Central Queensland Coal Project

Chapter 15 - Aquatic and Marine Ecology

Central Queensland Coal

CQC SEIS, Version 3

October 2020

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Terms and Abbreviations

µS/cm	Microsiemens per centimetre
°C	Degrees Celsius
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
As	Arsenic
ASSMP	Acid Sulfate Soil Management Plan
Bank Storage	Temporary source of groundwater stored within the banks of creeks or rivers which is derived from infiltration associated with flooding or rainfall.
BfMP	Bushfire Management Plan
Biosecurity Act	*Biosecurity Act 2014*
BoM	Bureau of Meteorology
BOS	Biodiversity Offset Strategy
CE	Critically Endangered
CHPP	Coal Handling and Preparation Plant
CIA	Cumulative Impact Assessment
cm	Centimetres
CQC	Central Queensland Coal
DAF	Queensland Department of Agriculture and Fisheries
DAWE	Department of Agriculture, Water and the Environment
DES	Queensland Department of Environment and Science
Disturbance Area or Disturbance Footprint	The area that will be directly disturbed by construction and operation of the mine, includes all mine pits, roads, infrastructure, dams and associated constructed facilities.
DIWA	Directory of Important Wetlands in Australia
DPA	Dugong Protection Area
DNRME	Department of Natural Resources, Mines and Energy
DSITIA	Department of Science Information Technology Innovation and the Arts
E	Endangered
EA	Environmental Authority
EC	Electrical Conductivity
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
Enhanced Leakage	Refers to the potential for water stored within the unsaturated zone to be depleted, due to the drawdown of the underlying water table aquifer, which can increase the rate of water infiltration from the unsaturated zone into underlying sediments.
EP Act	Queensland *Environmental Protection Act 1994*
EP Regulation	Queensland Environmental Protection Regulation 2019
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPC	Exploration Permit for Coal
EPP (Air)	Environmental Protection (Air) Policy 2019

EPP (Water and Wetland Biodiversity)	Environmental Protection (Water and Wetland Biodiversity) Policy 2019
ESCP	Erosion and Sediment Control Plan
ESD	Ecologically Sustainable Development
EV	Environmental Value(s)
FBA NRM	Fitzroy Basin Association Natural Resource Management
FHA	Fish Habitat Area
Fisheries Act	*Fisheries Act 1994*
GBR	Great Barrier Reef
GBRCMP	Great Barrier Reef Coastal Marine Park
GBRMP	Great Barrier Reef Marine Park
GBRWHA	Great Barrier Reef World Heritage Area
GDE	Groundwater Dependent Ecosystem(s)
GDEMMP	Groundwater Dependent Ecosystem Management and Monitoring Plan
GES	General Ecological Significance
GMMP	Groundwater Management Plan
ha	Hectares
HES	High Ecological Significance
HEV	High Ecological Value
HMMP	Hazardous Materials Management Plan (including spill management)
kL/day	Kilolitres per day
km	Kilometres
km^2	Square Kilometres
L	Litres
L/s/km	Litres per second per kilometre
LC	Least Concern
LUMP	Land Use Management Plan
m	Metres
m^2	Square metres
M	Migratory
mbgl	Metres below ground level
MDL	Mineral Development Licence
mg/L	Milligrams per litre
$Mg/m^2/day$	Milligrams per square metre per day
ML/a	Megalitres per annum
ML	Mining Lease Application
ML	Megalitres
mm	Millimetres
MNES	Matter of National Environmental Significance
Mo	Molybdenum
MSES	Matter of State Environmental Significance

MWMP	Mineral Waste Management Plan
NC Act	*Nature Conservation Act 1992*
NTU	Nephelometric turbidity unit
ODP	Offset Delivery Plan
OUV	Outstanding Universal Value
pH	Potential for Hydrogen
PMST	Protected Matters Search Tool
PRCP	Progressive Rehabilitation and Closure Plan
Project Area	Generally refers to Mining Lease Application 80187 and 700022 and the surrounding local areas
Project boundary	Mining Lease Application 80187 and 700022 boundaries
Project Site	Everything within the boundaries of Mining Lease Applications 80187 and 700022 – covers an area of 2,661 ha
QEOP	Queensland Environmental Offsets Policy
Ramsar	Convention on Wetlands of International Importance
RE	Regional Ecosystem
Reef 2050 Plan	Reef 2050 Long-Term Sustainability Plan
REMP	Receiving Environment Monitoring Program
Se	Selenium
SEIS	Supplementary Environmental Impact Statement
SEIS v2	Version 2 of the Supplementary Environmental Impact Statement
SLC	Special Least Concern
SO_4^{2-}	Sulphate
SSMP	Significant Species Management Plan
SWMP	Surface Water Management Plan
t	Tonnes
t/year	Tonnes per year
TEM	Transient Electromagnetic System
The Project	Central Queensland Coal Project
ToR	Terms of Reference
TSS	Total Suspended Solids
TSSC	Threatened Species Scientific Committee
V	Vulnerable
V	Vanadium
VM Act	*Vegetation Management Act 1999*
Water Table Aquifer	Defined for the purposes of this Project as an aquifer associated with the water table.
WMP	Mine Site Water Management Plan
WPA	Wetland Protection Area
WPMP	Weed and Pest Management Plan

15 Aquatic and Marine Ecology

15.1 Introduction

Activities undertaken during the construction and operation of the Central Queensland Coal (CQC) Project (the Project) have the potential to impact the surrounding and downstream aquatic and marine environments if not managed properly. This chapter addresses the relevant legislation and policies, the assessment methods, the existing aquatic and marine environmental values, identifies potential impacts, and proposes mitigation measures for the construction and operation of the Project.

This Chapter has been rewritten since that presented in the Supplementary Environmental Impact Assessment (SEIS) Version 2 (v2) to include recent work undertaken in 2019 and 2020. The recent work was undertaken to assess changes to the Project layout and operations that have occurred since SEIS v2, and to address comments by regulatory agencies on SEIS v2. See Chapter 3 – Project Changes and Responses to Regulator Comments for the full description of Project changes since SEIS v2, and the responses to submissions received relating to the SEIS v2. Furthermore, this chapter has been updated to address updates to any applicable legislation.

15.1.1 Environmental Objectives and Outcomes

The environmental objectives and performance outcomes relevant to aquatic and marine ecology are provided in Schedule 8, Part 3, Division 1 of the Environmental Protection Regulation 2019 (EP Regulation). Objectives and outcomes for flora, fauna, biosecurity and the marine environment that are specific to the Project are given in Table 1 of the Project Terms of Reference (ToR). The overarching objective is to operate the Project in a way that protects, to the greatest extent possible, the environmental values of the aquatic and marine environments.

15.1.1.1 EP Regulation Environmental Objectives and Performance Outcomes

The environmental objectives and performance outcomes relating to aquatic and marine ecology outlined in the EP Regulation are described below.

15.1.1.1.1 Environmental Objectives

Land

The activity is operated in a way that protects the environmental values of land, including soils, subsoils, landforms and associated flora and fauna.

Water

The activity will be operated in a way that protects environmental values of waters.

Wetlands

The activity will be operated in a way that protects the environmental values of wetlands.

15.1.1.1.2 Performance Outcomes

Land

1. There is no actual or potential disturbance or adverse effect to the environmental values of land as part of carrying out the activity.

2. All of the following apply:
    a. activities that disturb land, soils, landforms and the land use, flora and fauna associated with the land will be managed in a way that prevents or minimises adverse effects on the environmental values of land
    b. areas disturbed will be rehabilitated or restored to achieve sites:
        i. that are safe and stable
        ii. where no environmental harm is being caused by anything on or in the land and
        iii. that are able to sustain an appropriate land use after rehabilitation or restoration.
    c. the activity will be managed to prevent or minimise adverse effects on the environmental values of land due to unplanned releases or discharges, including spills and leaks of contaminants and
    d. the application of water or waste to the land is sustainable and is managed to prevent or minimise adverse effects on the composition or structure of soils and subsoils.

Water

1. There is no actual or potential discharges to waters of contaminants that may cause an adverse effect on an environmental value from the operation of the activity.
2. All of the following:
    a. the storage and handling of contaminants will include effective means of secondary containment to prevent or minimise releases to the environment from spillage or leaks
    b. contingency measures will prevent or minimise adverse effects on the environment due to unplanned releases or discharges of contaminants to water
    c. the activity will be managed so that stormwater contaminated by the activity that may cause an adverse effect on an environmental value will not leave the site without prior treatment
    d. the disturbance of any acid sulphate soil, or potential acid sulphate soil, will be managed to prevent or minimise adverse effects on environmental values
    e. acid producing rock will be managed to ensure that the production and release of acidic waste is prevented or minimised, including impacts during operation and after the environmental authority has been surrendered
    f. 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
    g. for a petroleum activity, the activity will be managed in a way that is consistent with the coal seam gas water management policy, including the prioritisation hierarchy for managing and using coal seam gas water and the prioritisation hierarchy for managing saline waste and
    h. the activity will be managed so that adverse effects on environmental values are prevented or minimised.

Wetlands

1. There will be no potential or actual adverse effect on a wetland as part of carrying out the activity.
2. The activity will be managed in a way that prevents or minimises adverse effects on wetlands.

15.1.1.2 Terms of Reference Environmental Objectives and Outcomes

The Environmental Objectives and Outcomes for flora, fauna, biosecurity and the marine environment given in the Project ToR are replicated below.

Flora and Fauna

- The activity will be operated in a way that protects to the greatest extent possible the environmental values of the land including flora and fauna. There will be no potential or actual adverse effect on a wetland as part of carrying out the activity.
- The project minimises serious environmental harm on areas of high conservation value and special significance and sensitive land uses at adjacent places. The location for the activity on a site protects all environmental values relevant to adjacent sensitive use.
- The project manages the impacts on the environment by seeking to achieve ecological sustainability, including, but not limited to, protected wildlife and habitat.
- Critical habitat receives special management considerations and protection through a management plan for the project.
- The project avoids significant residual impacts to matters of national environmental significance (MNES) and matters of state environmental significance (MSES), mitigates impacts where they cannot be avoided, and offsets any residual impacts.
- The project provides for the conservation of the marine environment, particularly the Great Barrier Reef Marine Park (GBRMP).
- The construction, operation and decommissioning of the project must be consistent with all statutory and regulatory requirements of the Commonwealth, state and local government and be consistent with their relevant plans, strategies, policies and guidelines that relate to the terrestrial and aquatic ecological environment.

Coastal environment

- The project's objective for the coastal environment is that its activities are operated in a way that avoids or minimises adverse impacts on coastal environmental values, processes, and resources.
- The construction, operation and decommissioning of the project must be consistent with all statutory and regulatory requirements of the Commonwealth, state and local government and be consistent with their relevant plans, strategies, policies and guidelines that relate to the coastal environment. The coastal environment is taken to include estuarine, littoral and marine environmental values, and the amenity of important natural coastal landscapes, views and vistas.

Biosecurity

- The construction, operation and decommissioning of the project must ensure:
  - the introduction and spread of weeds, pests (including marine pests) and disease, pathogens and contaminants are avoided or minimised
  - existing weeds and pests, including marine pests, are controlled and eradicated where practicable, including biosecurity threats and their management
  - the performance outcomes correspond to the relevant policies, legislation and guidelines, and that sufficient evidence is supplied (through studies and proposed management measures) to show these outcomes are achieved.

15.1.2 Terms of Reference Addressed in this Chapter

Table 15-1 presents the ToR relevant to the aquatic and marine ecology assessment and indicates which sections of this chapter address the ToR. It is important to note that this chapter solely deals with the ToR as they relate to the aquatic and marine environment. A number of these ToR also apply to other disciplines and may also be addressed in other chapters of this SEIS where required.

