

There are anticipated to be only limited volumes of PASS disturbed in the vicinity of the Namaleta Creek crossing. The area and volume of ASS that may be disturbed by the crossing will only be known once the final details regarding the crossing design, construction methodology are decided. Any ASS will be managed (test and treat the soils) in accordance with the detailed methods outlined in the Queensland Acid Sulphate Soil Technical Manual (Dear et al. 2002).

The impact of ASS on aquatic ecology is expected to be negligible.

16.7.8 Saline Water Ingress
The potential for saline water ingress is described in Chapter 13. Mining of the pits and water supply from the Namaleta borefield, is predicted to result in potential drawdowns of 0.4 m at reaches of the Creek immediately adjacent to the former kaolin mine. A reduction in local baseflow has the potential to change normal tidal behaviour that could result in increased seasonal saline excursion upstream. Groundwater monitoring is proposed at locations near Namaleta Creek (bores G12, G13 and G14 in the monitoring
programme described in Chapter 12) to detect any changes in salinity and inform operational decisions such as borefield pumping. In addition the exact location of future supply bores in the area will be chosen to avoid impacting baseflow and inducing potential intrusion of saline water.

The existing claystone and water pits from previous kaolin mine operation near Namaleta Creek will be used for storage of operational water. There is a low probability that drawing water levels down within these pits over an extended period of time may lead to advancement of saltwater interface over time from the estuarine environment into the Namaleta aquifer. During the previous kaolin mine operations, there was drawdown of water levels within the fluvial pit and claystone/water pits with no substantial changes in water salinity detected in monitoring bore adjacent to Namaleta Creek.

The potential impact of saline water ingress on aquatic ecology will be monitored, as described in Section 16.7.11 and mitigation measures, as described above and in Section 16.7.4.2 will be implemented.

16.7.9 Weeds and Pests

To some degree the Project is protected from the incursion of freshwater aquatic weed and pest species as the Project area is not accessible to road traffic and therefore roads will not act as a vector of weed and pest transport. There is potential for aquatic weeds and pests to be introduced to the Project area by equipment and machinery brought to site by barges.

The Project area is reasonably free of aquatic weeds that are known to be ecologically detrimental. There is a potential risk that new species of weeds could be introduced into the region through increased movement of vehicles, people and the requirement to bring in infrastructure from outside sources. There is potential for the Project to create conditions which are suitable for aquatic pest fauna species, or for Project activities to result in the introduction of pest species.

Gulf will develop and implement a Weed and Pest Management Plan, as described in Chapter 15.

16.7.10 Impacts to Stygofauna

The potential ecological impacts on stygofauna from changes in groundwater levels and flows are a function of:

- changes in hydrology caused by the Project (refer Chapter 13), and
- natural seasonal hydrological changes to which local groundwater ecosystems and species are adapted.

The potential impacts to stygofauna within the footprint area are minimal, as all stygofaunal taxa were recorded in control areas that will not be disturbed by the Project. However the following are considered sources of potential impact:

- vegetation clearing, where the water table intersects the root zone of the vegetation, an area that is thought to provide favourable habitat conditions for stygofauna
- contamination from above-ground sources (e.g. fuel or hydrocarbon spills)
- physical disturbance of groundwater ecosystems by:
  - removal of top soil, subsoil and bauxite mining
  - drawdown of water tables, and
  - compaction of shallow aquifers below haul roads.

Measures to mitigate impacts to stygofauna are the same for other ecological values, and include controls on vegetation clearing, progressive rehabilitation of mined areas, limiting haul trucks to haul roads, not mining during the wet season, and controls to prevent accidental release of chemicals, fuels or hydrocarbons (noting that these will be managed within the Port infrastructure area).
16.7.11 Aquatic Ecology Monitoring Programme

16.7.11.1 Overview

Aquatic ecology monitoring will be undertaken prior to and during Project activities. Aquatic fauna, flora and macroinvertebrate monitoring will be undertaken to improve the current understanding of macroinvertebrate communities and to assess whether the Project is impacting aquatic ecology. The monitoring program consists of riparian and wetland vegetation monitoring and aquatic macroinvertebrate monitoring.

Should ecological health monitoring confirm any deleterious impacts on wetland function, the mining/rehabilitation process will be accelerated in higher risk areas adjacent to buffers to reduce the timing of recovery of hydrogeological regimes.

The proposed aquatic ecology monitoring program has designed in conjunction with the surface water monitoring program described in Chapter 12. The proposed aquatic ecology monitoring locations are based on the surface water monitoring network described in Chapter 12 to ensure consistency between programs.

The proposed monitoring program has been developed to provide a technically rigorous water quality/aquatic ecology data foundation (spatial and temporal) that will enable the assessment of potential environmental harm to receiving surface waters and aquatic ecology as a result of the Project. It recognises the important link between water quality and stream flow monitoring for holistic data interpretation. The monitoring program will:

- establish consistent and longer-term ambient water quality/aquatic ecology databases.
- provide accurate water quality/aquatic ecology feedback for operational planning and decision-making.
- provide reliable quantification of the Project influences in local receiving waters/aquatic ecology.