Table 15-1: ToR cross-reference

Terms of Reference	Section of the SEIS
8.7 Flora and Fauna	
Describe the potential direct and indirect impacts on the biodiversity and natural environmental values of affected areas arising from the construction, operation and decommissioning of the project.	Section 15.4 Section 15.6
Consider any proposed avoidance and/or mitigation measures.	Section 15.5 Section 15.7
The EIS should provide information based on relevant guidelines, including but not limited to DES's EIS information guidelines that cover flora and fauna, aquatic ecology, coastal issues, ground-dependent ecosystems, water, matters of national environmental significance, and biosecurity.	Entire chapter
The assessment should include the following key elements:	
• identification of all significant ecological species and communities, including MSES and MNES, listed flora and fauna species, and regional ecosystems, on the project's site and in its vicinity	Section 15.3
• terrestrial and aquatic ecosystems (including groundwater-dependent ecosystems) and their interactions	
• biological diversity	
• the integrity of ecological processes, including habitats of listed threatened, near threatened or special least-concern species	
• connectivity of habitats and ecosystems	
• the integrity of landscapes and places, including wilderness and similar natural places	
• chronic, low-level exposure to contaminants or the bio-accumulation of contaminants	
• impacts (direct or indirect) on terrestrial and aquatic species and ecosystems whether due to: vegetation clearing; hydrological changes; discharges of contaminants to water, air or land; noise; etc.	Section 15.4 Section 15.6
• impacts of waterway barriers on fish passage in all waterways mapped on the Queensland Waterways for Waterway Barrier Works spatial data layer.	Section 15.6.5 Section 15.6.5.5.1
Describe any actions of the project that require an authority under the Nature Conservation Act 1992, and/or would be assessable development for the purposes of the Vegetation Management Act 1999, the Regional Planning Interests Act 2014, the Fisheries Act 1994 and the Planning Act 2016. Features to consider include regional ecosystems, environmentally sensitive areas, wetlands, nature refuges, protected areas and strategic environmental areas.	Chapter 2 – Legislation and Approvals Section 15.1.3
Propose practical measures to avoid, minimise, mitigate and/or offset direct or indirect impacts on ecological environmental values.	Section 15.5 Section 15.6 Section 15.7 Section 15.8

Terms of Reference	Section of the SEIS
Assess how the nominated quantitative indicators and standards may be achieved for nature conservation management.	Section 15.7
Address measures to protect or preserve any listed threatened, near-threatened or special least concern species.	Section 15.5 Section 15.6 Section 15.7 Section 15.8
Propose measures that would avoid the need for waterway barriers, or propose measures to mitigate the impacts of their construction and operation.	Section 15.7.1.2
Assess the need for buffer zones and the retention, rehabilitation or planting of movement corridors. The assessment should take account of the role of buffer zones in maintaining and enhancing riparian vegetation to enhance water quality and habitat connectivity.	Section 15.6.2.3 Section 15.7.1.3
Propose rehabilitation success criteria, in relation to natural values, that would be used to measure the progressive rehabilitation of disturbed areas. Describe how the achievement of the objectives would be monitored and audited, and how corrective actions would be managed. Proposals for the rehabilitation of disturbed areas should incorporate, in suitable habitat, provision of nest hollows and ground litter.	Chapter 11 – Rehabilitation and Decommissioning Section 15.7.1.7
Specifically address any obligations imposed by State or Commonwealth legislation or policy or international treaty obligations, such as the China–Australia Migratory Bird Agreement, Japan–Australia Migratory Bird Agreement, or Republic of Korea–Australia Migratory Bird Agreement.	Chapters 14 – Terrestrial Ecology and 16 - MNES
8.7.1 Offsets	
For any significant residual impacts, propose offsets that are consistent with the following requirements as set out in applicable State and Commonwealth legislation or policies: • Where a significant residual impact will occur on a prescribed environmental matter as outlined in the Environmental Offsets Regulation 2014, the offset proposal(s) must be consistent with the requirements of Queensland's Environmental Offsets Act 2014 and the latest version of the Queensland Environmental Offsets Policy. • Where the Commonwealth offset policy requires an offset for significant impacts on a MNES, the offset proposal(s) must be consistent with the requirements of the EPBC Act Environmental Offsets Policy (October 2012), the Offsets Assessment Guide and relevant guidelines (refer to also Appendix 3 of this TOR).	Section 15.8
8.8 Coastal environment	
Conduct impact assessment in accordance with the DES's EIS information guideline—Coastal.	Section 15.6
Provide illustrated details of the existing coastal zone that is potentially affected by the project and describe and illustrate any proposed works in the coastal zone, including a schedule of ongoing maintenance requirements. The description should at least address the following matters:	Section 15.6.6
• State or Commonwealth marine parks in the region of the project's site	
• separately mention marine plants and any fish habitat areas protected under the *Fisheries Act 1994*	Sections 15.6.4
Assess the potential impacts of the project's activities in the coastal zone	Section 15.6.6
Propose measures to avoid or minimise the potential impacts of the project's activities in the coastal zone. If acid sulfate soils would be disturbed, describe measures to avoid oxidation of the sulfides or to treat and neutralise the acid if it forms.	Section 15.6.6

Terms of Reference	Section of the SEIS
Detail any residual impacts that cannot be avoided, and propose measures to offset the residual loss.	Section 15.8
Develop and describe suitable indicators for measuring coastal resources and values, and set objectives to protect them in accordance with relevant State Planning Policy July 2014, guidelines and legislation. Refer to DES's guidelines on coastal development.	Section 15.7
Detail a monitoring program that would audit the success of mitigation measures, measure whether objectives have been met, and describe corrective actions to be used if monitoring shows that objectives are not being met.	Section 15.7

15.1.3 Relevant Legislation and Policy Instruments

Environmental protection of the aquatic and marine environment is governed by several legislative Acts, policies and guidelines. The impact assessment presented in this chapter has been undertaken in accordance with the requirements of these legislative instruments as described below.

15.1.3.1 Coastal Management Protection Act 1995

The *Coastal Protection and Management Act 1995* seeks to provide for the protection and management of the 'coastal zone' including its 'resources and biological diversity,' and ensure development decisions are aligned with the potential threat from 'coastal hazards.' The Act defines the 'coastal zone' under which the Act applies and specifies areas for controlling development and management practises including 'coastal management districts' and 'erosion prone areas.' The Coastal Management Plan has been prepared under the Act to describe how the coastal zone of Queensland is to be managed. The Project lies adjacent to the coastal zone as currently mapped. There will be no direct or indirect impacts to the coastal zone as a result of the construction or operation of the Project.

15.1.3.2 Environmental Protection Act 1994

The *Environmental Protection Act 1994* (EP Act) provides the key legislative framework for environmental management and protection in Queensland. The object of the EP Act is to 'Protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains ecological processes on which life depends' (section 3). The Project will be assessed under the bilateral agreement between the Australian and Queensland Governments (section 45 of the EPBC Act) using the EIS prepared in accordance with the EP Act, and the ToR for the EIS, which were prepared under the EP Act. The ToR addressed in this chapter are presented in Table 15-1.

15.1.3.3 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) establishes a process for assessment and approval of proposed actions that have, or are likely to have, a significant impact on MNES including listed threatened species, ecological communities and listed migratory species. Impacts to MNES associated with the aquatic and marine environment are assessed in this chapter. Any significant residual impacts on MNES as a result of the Project will be offset in accordance with the EPBC Act Environmental Offsets Policy.

15.1.3.4 Environmental Offsets Act

The *Environmental Offsets Act 2014*, Environmental Offsets Regulation 2014 and the Queensland Government Environmental Offsets Policy (QEOP) provide a streamlined framework for delivery of

environmental offsets in Queensland. An environmental offset may be required as a condition of approval where an activity is likely to result in a significant residual impact on a MSES. Impacts to MSES associated with the aquatic and marine environment are assessed in this chapter. Significant residual impacts on MSES as a result of the Project will be offset in accordance with the QEOP.

15.1.3.5 Fisheries Act 1994

The main purpose of the *Fisheries Act 1994* (Fisheries Act) is to provide for the use, conservation and enhancement of fish resources and habitats through the application of the principles of ecologically sustainable development (ESD) and through the promotion of ESD. The Act regulates, *inter alia*, impacts on fish passage, the removal of marine plants and development in fish habitat areas. The potential impacts of the Project on these values has been assessed in accordance with the requirements of this Act, and the results are presented in this chapter.

15.1.3.6 Nature Conservation Act 1992

The object of the *Nature Conservation Act 1992* (NC Act) is 'the conservation of nature while allowing for the involvement of indigenous people in the management of protected areas in which they have an interest under Aboriginal tradition or Island custom' (section 4). Impacts of the Project on habitat for animals and plants that are listed under the NC Act have been addressed in this chapter. The taking or handling of protected animals is also authorised under the NC Act. If required, Central Queensland Coal will obtain approval to take wildlife prior to construction activities commencing. Permits under the Act will also be obtained for fauna spotter catchers, as required under the Project's Significant Species Management Plan (SSMP).

15.1.3.7 Reef 2050 Plan Net Benefit Policy

The objective of the Reef 2050 Net Benefit Policy is to ensure decisions and actions to reduce pressures and impacts on the Great Barrier Reef (GBR) deliver a positive change in the condition and trend of GBR values, regardless of whether they occur within or outside the GBR. Net benefit is defined in the Net Benefit Policy as an overall improvement in the condition and/or trend of a GBR value, or those actions which result in the net improvement.

The Project has been considered in regard to the potential impact it may have on downstream values, including the GBR, as a result of decreased water quality via sediment run-off and increases in water quality parameters in the surrounding waterways which flow into downstream habitats. Consistency of the Project with the policy has been assessed as part of this chapter.

15.1.3.8 Guidelines

The assessment presented in this chapter has been undertaken in accordance with a range of Queensland and Australian Government guidelines including:

- EIS Information Guideline – Water (DEHP n.d.)
- EIS Information Guideline – Coastal (DEHP n.d.)
- EIS Information Guideline – Flora and Fauna (DEHP n.d.)
- EIS Information Guideline – Matters of National Environmental Significance (DEHP n.d.)
- IESC Information Guidelines – Explanatory Note for assessing GDE's (Doody et al. 2019)
- Matters of National Environmental Significance Significant Impact Guidelines 1.1 (DE 2013) and
- Queensland Environmental Offsets Policy Significant Residual Impact Guideline (DEHP 2014a).

15.1.4 Terminology

Flora nomenclature within this chapter follows taxonomy accepted by the Queensland Herbarium and Queensland Museum. Fauna nomenclature follows The field guide to the freshwater fishes of Australia (Allen et al. 2003) (for fish) and the Department of Environment and Science (DES) WildNet database taxonomy (for all other fauna), unless otherwise noted. All flora and fauna in this chapter will be referred to initially by both their common and scientific names and then for ease of reading only by common name.

15.2 Methods

15.2.1 Desktop Assessment

The desktop assessment was undertaken to obtain background information relating to the potential presence and distribution of species and communities relevant to the aquatic and marine environment. It involved review and analysis of ecological studies, database search results, relevant literature, field data and aerial imagery as outlined below.

15.2.1.1 Project Reports and Studies

This chapter has primarily drawn upon information presented in the Groundwater Dependent Ecosystems, Aquatic Ecology, Marine Ecology and the Great Barrier Reef Technical Report prepared by ELA (2020a) (Appendix A10a). In addition, numerous reports and ecological studies prepared for the EIS and SEIS's have informed the assessment presented in this chapter, including:

- Appendix 5a – Surface Water Quality Technical Report (Orange Environmental 2020)
- Appendix 5b – Flood Study and Site Water Balance (WRM 2020a)
- Appendix 5c – Mine Site Water Management Plan (WRM 2020b)
- Appendix 5d – Central Queensland Coal Project Supplementary Study Report Fluvial Geomorphology (Gippel 2020)
- Appendix 6a – Numerical Groundwater Model Technical Summary Report (ELA 2020b)
- Appendix 6b – Numerical Groundwater Model and Groundwater Assessment Report (Hydroalgorithmics 2020)
- Appendix 6d – Technical Report – Investigations on Groundwater – Surface Water Interactions (ELA 2020c)
- Appendix 6f – Transient Electromagnetic Survey (Allen 2019)
- Appendix 10b – Styx River Catchment Aquatic Baseline Monitoring Program (ALS 2011)
- Appendix 10c – Stygofauna Survey (GHD 2012)
- Appendix 10d – Groundwater Dependent Ecosystem Assessment Central Queensland Coal Project (3D Environmental 2020)
- Appendix 10e – Draft Groundwater Dependent Ecosystem Management and Monitoring Plan (GDEMMP) (ELA 2020d)
- Appendix 10f – Receiving Environment Monitoring Program (REMP) (ELA 2020e)
- Appendix 10g – Waterway Barrier Works Map Amendment Request (CQC 2018)
- Appendix 10h – Preliminary Isotope Study Results (CQC 2020)
- Appendix 11a – Biodiversity Offset Strategy (BOS) (CO2 Australia 2020)

- Appendix 15a – Erosion and Sediment Control Plan (Engeny 2020a)
- Appendix 15b – Styx Catchment Sediment Budget for the Great Barrier Reef (Engeny 2020b) and
- Appendix 10i – Pre-wet Season 2011 Estuarine Benthic Study (ALS 2012).

15.2.1.2 Database Searches

Database searches were undertaken over a 50 km radius for State databases and a 25 km radius for the Commonwealth EPBC Act Protected Matters Search Tool (PMST) report (DAWE 2016 and DAWE 2020a). The centre point used in the database searches was latitude -22.706, longitude 149.659. The PMST report and Queensland Government Wildlife Online reports were reviewed in both 2016 and 2020 and the complete reports are presented in Appendix A9f – 2016 and 2020 Database Searches.

The following databases were reviewed and assessed to support the aquatic and marine ecology assessment:

- publicly available regional ecosystem (RE) mapping including Version 10.0 (DNRME 2017) and Version 11.0 (DNRME 2020a)
- PMST report in 2016 and 2020 (DAWE 2016 and DAWE 2020a)
- Wildlife Online report in 2016 and 2020 (and 2020)
- Atlas of Living Australia species database (ALA 2018)
- Vegetation Management Wetlands Map (DNRME 2020b)
- map of Great Barrier Reef wetland protection areas and map of Queensland Wetland Environmental Values (DES 2020a)
- Directory of Important Wetlands in Australia (DIWA) (DAWE 2020b)
- Bureau of Meteorology's Groundwater Dependent Ecosystem (GDE) Atlas (BoM 2020)
- Aquatic Conservation Assessments for the riverine wetlands of the Great Barrier Reef Catchment (Inglis and Howell 2009) and
- Matters of State Environmental Significance Environmental Reports and associated data (DES 2019).

15.2.2 Field Surveys

A range of baseline surveys have been implemented since 2011 to characterise the ecological values of the Project Area, and to inform the impact assessment presented in this chapter. A summary of the surveys relevant to this chapter is presented in Table 15-2. The location of aquatic and subterranean ecology survey sites is illustrated on Figure 15-1. A total of 10 aquatic ecology sites have been repeatedly assessed throughout the field survey program, and a total of 30 bores were assessed for stygofauna presence.

Table 15-2: Summary of field survey program

Date	Consultant	Scope of survey and methods
1 to 6 June 2011	ALS Water Sciences	• A comprehensive dry season aquatic ecology survey of Exploration Permit for Coal (EPC) 1029. • Field assessments were undertaken by ALS Water Sciences at nine sites in the wider catchment surrounding the Project during June 2011.

Date	Consultant	Scope of survey and methods
		• Survey locations were selected to be representative of the overall aquatic stream environment within the Project Area and to provide baseline aquatic ecosystem parameter values. • The local area had experienced wet conditions in the months preceding the survey including over 500 mm in December 2010 (long-term December average 124 mm) and nearly 300 mm in March 2011 (long-term December average 133 mm). As a result, sampling conditions were considered highly suitable with abundant flowing water available in creeks. • Methods of assessment included: water quality sampling and analysis including assessment of flow velocities; macroinvertebrate sampling and analysis of community structure in accordance with the Queensland AUSRIVAS Sampling and Processing Manual (DNRW 2001); analysis of fish species diversity and abundance, community composition and community age structure at freshwater and estuarine sites; collection of records for aquatic reptiles and platypus; aquatic habitat assessments in accordance with the AusRivAS protocols.
26 to 28 November 2011	ALS Water Sciences	• Survey to characterise the estuarine receiving waters in terms of habitat, resident benthic fauna, water quality and sediment texture and chemistry. • Scope of work included: - Collecting benthic grab, water quality and sediment samples at sites within the Styx River estuary receiving waters and from two adjacent estuaries to the north. - Collecting information on estuarine habitat at each of the sites. - Assessing variation in the diversity, abundance and composition of benthic fauna along the estuarine gradient and comparing benthic diversity, abundance and composition between the Styx River estuary and the two 'reference' estuaries under baseline conditions. - Comparing water and sediment quality results against relevant guidelines. - Assess spatial variation in water and sediment quality within and between estuaries.
21 to 24 November 2011 15 to 18 March 2012	GHD	• Two targeted seasonal surveys of local and Project associated groundwater bores involving the collection of groundwater samples to examine the presence of stygofauna. • A total of 21 groundwater bore locations were sampled in 2011. • In 2012, 19 groundwater bores were sampled including nine bores that were not sampled in 2011. • Overall a total of 40 samples from 30 bores within were assessed for stygofauna presence. This includes 20 bores established specifically for the Project and 10 landholder bores. • Several bores are located outside of the likely area of groundwater drawdown impact and may therefore be considered as 'control' survey sites. All of the sampled bores are relatively shallow with the deepest water depth recorded being 16.6 m below ground level. • Groundwater samples were collected using a bailer lowered to approximately 3 m below the water surface prior to stygofauna

Date	Consultant	Scope of survey and methods
		sampling. Water was measured for temperature (°C), pH, electrical conductivity (EC) (µs/cm) and dissolved oxygen (mg/L and % saturation) using a YSI 556 multi-parameter water quality meter. Groundwater sampling preceded biological sampling to ensure the groundwater contained within the bore was undisturbed.
February 2017	CDM Smith	• A second less-intensive wet season aquatic ecology survey and habitat assessment, focussing on freshwater sites previously surveyed in 2011. • Conditions during the February 2017 survey were very hot and dry. Excepting a single day in January on which 212 mm was recorded at St Lawrence (located 74 km north of the Project Area), mean rainfall in the area was below average in the months preceding the survey and across the entirety of February. Although no flow was recorded at the time of the survey sizeable waterholes remained which were suitable for sampling. • Methods of assessment included: collection of water quality samples; analysis of fish species diversity and abundance, collection of records for aquatic reptiles and platypus; macroinvertebrate sampling and analysis in accordance with DNRW (2001) (only edge habitat was sampled for macroinvertebrates as no riffle habitat was available). • Only baited traps were deployed at each site for the sampling of aquatic vertebrates. • Captured fish were identified to species level on site after which they were released at the point of capture. An analysis of fish species diversity and abundance, community composition and community age structure was carried out at freshwater and estuarine sites in accordance with the Queensland Fish Monitoring Standard (Freshwater) and estuarine methods proposed by ALS (2011). Freshwater fish species were identified using Allen et al. (2003) and estuarine specimens identified using Kuiter (1996). • Baited opera house traps were deployed for capturing turtles during the survey. Traps were left partially submerged in shallow waters for a minimum of two hours before checking.
June and September 2017	CDM Smith	• Surveys of freshwater turtles at Deep Creek and Tooloombah Creek waterholes.
January 2018	CDM Smith	• A targeted vegetation assessment of the wetland flora values of two mapped wetlands located within the Project Site.
February 2018	CDM Smith	• A general assessment of GDE values associated with the Project Site.
16 to 18 July 2018	CDM Smith	• Analysis of water samples from Tooloombah and Deep Creek for radon isotopes and the stable isotopes to provide an indication of water sources supporting watercourse pools, which are hypothesised to be supported to some extent by groundwater discharge.
6 to 11 August and 28 to 31 August 2018	3D Environmental	• Identification of the source of water utilised by trees for transpiration within areas identified as potential GDEs within the area of potential groundwater drawdown (3D Environmental 2020) • Assessments at five sites with potential to be terrestrial GDEs (Wetland 1, Wetland 2, Vine Thicket, Tooloombah Creek and Deep Creek GDE assessment areas)

Date	Consultant	Scope of survey and methods
		• Assessment methods employed were: • Utilisation of drill core to provide evidence for tree rooting depth and characterise the local hydrogeological conditions • Soil moisture potential measurement • Leaf water potential measurement • Stable isotope analysis of xylem water, soil moisture, surface water and groundwater.
2011 to 2020	Central Queensland Coal	• Surface water quality monitoring data collected by Central Queensland Coal in the Styx River catchment since 2011, including: - June 2011 to July 2012 – 12 approximately monthly events by the CQC covering several storm events and otherwise mostly baseflow events - February 2017 to the present – 37 approximately monthly events by the CQC up to 28 May 2020 (for the purposes of this assessment), predominantly 'no flow' events – that is, events with little to no discernible longitudinal flow along the creeks, due to the extended dry conditions.
2017 to 2020	Central Queensland Coal and CDM Smith	• Pool surveys have been undertaken at various periods, with water quality sampling of the larger and more permanent pools undertaken on a regular basis (approximately monthly) in the period 2017 to present. This has resulted in over 40 inspections of a sub-set of the largest pools over a period of several years, with recordings made on whether the pool was flowing or dry.

15.2.3 Significant Impact Assessments

Based on the results of the desktop assessment and field surveys, for any MNES or MSES considered known or likely to occur, and where there is potential for the Project to impact the MNES or MSES, a significant impact assessment was undertaken in accordance with the following relevant guidelines:

- Matters of National Environmental Significance Significant Impact Guidelines 1.1 (DE 2013)
- EPBC Act referral guidelines for the Outstanding Universal Value of the Great Barrier Reef World Heritage Area (DE 2014) and
- Queensland Environmental Offsets Policy Significant Residual Impact Guideline (DEHP 2014a).

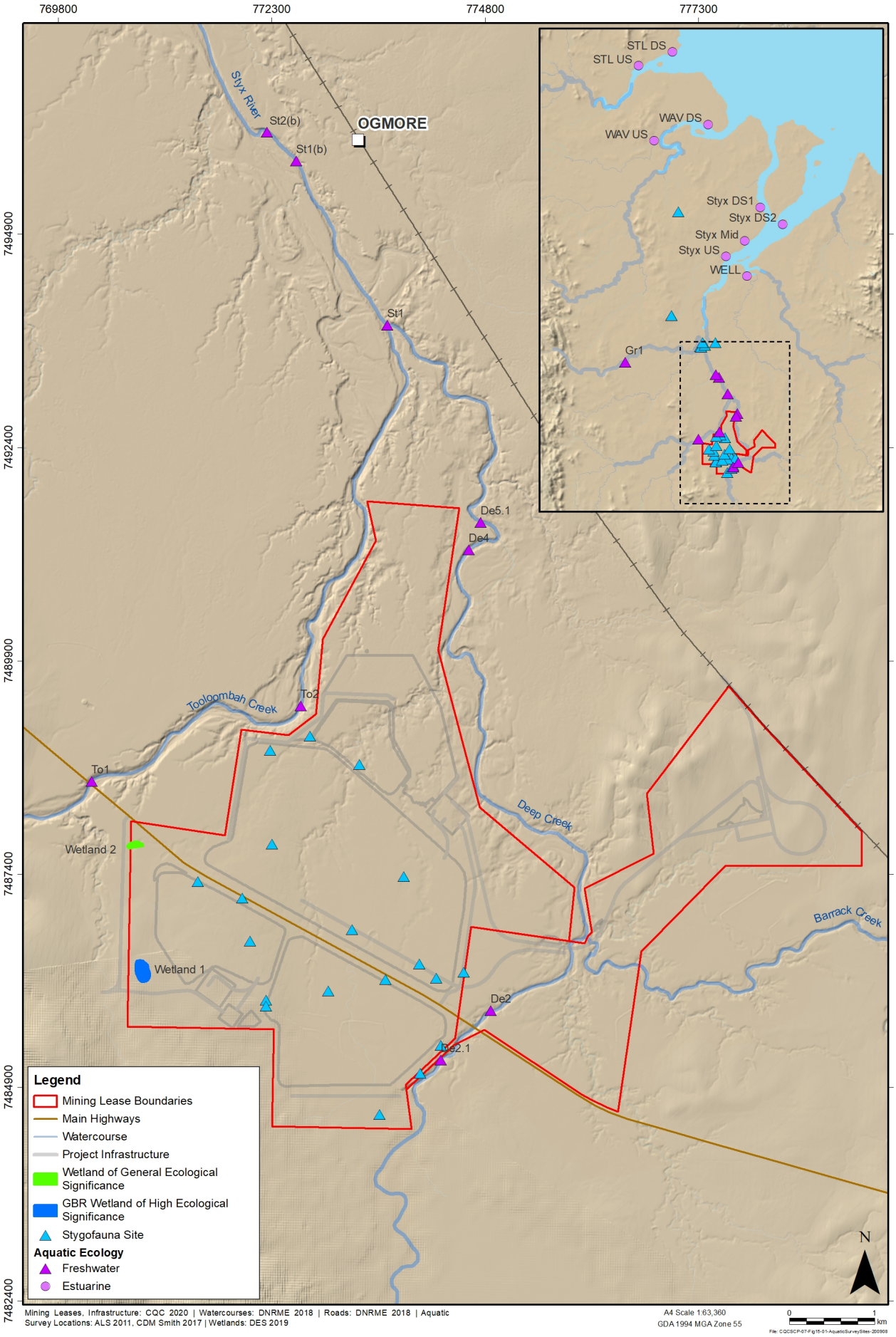

Figure 15-1: Aquatic and subterranean ecology survey sites

15.3 Description of Environmental Values

15.3.1 Site Context

The Project Site is wholly contained within the Styx River catchment and is bounded by Tooloombah Creek in the west and Deep Creek in the east (Figure 15-2). The Styx River catchment is a small catchment of approximately 3,000 km^2 located within the Central Queensland Coast region. It is formed by the Connors and Broad Sound Ranges to the west and discharges into the Coral Sea adjacent to Rosewood Island.