16.7.11.2 Riparian and Wetland Vegetation Monitoring

The proposed monitoring program for riparian and wetland vegetation will adopt the following framework:

- Select a series of reference sites to gather baseline data and information for each type. Permanently mark and map locations of reference sites, including boundary markers.
- Establish protocol for photo-monitoring and location of photo-monitoring points.
- Map boundaries of wetland types at a scale of 1:25,000 (possibly 1:10,000).
- Identify and describe wetland baseline conditions: undisturbed and intact with highest natural integrity to disturbed and modified condition with changed or lower natural integrity. Adopt integrity rating metric.
- Compile existing data (literature review, site-specific reports and environmental studies).
- Identify and characterise potential impacts and stressors: vegetation change, structural change, ground layer composition, replacement of species (e.g. grasses for sedges and forbs), fire incursion or heightened intensity, loss of species, soil drying-water deficits, dieback or vegetation health decline, species decline (presence/absence and abundance).
- Identify wetland indicator plant species relevant to varying conditions.
- Describe niches, specific habitats and zonation relevant to wetland indicator species.
- Compile comparison matrix: indicator plant species, indicator invertebrates/fauna, vegetation structure, physico-chemical and water status. Determine baseline wetland health indices.
Design and formulate monitoring schedule, parameters, metrics, timing intervals, reporting protocol and responsibilities.

Develop data management system, field pro forma and reporting schedule.

**16.7.11.3 Macroinvertebrate Monitoring**

Monitoring the state of the local aquatic ecological community is an important element of an effective monitoring program and has been proposed here for key sites. Sampling would be conducted less frequently than water sampling.

Aquatic macroinvertebrate sampling would be conducted by appropriately qualified individuals according to accepted protocols for assessment of macroinvertebrate community structure and condition. Sampling protocols and assessment methods that may be considered include AusRivAS and SIGNAL2 because they provide mechanisms for spatial and temporal comparisons in a monitoring context; however, variations on these methods or the use of other appropriate aquatic ecological assessment methods may be equally appropriate.

Aquatic ecological sampling and analysis will be conducted in accordance with the following:


A number of indices have been developed for freshwater macroinvertebrate communities to provide an indication of ecosystem health. At each site and within each habitat, taxonomic richness, Plecoptera, Ephemeroptera and Trichoptera (PET) richness, and Stream Invertebrate Grade Number-Average Level (SIGNAL) 2 scores will be calculated. These indices will provide an indication of the current ecological health of the receiving environment of the Project.

**16.7.11.4 Monitoring Locations and Design**

Proposed aquatic ecology monitoring locations are shown in Figure 16-15. The design of the proposed aquatic ecology monitoring programme, including sampling methods, frequency and parameters is described in Table 16-4.

The following manual biological sampling regime (referred to as ‘biological’ in Table 16-4) will be implemented for all sites:

- Manual biological sampling for aquatic macroinvertebrates – twice per year (Spring and late Summer/early Autumn).
- Continuous until the commencement of mining, then for the first two (2) years from following the commencement of mining.
- Sampling every three (3) years after the first two (2) years.

Additional biological sampling will be undertaken, as required, if any operation-related receiving waters water quality issue is identified.
<table>
<thead>
<tr>
<th>Site Name</th>
<th>Description</th>
<th>Site Function</th>
<th>Easting</th>
<th>Northing</th>
<th>Sampling Type (s)</th>
<th>Sampling Frequency</th>
<th>Comments</th>
<th>Analytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Namaleta Creek – upstream of bauxite mining</td>
<td>Reference site</td>
<td>610491</td>
<td>8685825</td>
<td>Manual – Macroinvertebrates</td>
<td>Biological</td>
<td>Aquatic macro-invertebrates</td>
<td>Summary statistics and accepted metrics (e.g. SIGNAL)</td>
</tr>
<tr>
<td>S2</td>
<td>Namaleta Creek, 100 m upstream of existing crossing</td>
<td>Reference site</td>
<td>609949</td>
<td>8686287</td>
<td>Manual – Macroinvertebrates</td>
<td>Biological</td>
<td>Aquatic macro-invertebrates</td>
<td>Summary statistics and accepted metrics (e.g. SIGNAL)</td>
</tr>
<tr>
<td>S6</td>
<td>Namaleta Creek: for an impacted site between 100 and 500 m downstream of kaolin mining area</td>
<td>Reference site prior to mining (downstream baseline for existing kaolin mine). Compliance site once mining commences</td>
<td>609392</td>
<td>8686912</td>
<td>Manual – Macroinvertebrates</td>
<td>Biological</td>
<td>Aquatic macro-invertebrates</td>
<td>Summary statistics and accepted metrics (e.g. SIGNAL)</td>
</tr>
<tr>
<td>S7</td>
<td>Namaleta Creek – downstream of Pits 14 and 15, crossover between freshwater</td>
<td>Reference site prior to mining. Compliance site</td>
<td>607021</td>
<td>8685776</td>
<td>Manual – Macroinvertebrates</td>
<td>Biological</td>
<td>Aquatic macro-invertebrates</td>
<td>Summary statistics and accepted metrics (e.g. SIGNAL)</td>
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</table>
## Aquatic Ecology and Stygofauna

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Description</th>
<th>Site Function</th>
<th>Easting</th>
<th>Northing</th>
<th>Sampling Type (s)</th>
<th>Sampling Frequency</th>
<th>Comments</th>
<th>Analytes</th>
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</thead>
<tbody>
<tr>
<td>and estuarine systems, downstream on intersection with mapped wetland drainage feature between Pits 14 and 15.</td>
<td>once mining commences</td>
<td>Manual – Riparian / Wetland Vegetation</td>
<td></td>
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<td>Annual (late wet and dry season)</td>
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<td></td>
<td>Species density, diversity, indicator species, canopy/ground foliage projective cover</td>
</tr>
<tr>
<td>S8 Namaleta Creek immediately upstream of current crossing</td>
<td>Reference site prior to mining. Compliance site once mining commences</td>
<td>Manual – Macroinvertebrates</td>
<td>609654</td>
<td>8686412</td>
<td>Biological</td>
<td></td>
<td></td>
<td>Summary statistics and accepted metrics (e.g. SIGNAL)</td>
</tr>
<tr>
<td>S9 Namaleta Creek immediately downstream of current crossing</td>
<td>Reference site prior to mining. (downstream baseline for existing kaolin mine). Compliance site once mining commences</td>
<td>Manual – Macroinvertebrates</td>
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<td>8686416</td>
<td>Biological</td>
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<td></td>
<td>Summary statistics and accepted metrics (e.g. SIGNAL)</td>
</tr>
<tr>
<td>S10 Lunette Swamp</td>
<td>Reference site prior to mining. Compliance site</td>
<td>Manual – Macroinvertebrates</td>
<td>612039</td>
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<td>Biological</td>
<td></td>
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<td>Summary statistics and accepted metrics (e.g. SIGNAL)</td>
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<td>Site Name</td>
<td>Description</td>
<td>Site Function</td>
<td>Easting</td>
<td>Northing</td>
<td>Sampling Type(s)</td>
<td>Sampling Frequency</td>
<td>Comments</td>
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</tr>
<tr>
<td>S11</td>
<td>Bigfoot Swamp</td>
<td>Reference site prior to mining. Compliance site once mining commences</td>
<td>612860</td>
<td>8695847</td>
<td>Manual – Riparian / Wetland Vegetation</td>
<td>Annual (late wet and dry season)</td>
<td>Vegetation Floristics</td>
<td>Species density, diversity, indicator species, canopy/ground foliage projective cover</td>
</tr>
<tr>
<td>S15</td>
<td>Skardon River South Arm – estuarine water – downstream of all pits (Pits 1, 2, 3, 6) and upstream of Port</td>
<td>Reference site prior to mining. Compliance site once mining commences</td>
<td>615996</td>
<td>8694458</td>
<td>Manual – Riparian / Wetland Vegetation</td>
<td>Annual (late wet and dry season)</td>
<td>Vegetation Floristics</td>
<td>Species density, diversity, indicator species, canopy/ground foliage projective cover</td>
</tr>
<tr>
<td>S16</td>
<td>Skardon River South Arm – estuarine water – downstream of all pits (Pits 1, 2, 3, 6) and upstream of Port</td>
<td>Reference site prior to mining. Compliance site once mining commences</td>
<td>617333</td>
<td>8695141</td>
<td>Manual – Riparian / Wetland Vegetation</td>
<td>Annual (late wet and dry season)</td>
<td>Vegetation Floristics</td>
<td>Species density, diversity, indicator species, canopy/ground foliage projective cover</td>
</tr>
<tr>
<td>S17</td>
<td>Skardon River South Arm – estuarine water – downstream of Port</td>
<td>Reference site prior to mining. Compliance site once mining commences</td>
<td>616666</td>
<td>8700463</td>
<td>Manual – Riparian / Wetland Vegetation</td>
<td>Annual (late wet and dry season)</td>
<td>Vegetation Floristics</td>
<td>Species density, diversity, indicator species, canopy/ground foliage projective cover</td>
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<td>Site Name</td>
<td>Description</td>
<td>Site Function</td>
<td>Easting</td>
<td>Northing</td>
<td>Sampling Type (s)</td>
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<tr>
<td>S18</td>
<td>Skardon River supratidal wetland</td>
<td>Reference site prior to mining. Compliance site once mining commences.</td>
<td>616466</td>
<td>8696897</td>
<td>Manual – Riparian / Wetland Vegetation</td>
<td>Annual (late wet and dry season)</td>
<td>Vegetation Floristics</td>
<td>Species density, diversity, indicator species, canopy/ground foliage projective cover</td>
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<tr>
<td>S19</td>
<td>Namaleta Creek</td>
<td>Reference site prior to mining. Compliance site once mining commences</td>
<td>610229</td>
<td>8686098</td>
<td>Manual – Riparian / Wetland Vegetation</td>
<td>Annual (late wet and dry season)</td>
<td>Vegetation Floristics</td>
<td>Species density, diversity, indicator species, canopy/ground foliage projective cover</td>
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<td>S20</td>
<td>Namaleta Creek</td>
<td>Reference site prior to mining. Compliance site once mining commences</td>
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<td>Manual – Riparian / Wetland Vegetation</td>
<td>Annual (late wet and dry season)</td>
<td>Vegetation Floristics</td>
<td>Species density, diversity, indicator species, canopy/ground foliage projective cover</td>
</tr>
</tbody>
</table>
16.8 MNES Significant Impact Assessment