The main watercourse of the Styx catchment is the Styx River, along with St Lawrence and Waverley Creeks. Key tributaries within the catchment include Deep, Granite, Montrose, Tooloombah, and Wellington Creeks. Many of the creeks are poorly documented and observations from surveys indicate that many of the smaller waterways are intermittent or ephemeral from the late dry season onward. A total of 14% of the catchment area consists of wetlands (estuarine 265 km^2, palustrine 89 km^2 and riverine 52 km^2) (DES 2020c).

The catchment is highly modified, and agriculture currently occupies 78% of the land use, predominantly for cattle grazing. Large areas of vegetation within the catchment have been cleared for grazing (80%). An earlier land condition survey conducted by Melzer et al. (2008) found the catchment to be degraded, noting that around 30% of the Styx catchment was in a high to very high disturbance class, generally represented by bare ground and eroded surfaces. The study noted several points in the catchment where 'erosion and land degradation must be considered severe'. Many of the creeks of the catchment record high turbidity during periods of high flow due to the presence of erodible and dispersive soils (Melzer et al. 2008). Weeds are also prevalent and are commonly observed along the watercourses and drainage lines.

The Project is located predominantly within the Deep Creek sub-catchment with a smaller area within the Tooloombah Creek sub-catchment. These Creeks drain into the Styx River and then into the Styx River and Broad Sound Estuaries. The downstream limit of the Styx River as defined under the *Water Act 2000* is located approximately 4 km downstream of the Project Site boundary, approximately 1.7 km further downstream from the confluence of Tooloombah and Deep Creek.

The Styx River estuary flows into Broad Sound, an extensive coastal embayment within the Great Barrier Reef World Heritage Area (GBRWHA) located approximately 10 km downstream of the Project Site. In addition to the GBRWHA, and as illustrated on Figure 15-3, there are a number of important environmental areas in the downstream environment including the:

- Broad Sound Wetland, listed on the Directory of Important Wetlands (DIWA)
- Broad Sound Fish Habitat Area (FHA) and
- Great Barrier Reef Marine Park (GBRMP) and Great Barrier Reef Coast Marine Park (GBRMCP).

Given the predominantly modified grazing nature of the Styx catchment, a slightly-moderately disturbed ecosystem type is adopted, both for fresh and estuarine waters. This corresponds to the management intent mapped for freshwaters, under the Styx River, Shoalwater Creek and Water Park Creek Basins Environmental Values and Water Quality Objectives (DEHP 2014b). Estuarine waters (mapped as commencing 3.1 km below the Ogmore Bridge) are identified as moderately disturbed for a short 2 km section before entering waters identified as slightly disturbed, both within the Styx River estuary and Broad Sound.

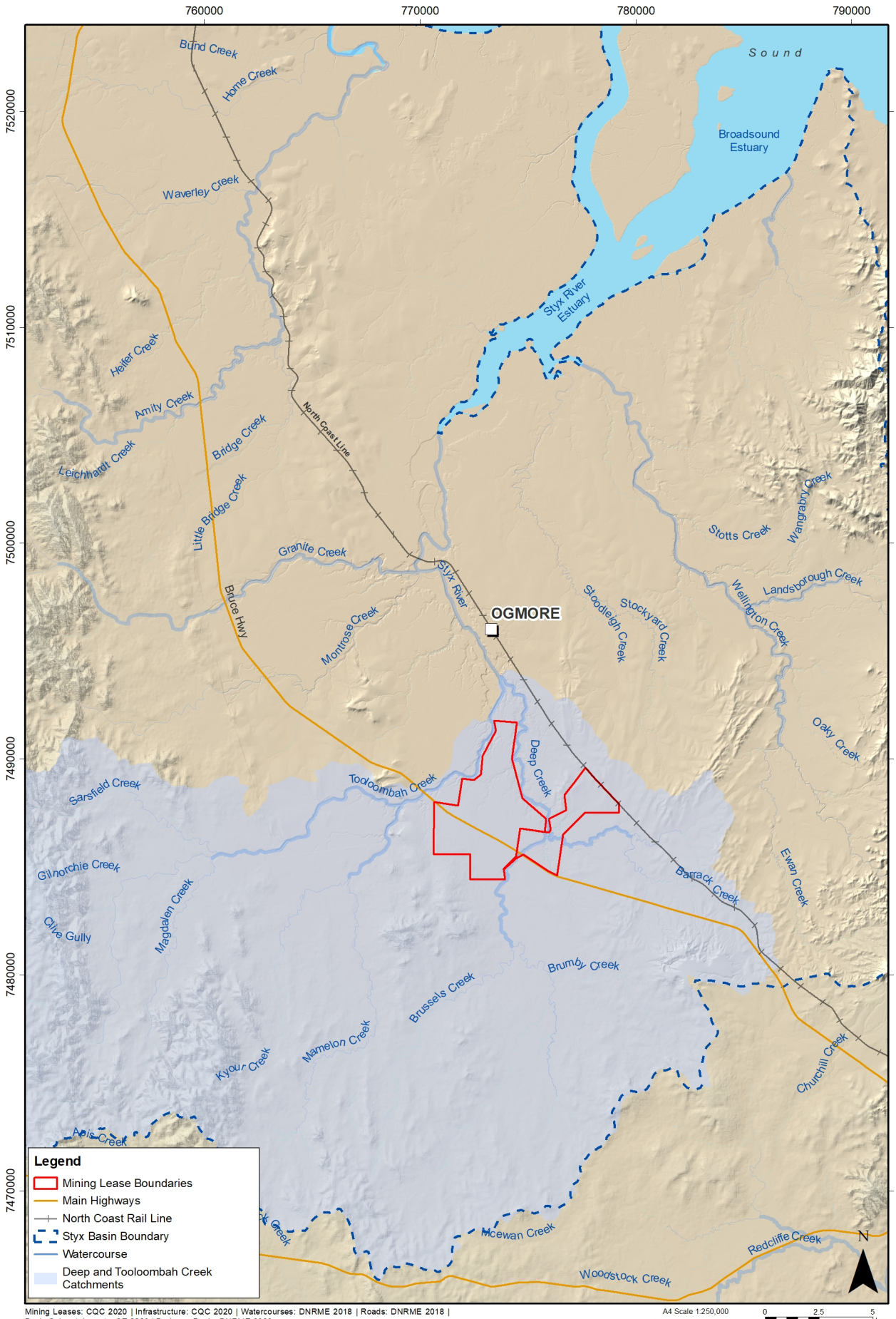

Figure 15-2: Project Site context

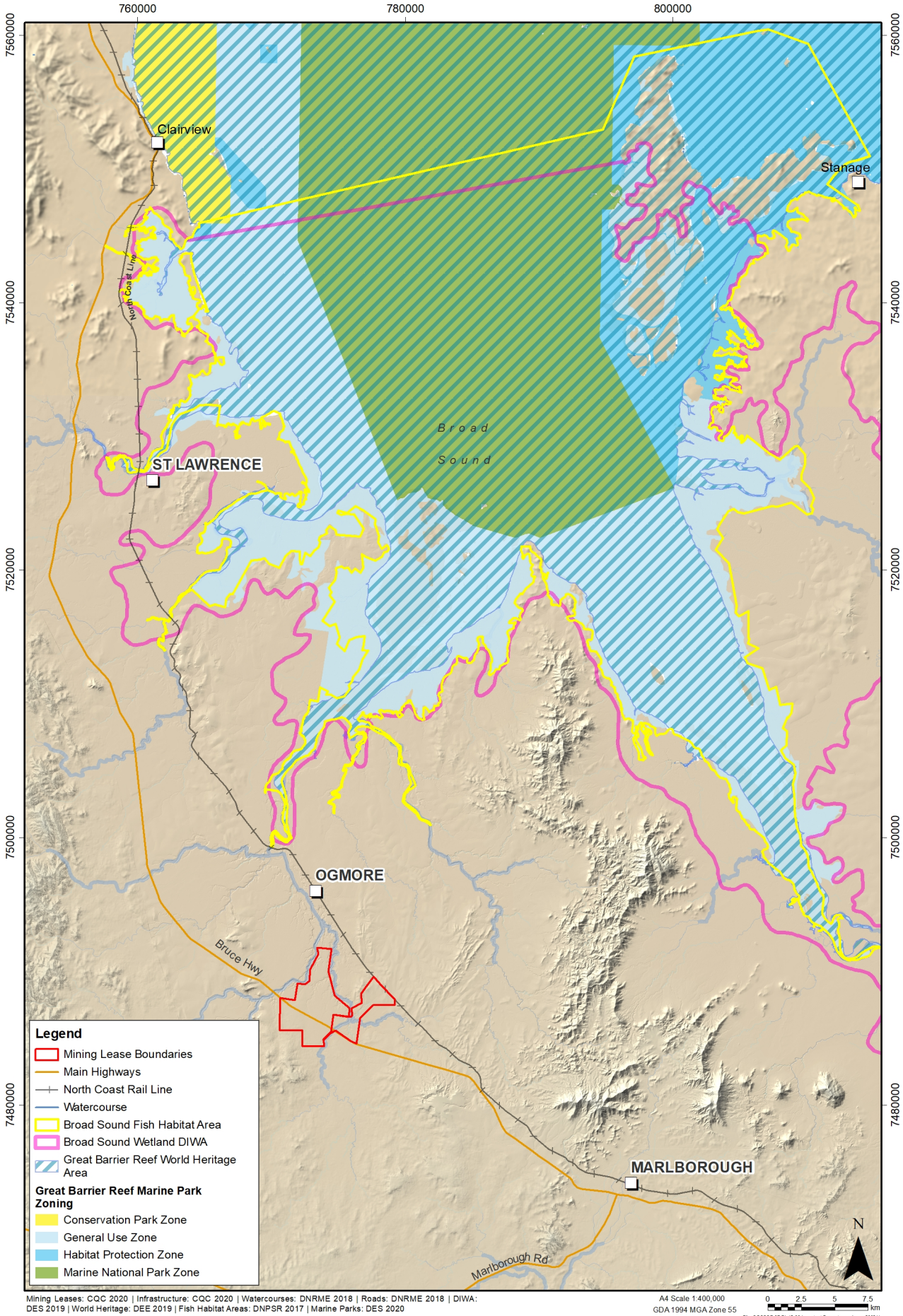

Figure 15-3: Important downstream environmental areas

15.3.2 Watercourses

As outlined above the Project Site is bounded by Tooloombah Creek in the west and Deep Creek in the east, with both creeks draining to the Styx River. Key tributaries of Tooloombah and Deep Creek include Barrack, Brumby, Brussels, Mamelon, Kyour, Magdalen and Sarsfield Creeks. There are also numerous smaller unnamed 1st and 2nd order watercourses throughout the Project Site and surrounds as illustrated in Figure 15-4.

15.3.2.1 Styx River

The Styx River is a tidally influenced river and estuary, approximately 35 km long (to the Broad Sound estuary) and is subject to one of the largest tidal ranges in Queensland. It is known for its tidal bore, a wave or series of waves that propagate upstream in certain rivers subject to large tidal ranges. The North Coast Rail Bridge is located approximately 10 km downstream from the Project and from here the Styx River estuary flows into Broad Sound Wetland. The lower Styx River forms part of the wetland's catchment. The tidally influenced portion of the Styx River is located up to approximately the Ogmore Road Bridge crossing with a transitional zone extending during peak tides (i.e. tidal bore) to the Tooloombah and Deep Creek confluence.