The ecological assessment identified that no listed MNES freshwater aquatic flora or fauna species were identified within and surrounding the Project disturbance area. Therefore it is not considered that these species will be significantly impacted by the Project. Species with a partial reliance on freshwater and marine / estuarine environments (refer Section 16.6.6) are described in Chapter 18.

16.9 MSES Significant Impact Assessment

MSES, and the chapter of the EIS in which an assessment of whether there are significant impacts to MSES, are described in Table 16-5. Some MSES have been mapped by State government and these are shown in Figure 16-16. The Queensland Environmental Offsets Policy Significant Residual Impact Guideline (EHP, December 2014) has been used for guidance in assessing whether there are significant residual impacts to MSES. As noted in this document, the criteria used to assess significance will be considered in the context of each project and should be used as guidance only.

Table 16-5 Chapter of EIS Describing Each MSES

<table>
<thead>
<tr>
<th>MSES</th>
<th>EIS Chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endangered regional ecosystem</td>
<td>Chapter 15</td>
</tr>
<tr>
<td>Of concern regional ecosystem</td>
<td>Chapter 15</td>
</tr>
<tr>
<td>Regional ecosystem intersecting with vegetation management wetlands</td>
<td>Chapter 16</td>
</tr>
<tr>
<td>Mapped essential habitat</td>
<td>Chapter 15</td>
</tr>
<tr>
<td>Ecosystem within a defined distance of the banks of a relevant watercourse</td>
<td>Chapter 16</td>
</tr>
<tr>
<td>Connectivity areas</td>
<td>Chapter 15</td>
</tr>
<tr>
<td>Wetlands in a wetland protection area or high ecological significance wetlands</td>
<td>Chapter 16</td>
</tr>
<tr>
<td>Wetland or watercourse in high ecological waters</td>
<td>Chapter 16</td>
</tr>
<tr>
<td>Strategic environmental area – designated precinct</td>
<td>Chapter 15</td>
</tr>
<tr>
<td>High risk area on a flora survey trigger map</td>
<td>Chapter 15</td>
</tr>
<tr>
<td>Area that contains endangered or vulnerable terrestrial plants</td>
<td>Chapter 15</td>
</tr>
<tr>
<td>Area that contains endangered or vulnerable freshwater aquatic plants</td>
<td>Chapter 16</td>
</tr>
<tr>
<td>Koala habitat</td>
<td>Chapter 15</td>
</tr>
<tr>
<td>Habitat for endangered, vulnerable or special least concern terrestrial animal</td>
<td>Chapter 15</td>
</tr>
<tr>
<td>Habitat for endangered, vulnerable or special least concern freshwater aquatic animal</td>
<td>Chapter 16</td>
</tr>
<tr>
<td>Habitat for endangered, vulnerable or special least concern marine animal</td>
<td>Chapter 18</td>
</tr>
<tr>
<td>Protected areas</td>
<td>Chapter 15</td>
</tr>
<tr>
<td>Highly protected areas of State marine parks</td>
<td>Chapter 18</td>
</tr>
<tr>
<td>Fish habitat areas</td>
<td>Chapter 18</td>
</tr>
<tr>
<td>Waterway providing for fish passage</td>
<td>Chapter 16</td>
</tr>
<tr>
<td>Marine plants</td>
<td>Chapter 18</td>
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<td>MSES</td>
<td>EIS Chapter</td>
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<td>----------------------------------------</td>
<td>-------------</td>
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<tr>
<td>Legally secured offset areas</td>
<td>Chapter 15</td>
</tr>
</tbody>
</table>
16.9.1 Regional Ecosystem Intersecting with Vegetation Management Wetlands

The Project will not directly impact any regional ecosystem that intersects with an area shown on the vegetation management wetlands map (Figure 16-8) except for:

- the southern side of the crossing of Namaleta Creek, comprising vegetation map units 5a (RE 3.3.49, sparse structure category), 5c (RE 3.3.9, mid dense structure category) and 6 (RE 3.5.2, sparse structure category)
- the crossing of a mapped wetland area between Pits 14 and 15 south of Namaleta Creek comprising vegetation map unit 9 (RE 3.3.22a, sparse structure category)

The area of overlap between these proposed crossing areas and the mapped wetland areas is:

- 0.5 ha for Namaleta Creek (south side)
- 0.5 ha for the mapped wetland area crossing

The vegetation wetlands map (Figure 16-8 and Figure 16-17) shows that the proposed Namaleta Creek crossing area at the existing crossing location is not within a mapped wetland area. This is likely due to recognition within the State mapping system of pre-existing disturbance in this area. On the south side of Namaleta Creek there is a mapped wetland area that intersects with vegetation maps units 5a (RE 3.3.49, sparse structure category, 0.1 ha), 5c (RE 3.3.9, mid dense structure category, 0.1 ha) and 6 (RE 3.5.2, sparse structure category, 0.3 ha). RE 3.5.2 is not associated with wetlands. The regional ecosystems of the mapped wetland areas in this area are a mix of ‘mid dense’ and ‘sparse’ structural category regional ecosystem where clearing of greater than 2 ha is considered a significant residual impact. As the extent of potential impact within these regional ecosystems is not greater than 0.5 ha, the impact is not considered to be significant. The clearing width is currently mapped at approximately 25 m. However, this can be reduced to less than 20 m, which is not considered to be a significant residual impact in ecosystems dominated by sparse structural category.

The wetland at the crossing location between Pits 14 and 15 would not be classifiable as wetland as it is dominated by RE 3.3.22a. The regional ecosystems of the mapped wetland areas at this crossing area are ‘sparse’ structural category regional ecosystem where clearing of greater than 2 ha is considered a significant residual impact. As the extent of potential impact within this regional ecosystems is not greater than 0.5 ha, the impact is not considered to be significant. The clearing width is currently mapped at approximately 25 m. However, this can be reduced to less than 20 m, which is not considered to be a significant residual impact in ecosystems dominated by sparse structural category.

The defining bank (i.e. the bank which confines seasonal flows but may be inundated by flooding from time to time) of Namaleta Creek is approximated by the 1m AHD contour, as shown on Figure 16-17. Clearing will occur within 50m of the defining bank, and represents a clearing area of 0.4 ha. However in this zone within 50 m of the defining bank of Namaleta Creek, there is virtually no overlap with mapped wetland (VM Act). This includes the footprint of the existing crossing and therefore this is not considered to be a significant residual impact.

There are no defined banks in the mapped wetland area on the south side of Namaleta Creek or in the mapped wetland between Pits 14 and 15.
Defining Banks of Namaleta Creek and VM Act Mapped Wetland

Legend
- Mining Lease Boundaries
- Existing Disturbance Footprint
- Proposed Bauxite Mining Area
- Haul Road
- Crossing
- VMA Watercourses
- VMA Wetlands
- Defining Bank (1m elevation contour)
- 50m Buffer of Defining Bank
16.9.2 Ecosystem within a Defined Distance of the Banks of a Relevant Watercourse

State mapped vegetation management watercourses are shown in Figure 16-8, with the only mapped watercourse potentially impacted by the Project being Namaleta Creek. Namaleta Creek has a stream order 1 and therefore the ‘defined distance from the defining bank’ is 10 m. There are defined banks of Namaleta Creek where the natural channel intersects the existing crossing, approximated by the 1m AHD contour, as shown on Figure 16-17. Additional clearing will be required in this area to upgrade the existing crossing. The area of clearing within 10m of the defining bank of Namaleta Creek is 0.2 ha. This includes the footprint of the existing crossing and therefore this is not considered to be a significant residual impact.

There is no mapped watercourse in the area on the south side of Namaleta Creek or in the mapped wetland between Pits 14 and 15 (refer to Figure 16-8). Therefore there are no defining banks in these areas and no significant residual impacts.

With the proposed crossing design, timing and construction methodology described in Section 16.7.3, residual impacts are not considered to be significant.

16.9.3 Wetlands in a Wetland Protection Area or High Ecological Significance Wetlands

There are no wetlands in a wetland protection area within or surrounding the Project area.

The only HES wetland within the Project footprint is the mapped HES wetland area between Pits 14 and 15 south of Namaleta Creek. Measures to mitigate impacts on this wetland are described in Section 16.7.3.2. On the basis of recent limited site inspections and photo interpretation this area has been provisionally reclassified as RE 3.3.22a subject to detailed ground truthing (refer Chapter 15). On this basis the area would not be classifiable as wetland as it is dominated by RE 3.3.22a (classified as “floodplain (other than floodplain wetlands)” by EHP). The area of mapped HES wetland that may be cleared is approximately 0.5 ha, and is likely to be less (potentially nil) area following field surveys to confirm that this area is not a HES wetland.

Other HES wetlands with and surrounding the Project area are shown in Figure 16-7 and include Bigfoot Swamp, Namaleta Creek (estuarine environment) downstream of the Project activities and the wetland complexes to the west of the Project area. Potential impacts to water quality of wetlands are described in Chapter 12. Hydrological impacts of the Project on these mapped HES wetlands are described in Chapter 13.

The Project is unlikely to have a significant residual impact on a mapped HES wetland:

- Project activities, including the crossing, are unlikely to result in measurable change in water quality of HES wetlands that exceeds water quality guidelines for the waters.
- Project activities, including the crossing, are unlikely to result in the habitat or lifecycle of native species, including invertebrate fauna and fish species, dependent upon HES wetlands being seriously affected.
- The Project is unlikely to result in a substantial and measurable change in the hydrological regime or recharge zones of wetlands
- Project weed and pest management will minimise the potential for the establishment of an invasive species that is harmful to the environmental values of the wetland, or an existing invasive species being spread in the wetland.