The sub-catchments of the Styx River catchment, i.e. below the confluence of Tooloombah and Deep Creeks, are dynamic estuarine environments where freshwater mixes with seawater providing brackish to saline conditions. Water samples collected periodically from two monitoring locations along Styx River (St1, located at the confluence of Deep and Tooloombah creeks and St2, located at the Ogmore Bridge) found salinity ranging from fresh (125 µS/cm) to saline (more than 35,000 µS/cm), depending on timing, tidal state and location of sampling.

A major assemblage of Marine Couch (*Sporobolus virginicus*) has been observed just upstream of the Ogmore bridge, with lesser occurrences up to the Tooloombah and Deep Creek confluence (CDM Smith 2018). Mangrove communities occur along the banks of the Styx River beginning 20 km downstream (or 15 km directly north) of the Project boundary becoming more extensive near Rosewood Island. There are no seagrass beds mapped near the Styx River estuary or surrounds.

Using the Queensland water quality guidelines (DEHP 2013) no upper estuary can be defined for the Styx River Estuary. The middle estuary begins below the normal tidal limit (the mean high water spring) and extends downstream to the lower estuary, mapped as a short 1 km section before entering the enclosed coastal waters of Broad Sound. From this and the monitoring results it may be concluded that the St1 site is freshwater, though influenced at times by peak tides (as defined by the highest astronomical tide), with the St2 site mid-estuary.

15.3.2.2 Tooloombah and Deep Creek

Tooloombah and Deep Creek are ephemeral creeks with flow currently occurring approximately 24% of the time, predominantly during the wet season. At other times, the creeks are dry or form a series of disconnected pools, which gradually reduce in size due to evaporation. Some pools are fed by groundwater, resulting in their persistence during the dry season for longer than other pools.

Tooloombah and Deep Creek are waterways mapped as 'major' under the Department of Agriculture and Fisheries (DAFs) Waterway Barrier Works for Fish Passage mapping layer (Figure 15-5). A number of smaller waterways are present within the Project Site and are mapped as low to moderate risk. Only one small section of waterway is mapped as high risk within the Project

Site. This is a section of a drainage line to the north of the Bruce Highway. The Project lies within a highly modified landscape with many existing barriers to fish passage, including multiple dams and artificial embankments.

Deep Creek has a total catchment area of 298 km^2 and consists of a channel up to 10 m deep and 2 to 10 m wide. The creek bed is comprised of silts, clays and sand with minimal aquatic vegetation. Deep Creek is highly responsive to rainfall, with sharp rises in stream height and turbidity during rainfall events. Anecdotal evidence suggests large seasonal flow events are around 4 m deep and can persist for several days only. Water salinity data (as EC) shows water is generally fresh, ranging from 35.9 to 805 µS/cm EC. A seasonal influence is evident, with a general salinity increase during periods of dry / no flow and following the first flush of salts and nutrients experienced at the beginning of the wet season. Pooled surface water in Deep Creek has relatively high turbidity, which is possibly the result of the finer streambed substrate being mobilised by turbulent streamflow and cattle having access to the pools, along with fine grained sediments that do not readily settle out.

Tooloombah Creek has a total catchment area of 369.7 km^2 and consists of a channel which is generally deeper than Deep Creek, and is 4 to 15 m wide with steep, vegetated slopes and minimal erosion. Outcropping sandstone occurs along the slopes and the creek bed is mostly rocky (gravel and boulders). On average, there are approximately three flow events per year within the creek, during which the creek has an average depth of 4 m. These flows are short-lived (a few days maximum) and occur during high rainfall events. Water salinity is generally higher than Deep Creek, ranging from around 170 to 2,700 µS/cm EC. A seasonal influence is also evident as per Deep Creek. The higher water salinity concentrations are possibly evidence of a greater degree of groundwater – surface water interaction along Tooloombah Creek than is evident along Deep Creek or a possibly more saline catchment. Large pools of water have been observed in the creek during baseline surveys. These pools are typically less turbid than those in Deep Creek which is reflective of less catchment erosion, slower flows and fewer fine-grained sediments.

Cattle access visibly impacts ecological values on the creeks including damaging streambank and streambed stability, denuding stream bank vegetation, degrading water quality (increase in suspended sediments and nutrients) and decreasing the natural level of water in waterholes. These factors result in an aquatic environment that is highly variable, and mostly utilised by species that either have short life cycles, are mobile or are tolerant of a wide range of environmental conditions.

Despite the dominant agricultural landscape and widespread erosion, riparian vegetation persists along the waterways and ranges in condition from poor to good. Riparian corridors consist of a narrow band of vegetation dominated by forest red gum (*Eucalyptus tereticornis*) and *Melaleuca* spp. (*M. leucadendra and M. fluviatilis*). The riparian zone of Tooloombah Creek is dominated by rainforest species and weeping bottlebrush (*Melaleuca viminalis*).

Weeds are abundant within riparian areas. Rubber vine (*Cryptostegia grandiflora*) and lantana are common, often forming dense infestations (up to 4m in height) along the creeks. Bellyache bush (*Jatropha gossypifolia*) also occurs in patches along the margins of both creeks (CDM Smith 2018). Parthenium (*Parthenium hysterophorus*) was only observed along Tooloombah Creek and not within the Project Site itself. Feral pigs and the introduced Chital (*Axis axis*) deer are also present and have been regularly observed including along the creek lines themselves and in or near mapped wetlands on the Project Site.

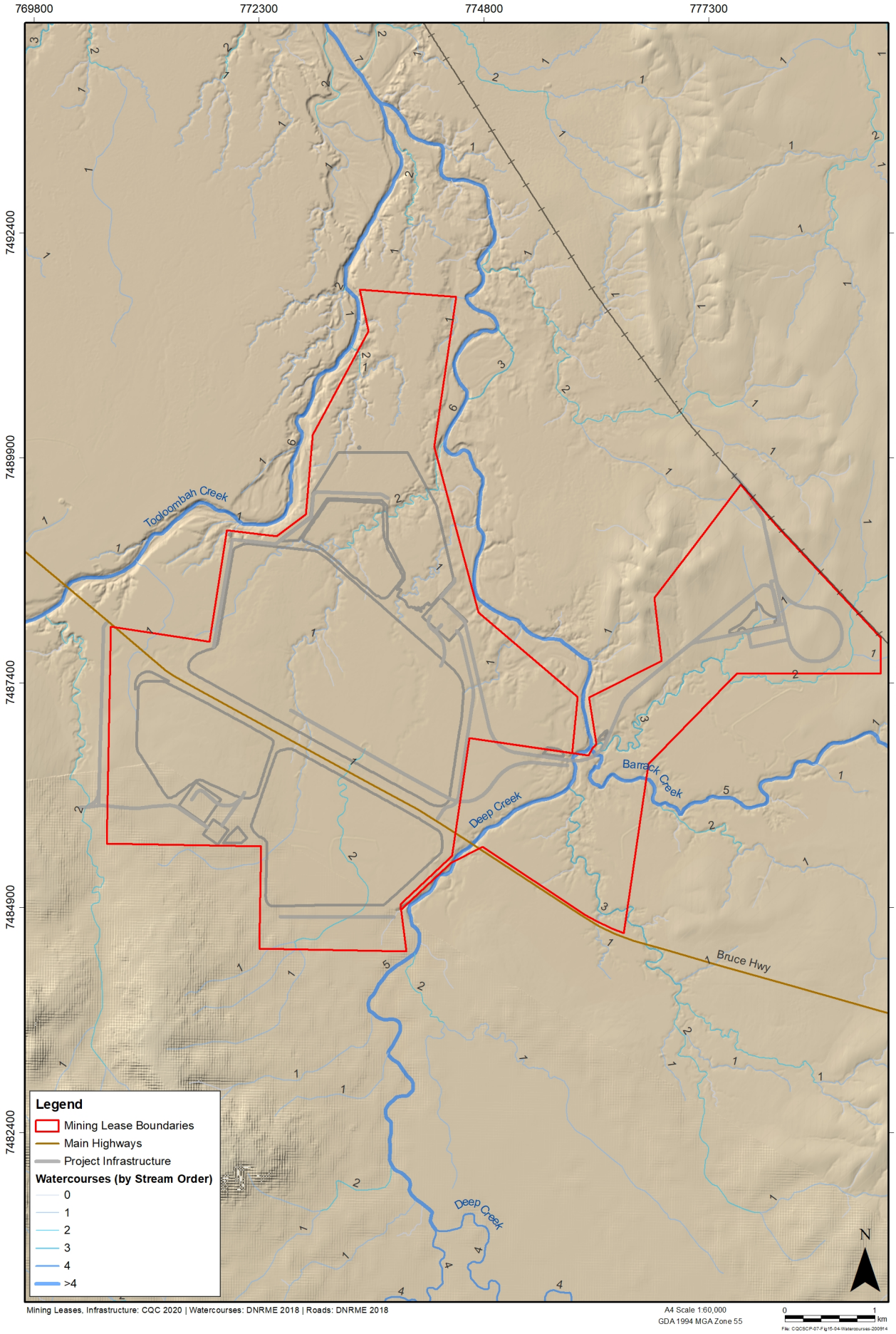

Figure 15-4: Watercourses of the Project Area

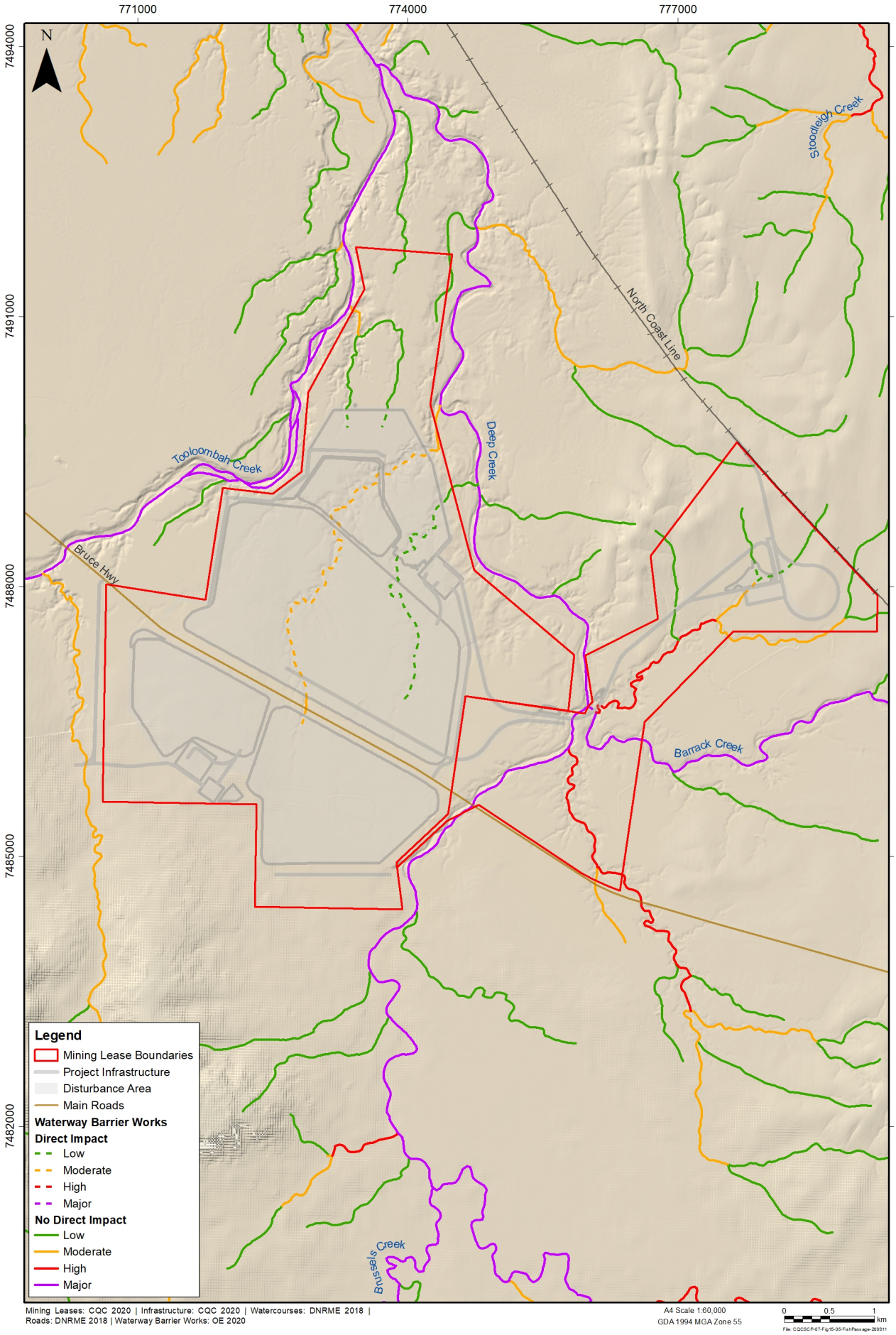

Figure 15-5: Waterway barrier works for fish passage

15.3.3 Wetlands of the Project Site

Databases searches identified several wetland values within or directly adjacent to the Project Site as described in Table 15-3. The location of these wetland values is illustrated on Figure 15-6. The results of field surveys of these wetlands are presented in the following sections.