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3 Queensland Environmental Offset Policy V1.1, Appendix 3, Dec 2014
16.9.4 Wetland or Watercourse in High Ecological Waters

Chapter 12 describes the waters ofNamaleta Creek as ‘high ecological value’ despite the presence of past kaolin mining operations. The wetlands within and surrounding the Project area are considered to be high ecological value waters (waters in which the biological integrity of the water is effectively unmodified or highly valued).

The only wetland within the Project footprint that may be in high ecological value waters is the mapped HES wetland area between Pits 14 and 15 south of Namaleta Creek (refer Figure 16-7). Measures to mitigate impacts on this wetland are described in Section 16.7.3.2. On the basis of recent limited site inspections and photo interpretation this area has been provisionally reclassified as RE 3.3.22a subject to detailed ground truthing (refer Chapter 15). On this basis the area would not be classifiable as wetland as it is dominated by RE 3.3.22a (classified as “floodplain (other than floodplain wetlands)” by EHP). The area of mapped wetland in high ecological value waters that may be cleared is approximately 0.5 ha, and is likely to be less (potentially nil) area following field surveys to confirm that this area is not a HES wetland.

The crossing of Namaleta Creek is not within a watercourse with high ecological value waters.

Potential impacts to water quality of wetlands are described in Chapter 12. Hydrological impacts of the Project on these mapped HES wetlands are described in Chapter 13.

The Project is unlikely to have a significant residual impact on a wetland or watercourse in high ecological value waters:

- Project activities are unlikely to result in measurable change in water quality of such wetlands and watercourses that exceeds water quality guidelines for the waters.
- Project activities are unlikely to result in the habitat or lifecycle of native species, including invertebrate fauna and fish species, dependent upon such wetlands or watercourses being seriously affected.
- The Project is unlikely to result in a substantial and measurable change in the hydrological regime or recharge zones of such wetlands.
- Project weed and pest management will minimise the potential for the establishment of an invasive species that is harmful to the environmental values of the wetland, or an existing invasive species being spread in the wetland.

16.9.5 Area that Contains Endangered or Vulnerable Freshwater Aquatic Plants

No endangered or vulnerable aquatic plants, with a moderate, likely or confirmed occurrence, were identified during field surveys or desktop review. *Lycopodiella limosa* is listed as near threatened under the NC Act. Therefore there are no predicted significant residual impacts to endangered or vulnerable aquatic plants.

16.9.6 Habitat for Endangered, Vulnerable or Special Least Concern Freshwater Aquatic Animal

No endangered, vulnerable or special least concern freshwater aquatic fauna species with a moderate, likely or confirmed occurrence, were identified during field surveys or desktop review. Aquatic fauna species with habitat reliance on freshwater and marine water are described in Chapter 18. Therefore there are no predicted significant residual impacts to endangered or vulnerable freshwater aquatic fauna species.

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4 As defined under the Environmental Protection (Water) Policy 2009.
16.9.7 Waterway Providing for Fish Passage

Waterways for waterway barrier works are mapped by State government. Namaleta Creek and the ‘wetland / watercourse’ between Pits 14 and 15 are mapped as having a ‘moderate’ risk of impact (Refer to Figure 16-12). Based on aerial imagery and site knowledge / surveys, the ‘wetland / watercourse’ between Pits 14 and 15 is not considered to be a watercourse providing for fish passage.

The only potential waterway barriers that will be constructed for the Project are the Namaleta Creek crossing and the ‘wetland / watercourse’ crossing between Pits 14 and 15, as described in Section 16.7.3 and Section 16.7.3.2. The upgraded Namaleta Creek crossing is likely to improve fish passage compared to the current crossing design.

The Project is unlikely to have a significant residual impact on a waterway providing for fish passage as it is unlikely to:

- result in the mortality or injury of fish
- result in conditions that substantially increase risks to the health, wellbeing and productivity of fish seeking passage such as through the depletion of fishes energy reserves, stranding, increased predation risks, entrapment or confined schooling behaviour in fish
- reduce the extent, frequency or duration of fish passage previously found at a site
- substantially modify, destroy or fragment areas of fish habitat (including, but not limited to in-stream vegetation, snags and woody debris, substrate, bank or riffle formations) necessary for the breeding and/or survival of fish
- result in a substantial and measurable change in the hydrological regime of the waterway, for example, a substantial change to the volume, depth, timing, duration and frequency of flows
- lead to significant changes in water quality parameters such as temperature, dissolved oxygen, pH and conductivity that provide cues for movement in local fish species.

16.10 Residual Impacts and Offsets

The above assessment demonstrates that there will be no significant residual impacts to MNES or MSES from the Project. No offsets are proposed for the Project.