Table 15-3: Wetland values of the Project Site

Search	Relevant Legislation	Wetlands within the Project Site	Wetlands outside of the Project Site
Vegetation Management Wetlands	*Vegetation Management Act 1999*	Two wetlands located within the Project Site (herein referred to as Wetland 1 and Wetland 2) are identified on the Vegetation Management Wetlands Map: • Wetland 1 – a Great Barrier Reef (GBR) wetland of high ecological significance (HES) located in a GBR wetland protection area (WPA). • Wetland 2 –a wetland of general ecological significance (GES). (DNRME 2020b)	The closest wetland on the vegetation management wetlands map, outside of the Project Site, is located 7.3 km to the north.
Map of Queensland Wetland Environmental Values and Map of Great Barrier Reef Wetland Protection Areas	Environmental Protection Regulation 2019. Great Barrier Reef Wetland protection areas are also mapped for referral under the State Assessment Referral Agency.	Wetland 1 is identified on the Map of Queensland Wetland Environmental Values. It is a GBR wetland of HES (DES 2020a). Wetland 1 is also a wetland within a WPA and Great Barrier Reef WPA (DES 2020a). Wetland 2 is identified on the Map of Queensland Wetland Environmental Values. It is a wetland of GES. A tributary of Deep Creek located within the Mining Lease Application (ML) is mapped as a wetland of GES.	Outside of the Project Site, sections of Tooloombah and Deep Creek (and their tributaries) are mapped as wetlands of GES. A number of GBR wetlands of HES within GBR WPAs are located outside of the Project Site including: one 10 km to the west, three located 14 km north, one located 12 km north-west and one located 16 km north-west.
Regional Ecosystem mapping and aerial imagery	*Vegetation Management Act 1999*	There are several natural and artificial wetlands of varying size present across the Project Site. The majority of these have been artificially created ('turkey nest' dams and dammed creek lines), although there are small natural freshwater wetlands of RE 11.3.27.	Numerous artificial wetlands and freshwater wetlands are located within the Project Area.

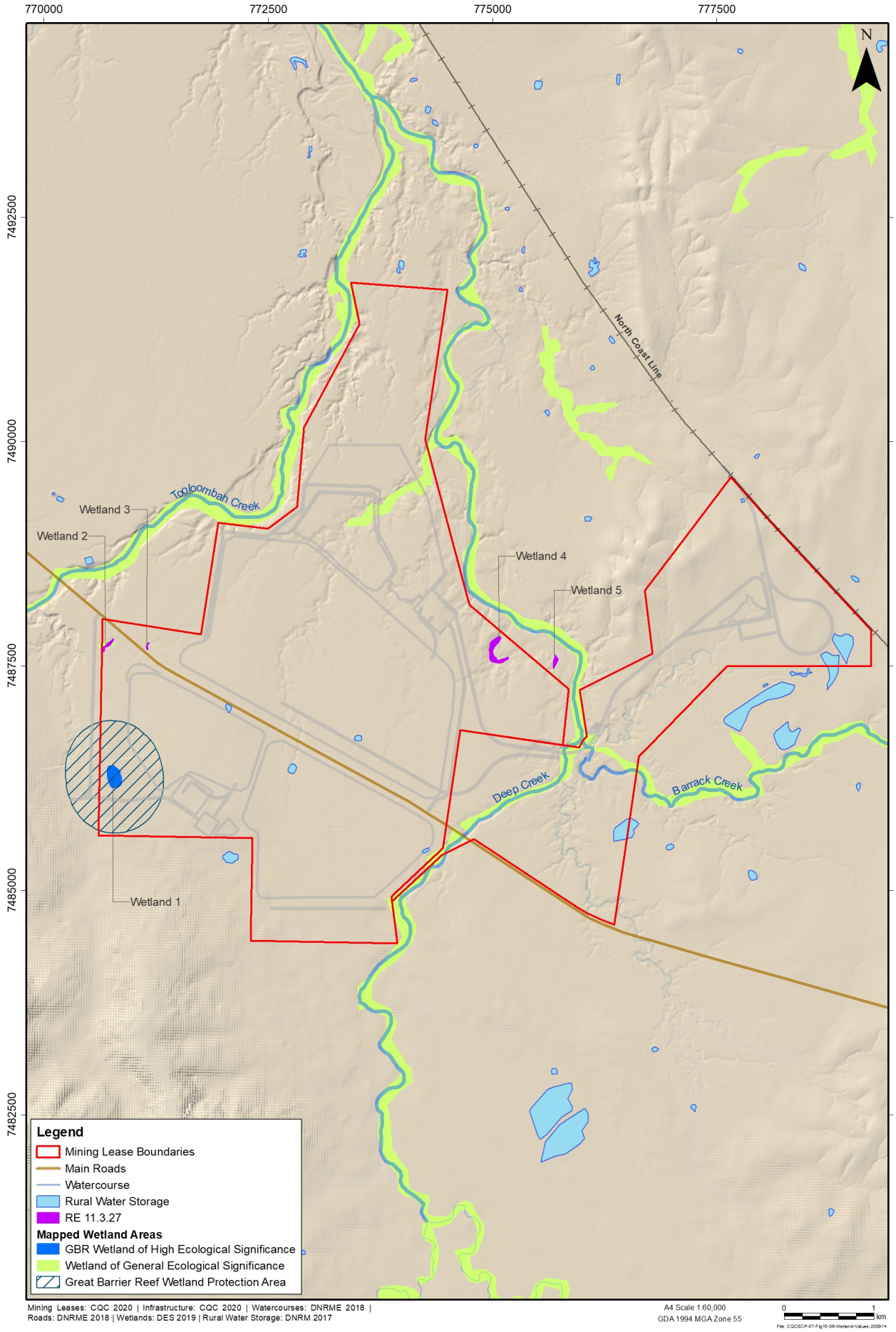

Figure 15-6: Wetland values of the Project Site

15.3.3.1 Wetland 1

Wetland 1 is an artificial/modified, palustrine wetland (non-riverine vegetated wetland). It is classified as a GBR wetland of HES located in a GBR WPA and mapped on the vegetation management wetlands map under the VM Act. Wetland 1 is mapped as a GDE in the Bureau of Meteorology's (BoM) GDE Atlas as a high potential aquatic GDE and low/moderate potential terrestrial GDE (BoM 2020). Wetland 1 has a 'Very High' significance aquatic conservation assessment of Great Barrier Reef catchments 'Aquascore' (Inglis and Howell 2009) (Figure 15-7). It is characterised by coastal/sub-coastal non-floodplain tree swamps (melaleuca and eucalypt). Wetland 1 is approximately 4 ha in size and 200 m wide.

A number of field surveys have been undertaken to characterise the physical and biological values of Wetland 1. Initial field surveys in 2011 identified Wetland 1 as a closed natural depression with broad, open margins of shallow water (< 30cm deep) tending deeper (>30 cm) towards its centre. It is described as an internally drained, circular wetland, enclosed by low sandstone rises with no drainage outflow, situated on a clay pan. Soils are heavy clays to a depth of 1.5 m. Given there is no catchment outflow, any captured surface water either evaporates or percolates into the soil.

Wetland 1 is ephemeral and has been assessed in both dry and wet conditions. During the vegetation assessment in 2011 water was present in the wetland. It was completely dry during an inspection in February 2017, however, as illustrated in Plate 15-1, filled following heavy rains in May 2017. It was relatively dry in January 2018 and the soil was generally damp with some areas of shallow water (10 cm depth) in the centre and north of the wetland, no open water was present and no water quality samples were able to be collected (Plate 15-2). Wetland 1 was also dry in August 2018.

A BioCondition assessment in 2018 confirmed that Wetland 1 is consistent with RE 11.3.12 and is surrounded by mixed eucalypt woodlands of RE 11.5.8 and 11.4.2. Vegetation within Wetland 1 consists of a central woodland of broad-leaved paperbark (*Melaleuca viridiflora*) 12 to 18 m tall with a patchy 30% canopy cover and a single red gum (*Eucalyptus tereticornis*) located within the centre of the swamp. There are a variety of sedges present at the centre of the wetland as well as a sparse cover of hydrophytes, including swamp lily (*Ottelia ovalifolia)*. In January 2018 the edge of the wetland was dominated by *Eleocharis pallens* and the centre of the wetland was wetter and dominated to a lesser extent by *Eleocharis sphacelata* with a variety of other species occurring throughout including swamp rice grass (*Leersia hexandra*), bunchy sedge (*Cyperus polystachos*), olive hymenachne (*Hymenachne amplexicaulis*) and mexican primrose-willow (*Ludwigia octovalvis*). Other species present as scattered occurrences include a variety of sedges (*Cyperus cyperoides*, *Cyperus haspan* and *Fimbristylis sieberiana*), floating primrose-willow (*Ludwigia peploides*), common nardoo (*Marsilea drummondii*) and budda pea (*Aeschynomene indica*).

Frog species recorded in January 2018 included eastern sedgefrog (*Litoria fallax*) and desert froglet (*Crinia deserticola*). Few waterbirds were observed as present during field inspections with only pacific black duck (*Anas superciliosa*) recorded. Cattle were present using the wetland area on all inspections in 2017 and 2018. Feral pigs (*Sus scrofa*) were also observed in the area.

Plate 15-1: Wetland 1 in wet conditions following Cyclone Debbie

Plate 15-2: Wetland in predominantly dry conditions

15.3.3.2 Wetland 2

Wetland 2 is a coastal/sub-coastal floodplain swamp palustrine wetland. It is classified as a wetland of GES and mapped on the vegetation management wetlands map under the VM Act. Wetland 2 is mapped on the GDE Atlas as a high potential aquatic GDE and low potential terrestrial GDE and has a 'Very High' significance aquatic conservation assessment of Great Barrier Reef catchments 'Aquascore' (Inglis and Howell 2009) (Figure 15-7). Wetland 2 is approximately 0.6 ha in size, 180 m in length and 40 m wide.

A number of field surveys have been undertaken to characterise the physical and biological values of Wetland 2. Water levels within the wetland appear to be relatively constant, indicating the wetland may be permanent. Water depth in the centre of the wetland could not be measured but is likely to be in excess of 1 m based on the water depth encountered around the vegetated edges during field surveys. Wetland 2 forms a narrow internally draining depression located on a floodplain and appears connected to an indistinct floodplain. Whilst drainage linkages are indistinct, it appears that Wetland 2 feeds a visible drainage depression on the east side of the Bruce Highway.

A BioCondition assessment in 2018 confirmed that Wetland 2 is consistent with RE 11.3.27 and is surrounded by intact woodland of RE 11.4.2. The wetland is characterised by dense fringing erect aquatic plant species including giant sedge (*Cyperus exaltatus*), *Eleocharis sphacelata*, *Digitaria divaricatissima*, and olive hymenachne. Open water comprises the remainder of the wetland with floating aquatic vegetation present dominated by a relatively constant cover of blue lotus (*Nymphaea caerulea*), with swamp lily, and water snowflake (*Nymphoides indica*) also present to a lesser extent. Other plant species recorded include floating primrose-willow, common nardoo, swamp rice grass and red water fern (*Azolla pinnata*). The wetland is bordered by sparse forest red gum and ironbark (Plate 15-3).

Low numbers of wetland bird species have been recorded at the wetland including straw-necked Ibis (*Threskiornis spinicollis*), brolga (*Antigone rubicunda*), pacific black duck, cotton pygmy-goose (*Nettapus coromandelianus*) and plumed whistling-duck (*Dendrocygna eytoni*). No fish were present in the wetland. Evidence of feral pig damage was observed around the edges of the wetland in January 2018.

In-situ water quality analyses recorded low turbidity (6.4 NTU) and EC (56 µs/cm), with a neutral pH (7.03). Laboratory analyses recorded low suspended solids (56 mg/L), low levels of metals with the exception of elevated iron concentrations and elevated total nitrogen and total phosphorus above the water quality objectives for lowland fresh waters in the Styx River Basin.

Plate 15-3: Wetland 2 (January 2018)

15.3.3.3 Other Wetland Habitat

In addition to Wetland 1 and Wetland 2 there are several natural and artificial wetlands of varying size present across the Project Site. The majority of these have been artificially created ('turkey nest' dams and dammed creek lines), although there are small natural freshwater wetlands of RE 11.3.27. Artificial wetlands such as farm dams are likely to provide habitat for semi-aquatic species including freshwater turtles and amphibians. However, as there is no consistent connection to waterways, these areas are unlikely to support functional populations of aquatic fauna such as fish. Analysis of aerial imagery indicates large portions of the Project Site are likely to retain water for substantial periods following heavy rains. Conditions were very dry at the time of the February 2017 survey, but water was still present throughout ML 80187. Many of these waterbodies appear relatively shallow, providing suitable habitat for a range of wetland bird species and amphibians.

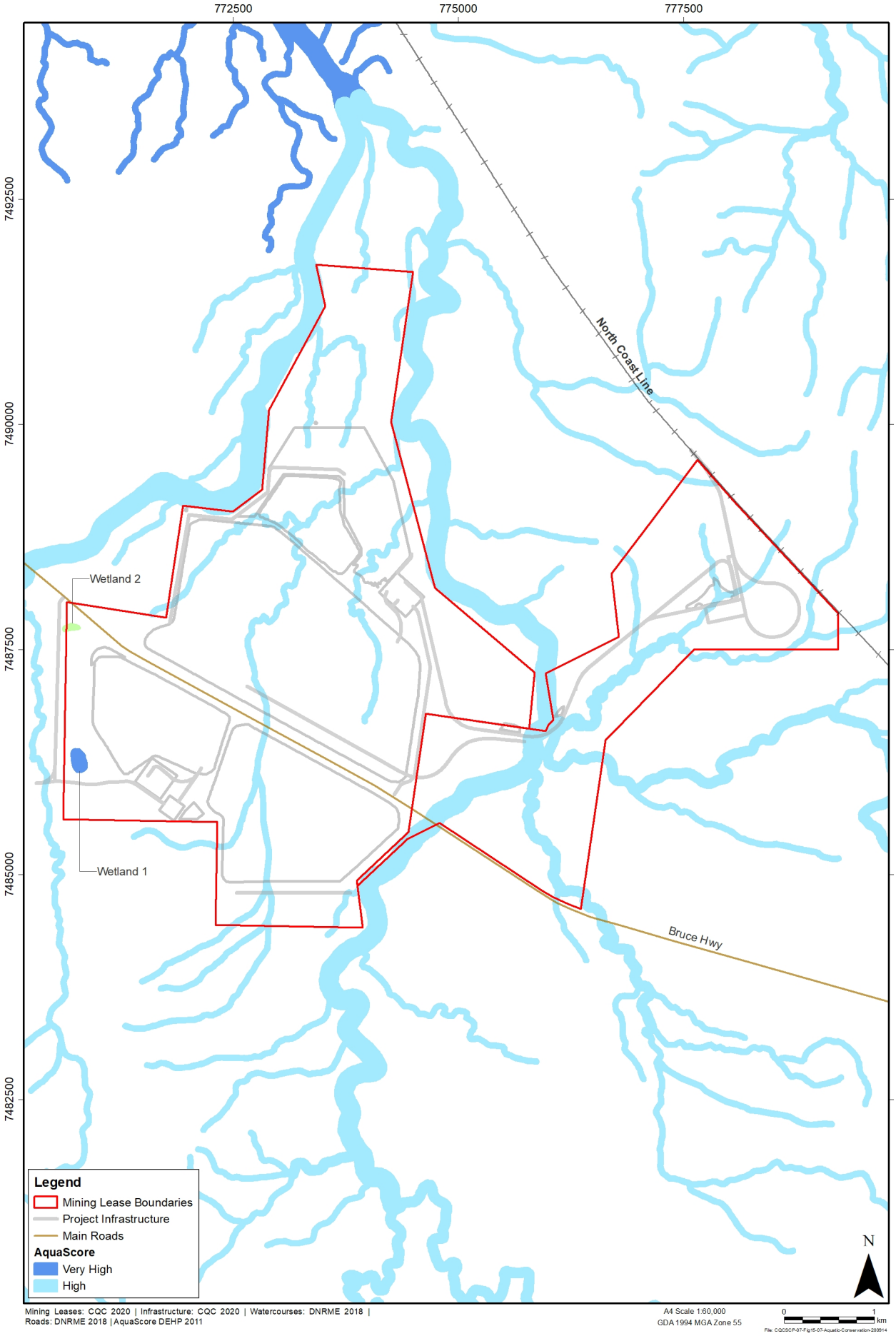

Figure 15-7: Aquatic conservation assessment mapping for the Project Area

15.3.4 Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystems are defined as ecosystems that require access to groundwater to meet all or some of their water requirements in order to maintain the communities of plants, animals and ecological processes they support, as well as the ecosystem services they provide (Doody et al. 2019). Three classes of GDEs are relevant to this assessment:

- Subterranean GDEs - Aquifer and cave ecosystems provide unique habitats for living organisms, such as stygofauna and troglofauna. These ecosystems typically include karst aquifer systems, fractured rock and saturated sedimentary environments. The hyporheic zones of rivers, floodplains and coastal environments are also included in this category.
- Aquatic GDEs - Ecosystems dependent on the surface expression of groundwater. They include wetlands, lakes, seeps, springs, river baseflow, coastal areas and estuaries that constitute brackish water and marine ecosystems.
- Terrestrial GDEs - Ecosystems dependent on subsurface presence of groundwater. They include terrestrial vegetation that depends on groundwater fully or on a seasonal or episodic basis to prevent water stress and generally avoid adverse impacts to their condition.

Whilst Terrestrial GDEs are not directly relevant to the assessment of aquatic and marine values, impacts on riparian Terrestrial GDEs has the potential to impact the waterways surrounding the Project Site and downstream areas, particularly through increased erosion and sedimentation and changes to water quality. As such, a summary of the Terrestrial GDE values of the Project and associated impact assessment is presented in this chapter. The detailed assessment is presented in full in Chapter 14 – Terrestrial Ecology.

15.3.4.1 Characterising Aquatic and Terrestrial GDEs

To characterise the types, nature, and location of Aquatic and Terrestrial GDEs within and surrounding the Project Site a multidisciplinary assessment has been undertaken drawing on numerous studies completed for the EIS and SEIS's, and utilising multiple lines of evidence including:

- GDE investigations by 3D Environmental (2020) to identify the source of water utilised by trees for transpiration including:
  - drill cores to provide evidence for tree rooting depth and characterise the local hydrogeological conditions
  - soil moisture potential measurement
  - leaf water potential measurement and
  - stable isotope analysis of xylem water, soil moisture, surface water and groundwater
- results of a stable isotope analysis undertaken by CDM Smith in 2018 to provide an indication of water sources supporting watercourse pools, which are hypothesised to be supported to some extent by groundwater discharge (CQC 2020)
- ground-truthing of RE within and adjacent to the Project Site to determine the likelihood for them to be Terrestrial GDEs
- results of the transient electromagnetic (TEM) survey which mapped EC at various depths across the Project Site to support of improved groundwater conceptualisation and modelling and assess salinity of groundwater sources (Allen 2019)

- outcomes of the revised regional numerical groundwater model which predicts drawdown depths of the water table across the Project site and surrounds (HydroAlgorithmics 2020)
- results of the revised flood study and site water balance by (WRM 2020)
- results of the fluvial geomorphology study to document the geomorphological character of the Project Site and Near Surrounds (Gippel 2020)
- analysis of surface water and groundwater data, including groundwater quality and water level data from several recently installed bores and stream flow data collected from gauges installed at Tooloombah and Deep Creek in 2019 (Orange Environmental 2020a and 2020b)
- assessment of the interactions between groundwater and surface water (ELA 2020a)
- data collected through geological coring of the soil profile including analysis of hydrogeological and geological data from alluvial drilling transects collected onsite from May to June 2020 (ELA 2020a)
- observational pools surveys of Tooloombah and Deep Creek (CQC 2020b) and
- examination of aerial photography to assess the persistence of pools over dry periods (ELA 2020b).

15.3.4.2 Definitions Relevant to the GDE Assessment

In characterising GDEs it is important to note that the Independent Expert Scientific Committee Guidelines (Doody et al. 2019, p13) state that the definition of **groundwater** includes '*water in the soil capillary zone (capillary fringe) but not the water held in the soil above this zone in the unsaturated or vadose zone. Within the saturated zone, pores are filled with water, whereas the capillary fringe and unsaturated zone increasingly have pores containing air as well as water. Water in caves that is sourced from groundwater is also included as groundwater, as are perched aquifers in the unsaturated zone.*'

This assessment also refers to the concept of **bank storage**. In the context of this assessment bank storage is a temporary source of groundwater stored within the banks of creeks or rivers which is derived from infiltration associated with flooding or rainfall. Water held in bank storage may be released to the adjacent creek or river over varying timescales following the recession of surface water levels. Water can also be held in bank storage for prolonged periods, where it may be accessed by Terrestrial GDEs.

In this assessment, the **water table aquifer** refers to an aquifer lying under the water table (as opposed to a perched aquifer). In most parts of the Project Site and surrounds, this is the alluvial aquifer. However, in some locations, particularly at Tooloombah Creek, the creek channel intersects the deeper weathered Styx Coal Measures. The term 'water table aquifer' therefore refers to the aquifer associated with the water table, regardless of which geological layer the aquifer is located within.

Enhanced leakage refers to the potential for water stored within the unsaturated zone to be depleted, due to the drawdown of the underlying water table aquifer, which can increase the rate of water infiltration from the unsaturated zone into underlying sediments. The depiction of groundwater sources as relevant for this assessment is presented in Figure 15-8. The top row shows storm event or wet season conditions, the middle row shows post event conditions, and the bottom row shows dry season conditions. As can be seen from this figure:

1. changes to the water table aquifer and bank storage occur in response to seasonal conditions (see differences between rows on Figure 15-8) and

2. in a given location, the response of the water table and the bank storage to seasonal conditions will differ, depending upon the distance between the base of the creek and the water table (see differences between columns on Figure 15-8).