16.11 Risk Assessment

A risk assessment assessing the likelihood and significance of impacts to aquatic ecology and stygofauna from the Project is provided in Table 16-6. The risk assessment considers mitigated risk; that is, the impact from the Project with the implementation of management measures. The mitigated risk does not include mitigation associated with offsets, which is the primary measure to mitigate residual risk. The risks to conservation significant aquatic ecosystems, fauna and flora, and stygofauna are low to medium.

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<tbody>
<tr>
<td>Threatened Aquatic Fauna</td>
<td>Refer Sections 16.6.5, 16.8 and 16.9.5</td>
<td>n/a</td>
<td>Rare</td>
<td>Minor</td>
<td>Low</td>
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<tr>
<td>Threatened terrestrial flora</td>
<td>Refer Sections 16.6.6, 16.8 and 16.9.6</td>
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<td>Rare</td>
<td>Minor</td>
<td>Low</td>
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### Environmental Value

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<tr>
<td>Changes to hydrology significantly impact wetland and watercourse ecosystems.</td>
<td>Refer Sections 16.7</td>
<td>Unlikely</td>
<td>Moderate</td>
<td>Medium</td>
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<td>Impacts on water quality significantly impact wetland and watercourse ecosystems.</td>
<td>Refer Sections 16.7</td>
<td>Unlikely</td>
<td>Minor</td>
<td>Low</td>
</tr>
<tr>
<td>Direct impacts (i.e. Project footprint) significantly impact wetland and watercourse ecosystems.</td>
<td>Refer Sections 16.7</td>
<td>Unlikely</td>
<td>Minor</td>
<td>Low</td>
</tr>
<tr>
<td>Waterway barriers significantly impact fish passage</td>
<td>Refer Section 16.9.7</td>
<td>Unlikely</td>
<td>Minor</td>
<td>Low</td>
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**Stygofauna** Refer Sections 16.6.11 and 16.7.10 Refer Section 16.6.10 Unlikely Minor Low

### 16.12 Cumulative Impacts

Chapter 15 describes the projects considered as potentially having a cumulative impact with the Skardon River Bauxite Project. The only project considered to have a cumulative impact on aquatic ecology with the Skardon River Bauxite Project is Metro Mining Ltd’s Bauxite Hills project, which is described in Chapter 15.

Metro Mining has commissioned ecological studies of their project site. Discussions with ecologists from the Metro Mining’s project team (AMEC) and review of AMEC’s ecology report (AMEC 2015) identified that species were generally consistent between sites and there were no MNES or MSES flora or fauna species located on the Bauxite Hills Project site that were also not located on the Skardon River Bauxite Project site. Neither project is expected to cause significant long term impacts to MNES/MSES aquatic flora or fauna following the implementation of mitigation and management measures. It is expected that the projects considered together will not cause impacts that significantly increase the cumulative impacts of the other project.

It is expected that Metro Mining will not undertake bauxite mining activities directly within wetlands, as these areas do not contain economic bauxite resources. It is also expected that Metro Mining will implement similar water management measures, and erosion and sedimentation controls, to minimise impacts to surface water quality. These measures will not only minimise environmental impacts but also minimise the potential for sediment laden or otherwise contaminated runoff to transfer from one project to the other. Therefore it is not expected that there will be cumulative impacts on surface water quality and hence on aquatic ecology.

The proposed mining areas for the Bauxite Hills Project have the potential to impact the same waterways and wetlands as the Skardon River Bauxite Project, namely:

- Bigfoot Swamp and Lunette Swamp
- western side of Skardon River South Arm which runs adjacent to pits proposed by Bauxite Hill Project

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5 Bauxite Hills Mine Project Aquatic Ecology Assessment, AMEC Foster Wheeler 2015
Drainages and waterways to the west of the mining leases

The Bauxite Hills Project will not impact any catchments in the Namaleta Creek and hence there are not expected to be cumulative impacts to Namaleta Creek hydrology.

The majority of the Bauxite Hills Project mining areas will occur down gradient of the Skardon River Bauxite Project, other than those to the east of Skardon River South Arm. The Skardon River Bauxite Project will not impact these catchments to the east of Skardon River South Arm and hence there are unlikely to be cumulative hydrological impacts to the east of Skardon River South Arm.

The Bauxite Hills Project has two proposed mining areas located upstream of Bigfoot Swamp. These areas are far closer to Bigfoot Swamp than any mining activities proposed for the Skardon River Bauxite Project and have a larger footprint in the Bigfoot Swamp catchment than the Skardon River Bauxite Project. It is expected that any impacts on Bigfoot Swamp hydrology (surface water and groundwater) would result mainly from the Bauxite Hills Project.

There is potential for the Bauxite Hills Project to have a small pit north of Lunette Swamp, however this is likely to be downstream (surface water) and down gradient (groundwater). Given that Gulf will have a number of small pits near Lunette Swamp, there is limited potential for a cumulative impact on the hydrology of Lunette Swamp with impacts limited to those form Gulf Alumina’s Project.

Potential cumulative impacts from mining to groundwater hydrology include increased groundwater recharge flux and base flow rates which may result in an elevation of seasonal groundwater levels in and adjacent to wetlands, however the wetland vegetation in these areas is adapted to such variations. As discussed above in Section 16.7.4, this may result in maintenance of higher soil moisture in soils fringing the swamp for longer periods and should maintain the existing wetland assemblages which are resilient to such conditions. Fringing vegetation may experience a short term increase in sedge populations in the ground layer and perhaps a longer term increase in higher soil moisture tolerant canopy species such as *C. novoguineensis*. Such impacts could be mitigated by coordinated mining and rapid rehabilitation of the nearest mining areas by Metro Mining and Gulf Alumina. Long term changes to aquatic vegetation community density and diversity and in-stream aquatic fauna ecology is considered unlikely.

Gulf Alumina has proposed a buffer around the fringing supratidal wetland area along the Skardon River South Arm. However parts of this buffer area exist outside of Gulf’s mining lease and within a narrow zone alongside the Skardon River South Arm, on Metro Mining’s mining lease. Publically available information from Metro Mining indicates that this area may contain a haul road to support movement of bauxite within their tenements to a new proposed Port location. Metro Mining’s associated infrastructure including internal roads, haul roads and barge load-out facility will require the clearing of approximately 22 ha (Option 1) and 30 ha (Option 2) of riparian and mangrove habitat (AMEC 2015). Metro Mining does not propose mining in this narrow corridor and therefore cumulative impacts to this supratidal wetland will be limited to a combination of hydrological/hydrogeological impacts from Gulf Alumina’s mining areas and the haul road proposed by Metro Mining. This area will be subject to ongoing and cooperative monitoring to establish if impacts to aquatic ecology are occurring and the potential cause of impacts.

Gulf Alumina will seek to cooperate and consult with Metro Mining on all aspects of water management, water monitoring, identification of potential cumulative impacts and measures to mitigate impacts.

16.13 Conclusion

A field survey for freshwater aquatic flora and fauna was conducted in March 2015. Vegetation and flora surveys, including wetland and watercourse vegetation and flora were completed in mid-April 2010, early June 2010, early April 2011 and February 2015. A stygofauna survey at 10 bores in or near the Project area was completed in April 2015.
Desktop reviews have been undertaken for the area potentially impacted by the Project, including Commonwealth and State databases and mapping, regional ecosystems, wetlands, fauna and flora databases, detailed aerial imagery, published literature by third parties, other environmental studies for the EIS, environmental studies for other projects in the region, and historical data and reports from the Project area.

The freshwater wetland ecosystems within and surrounding the Project area are Lunette Swamp, Bigfoot Swamp, Namaleta Creek, supratidal wetlands to the west of the Skardon River South Arm and wetland complexes to the west and north of the Project area. Based on data review, a State mapped high ecological significance (HES) wetland between Pits 14 and 15 is unlikely to be associated with wetland habitat.

Vegetation communities (regional ecosystems) have been defined based on field surveys and aerial imagery. These vegetation communities include the wetland and watercourse ecosystems in the Project area.

Aquatic flora and fauna surveys and desktop reviews did not identify any EPBC Act and NC Act listed threatened freshwater species with a possible / moderate, high / likely or confirmed occurrence in the Project area. One near-threatened flora species under the NC Act (not a MSES) has a moderate likelihood of occurrence in wetland habitat.

Surveys revealed low macroinvertebrate taxonomic richness within the lotic environment of Namaleta Creek (likely to due to survey within the monsoon season) and the wetland systems Lunette Swamp and Bigfoot Swamp. The macroinvertebrate communities present at the time of the survey, are likely to be representative of undisturbed systems within the catchment, sampled during the monsoon season.

A total of seven species of fish (none listed under the NC Act or EPBC Act) were captured and/or observed within the survey. The low number and diversity of fish species recorded may be representative of the timing of the survey, but is likely to be representative of undisturbed systems within the catchment.

Of the ten bores surveyed for stygofauna, six bores each contained an individual stygofaunal specimen. Only two stygofaunal taxa were found, oligocheates (segmented worms) and acarina (freshwater mites), which are commonly found in a range of aquatic (surface freshwater, groundwater and marine) and terrestrial habitats.

Potential impacts on aquatic ecology and stygofauna include direct impacts associated with the crossing of Namaleta Creek and the HES wetland (less than 2 ha), indirect impacts associated with changes to hydrology and water quality from mining activities, and the introduction of weeds and pests.

The primary management and mitigation measures for these impacts are:

- environmental buffers zones surrounding wetlands and watercourses (mostly 100m) where mining will not occur
- controls on vegetation clearing and haul road usage
- design, timing and construction methodology for wetland / watercourse crossings
- mine site water management to minimise impacts to water quality
- controls to prevent accidental release of chemicals, hydrocarbons and fuel
- ongoing surface water and groundwater quality and depth monitoring
- progressive rehabilitation of mining areas using native vegetation
- weed and pest management.

The EPBC Act Significant Impact Guidelines and the Queensland Environmental Offsets Policy Significant Residual Impact Guideline were used to assess whether the Project would result in significant residual impacts to aquatic MNES and MSES respectively. These assessments found that there would not be significant residual impacts to aquatic ecosystems, fauna and flora that are MNES or MSES.