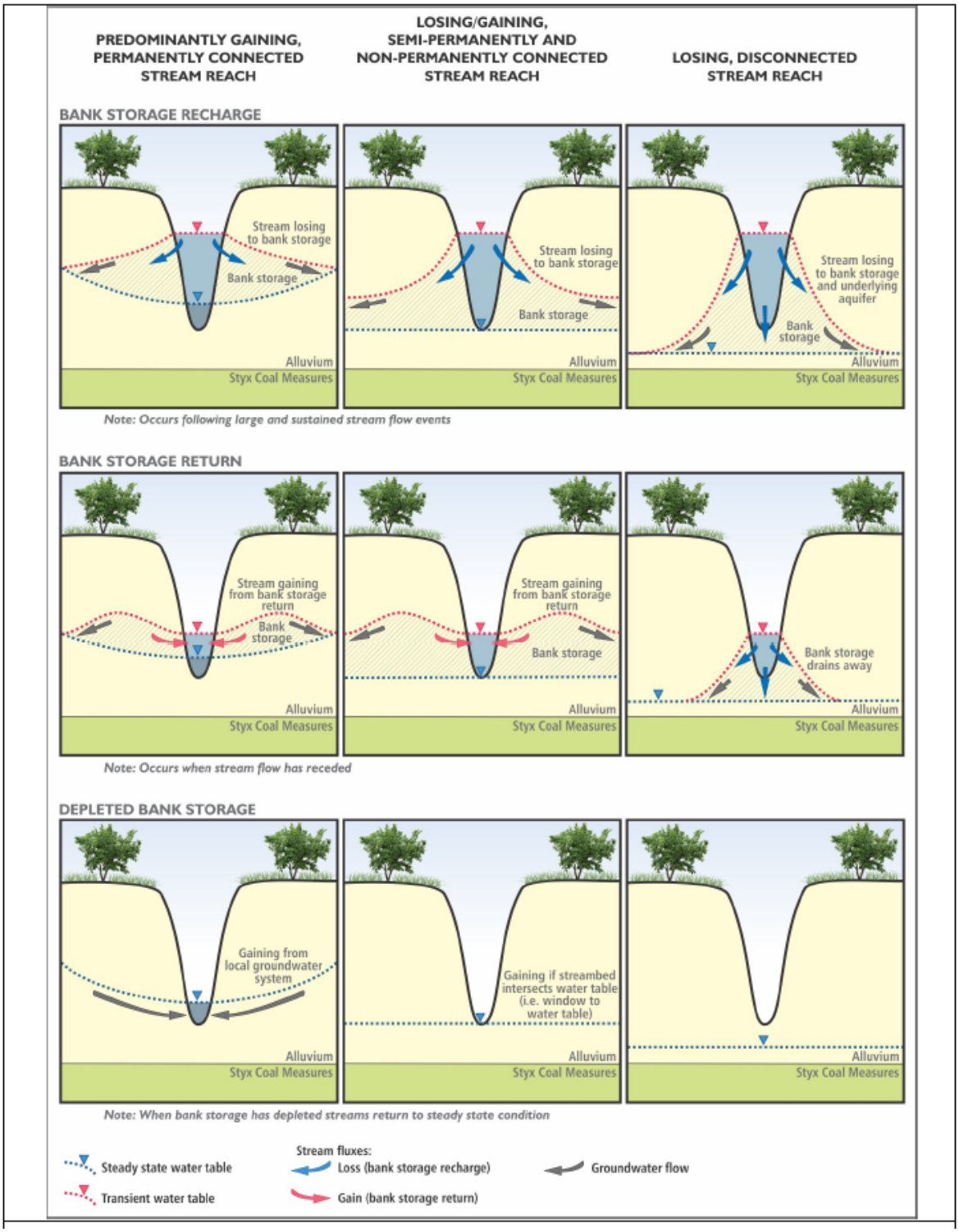

Figure 15-8: Mechanisms of surface water – groundwater interactions

15.3.4.3 Subterranean GDEs

The groundwater invertebrate (stygofauna) community is generally dominated by small crustaceans, occurring in aquifers with sufficient pore space to complete their life cycle, and are most common in alluvial sediments, karstic aquifers, and fractured rock (Glanville et al. 2016). Stygofauna were collected from bores intersecting the alluvium near the Styx River during baseline studies, but are likely to occur more broadly than the points of collection. The Styx River alluvium extends south from the collection bores, through ML 80187, and further south for another 12 km. This makes it unlikely that the stygofauna taxa sampled as part of the Project investigations are short range endemics.

Stygofauna are found in aquifers with relatively shallow water tables (within 20 m of the surface), and a strong hydrological connection to the surface. This is because these habitats are generally good sources of organic carbon, needed to fuel groundwater food webs. The Styx Basin contains large sections of shallow aquifers available to stygofauna, particularly the alluvial sediments associated with surface drainage and fractured or weathered rocks.

Six taxa were classified as stygofauna during baseline surveys as part of the EIS:

- Bathynellacea (syncarid crustacean)
- three Families of Oligochaeta (segmented worms)
- one species from the Subclass Copepoda and
- one species from the Subclass Acari.

Of these taxa, the oligochaetes and Acari are most likely to be members of the soil invertebrate community, rather than the stygofauna community (Halse and Pearson 2014). Copepoda could be stygofauna, as groundwater copepods are known from Queensland. However, there is a possibility that these could also be of surface water origin and that eggs or adult specimens have entered an open bore cavity and persisted in the bore cavity. Bathynellacea is a group of crustaceans known only from aquifers, so this taxonomic group is definitely stygofauna. This order is amongst the most diverse and widespread group of stygofauna in Australia, with little information relating to this group known from Queensland (Little et al. 2016).

The stygofauna collected during baseline EIS surveys came from bores close to rivers and with water of relatively low EC. Stygofauna are most commonly collected in groundwater with EC <5,000 µS/cm (Doody et al. 2019), although have been collected from aquifers exceeding 50,000 µS/cm on rare occasions (DES 2018). There is variability in the EC of the water table aquifers of Deep Creek, Tooloombah Creek and Styx River (HydroAlgorithmics 2020). Transient electromagnetic surveys indicate that soil moisture in upper layers to a depth of approximately 7 m is relatively fresh over most of the aquifers (EC < 4000 µS/cm), and saline below depths of approximately 12 m. EC in deeper parts of the aquifer is generally high, with alluvial bores screened between 12 and 18 m showing median ECs of 5,270 to 47,700 µS/cm.

These data suggest that there is a lens of fresh water either within or immediately above the water table aquifer overlying denser saline water. If this is the case, then it is possible that the upper parts of the aquifer are suitable for stygofauna. This is not always possible to determine from survey results, as most bores are screened beneath the freshwater layer. The Project Area is therefore likely to contain a mosaic of areas that are suitable and unsuitable for stygofauna, depending on local hydrogeological conditions and the depth of underground water resources.

The impact assessment has been completed, based on the high likelihood that stygofauna communities extend throughout the Styx River alluvium, as well as the alluvium of Tooloombah Creek and Deep Creek, but that their distribution is generally limited to parts of the aquifer where EC is less than 7,000 µS/cm. EC in the central part of the aquifer is higher (up to 37,400 mg/L) than in the coastal section near Broad Sound, or close to waterways (CDM Smith 2018- SEIS v2 Chapter 10), and is less suitable for stygofauna.

Likewise, there are areas suitable for stygofauna in the aquifer south of the mine, with a borehole (BH29) having EC <500 µS/cm. Although no stygofauna were collected from bores south of the mine, it is possible that stygofauna occur in this region. The taxa living in the southern section of the aquifer would be similar to those living in the northern section, given the likely connectivity. However, numbers of stygofauna would probably be higher in the north, due to the more extensive distribution of suitable habitat in this area.

More extensive and targeted sampling of stygofauna will be undertaken as part of the adaptive management framework associated with the GDEMMP. This will provide further information on the distribution of stygofauna across parts of the Project Area that will be subject to groundwater drawdown, and allow the response of stygofauna to Project-related changes in the water table aquifer to be monitored.

15.3.4.4 Aquatic GDEs

GDE mapping on the Bureau of Meteorology's GDE Atlas (BoM 2020), presented in Figure 15-9, indicates the potential presence of Aquatic GDEs within and adjacent to the Project Site including the Styx River, Tooloombah Creek, Deep Creek, Barrack Creek, Wetland 1 and 2, and a number of small farm dams. Investigations undertaken as part of the EIS and SEIS also indicate that:

- There is potential for baseflow of groundwater into Tooloombah and Deep Creek in some locations and as such these waterway sections are consistent with the definition of Aquatic GDEs.
- Throughout the wet season, flows within Tooloombah and Deep Creek are primarily driven by rainfall-generated surface water runoff and associated baseflow. Rising levels within the creeks and enhanced recharge through more permeable alluvial areas around the creeks causes a corresponding mounding of groundwater within the bank adjacent to the creeks.
- During the dry season in Tooloombah Creek this bank flow reverses and can supply a prolonged baseflow for the pools. Conversely, bank flow storage in Deep Creek does not return to the creek in the dry season as found in Tooloombah Creek, and therefore is unable to sustain pools through the dry season, other than potentially downstream towards the confluence of Deep and Tooloombah Creeks. As such, pools in proximity to the Project in Deep Creek are determined to be ephemeral, other than one very small semi-permanent pool (De5).
- These findings match the observations of pool persistence in the creeks in proximity to the Project.
- Each pool is likely to have a differing degree of groundwater input, which may be a permanent connection or a temporary one through the wet season and parts of the dry season, as bank storage is depleted in return flows back to the creek. The differences in connectivity may be due to differences in elevation and permeability of the underlying geology, which varies spatially.

- Aquatic GDEs in the lower catchment closer to the Deep and Tooloombah Creek confluence are likely to have year-round access to groundwater, whereas those in the upper to middle reaches may only have seasonal connection to groundwater.
- As there is also spatial variability in the salinity of groundwater (as indicated through monitoring of groundwater bores), each pool is likely to have a unique pattern of water chemistry.
- *Melaleuca leucadendra* occurring along the riparian fringe of Tooloombah and Deep Creek, and near groundwater-fed pools, are consistent with the definition of an Aquatic GDE, as they are shallow rooted and utilising groundwater fed stream pools and fluvial sands.
- Wetland 1 and Wetland 2 are not supported by the surface expression of groundwater and are therefore not Aquatic GDEs. Water and associated soil moisture at Wetland 1 and Wetland 2 are derived from surface water, rather than the surface expression of groundwater.

There have been a range of investigations of the number and distribution of pools that may receive groundwater inputs across the Project Site and surrounds. A summary of the results of this assessment in terms of the potential persistence of each surveyed pool is presented in Table 15-4. The location of pools is illustrated on Figure 15-10.

The pools investigation found that the Tooloombah Creek Gauging Station Pool (ToGS1) persists through the dry season as a permanent pool and is likely to be permanently connected to (relatively saline) groundwater. Investigations also indicated that other large pools on Tooloombah Creek (To1, To2, To3) are considered to be permanent or semi-permanent, with all being recorded as dry on <10% of regular inspections. These pools are also likely to receive groundwater inputs all year round, although modelling work indicates this lasts for less time and is much less important than for the abovementioned gauging station pool. In contrast, at Deep Creek and associated tributaries, most pools are ephemeral, drying out at various stages during the dry season. However, there is a clear trend of increasing permanence (and likely groundwater inputs) with distance downstream. De5 (located furthest downstream) was recorded as dry on <10% of regular inspections and has therefore been categorised as semi-permanent.

Table 15-4: Summary of pools adjacent to Project Site and potential groundwater dependence

Site ID	Persistence	Comments
4	Ephemeral	Medium pool. Ephemeral (satellite imagery shows water in 2011, dry in April and September 2018).
5	Permanent	Medium-large pool. Appears permanent (satellite imagery shows water in 2011, throughout 2018, observed in February 2018, part of To1 pool).
6	Permanent	Medium pool. Appears permanent (satellite imagery shows water in 2011, April and September 2018, though drying out in September 2018).
7	Unknown	Small pool. Water observed in January-February 2018. Otherwise satellite imagery inconclusive.
11	Permanent	String of medium pools. Appears permanent (satellite imagery shows water in 2011, April and September 2018, field observations show water in May 2020).
12	Permanent	Stretch of medium to large pools leading up to confluence. Appears permanent (satellite imagery shows water in 2011, April and September 2018, field observations show water in May 2020).
13	Permanent	Permanent, tidally affected downstream from confluence. Observations, sampling and satellite imagery confirm (satellite imagery shows water in 2011, April and Sep 2018).

Site ID	Persistence	Comments
17	Permanent	Medium pool. Appears permanent (satellite imagery shows water in water in 2011, April and September 2018), but also appears to be the result of the damming of the creek lower down (dam present in satellite imagery 2011, 2018).
22	Ephemeral	Small pool, observed in June 2020. Satellite imagery inconclusive, likely ephemeral.
23	Ephemeral	Medium pool, observed in June 2020. Satellite imagery inconclusive, likely ephemeral.
24	Ephemeral	Medium pool, observed in June 2020. Satellite imagery inconclusive, likely ephemeral.
25	Ephemeral	Medium pool, observed in June 2020. Satellite imagery inconclusive, likely ephemeral.
26	Ephemeral	Small pool. Pool observed in June 2020. Satellite imagery inconclusive, likely ephemeral.
27	Ephemeral	String of small to medium sized ephemeral pools, observed in June 2020.
28	Ephemeral	String of small to medium sized ephemeral pools, observed in June 2020.
29	Ephemeral	String of small to medium sized ephemeral pools, observed in June 2020.
30	Ephemeral	Medium to large sized pool / string of pools, observed in June 2020. Satellite imagery inconclusive. Likely ephemeral.
31	Ephemeral	String of small ephemeral pools, joining at times into larger pool. Water present in satellite imagery in 2011, and perhaps in April 2018, but the sandy river bed is evident in September 2018.
32	Ephemeral	Medium pool, present in 2011 and April 2018 satellite imagery, but appears dry in September 2018 imagery. Since To1 upstream dries out, likely this is also ephemeral.
33	Permanent	Appears to be well connected to the confluence site, but Sep 2018 may show disconnection and drying up of this section.
34	Ephemeral	Medium disconnected pools apparent in 2011, disappear in 2018 (both April and September) satellite imagery.
35	Ephemeral	Small pool identified in 2011, appears to disappear in later satellite imagery (April, September 2018).
Ba1x	Ephemeral	Small pool. Dry in 2 out of 4 recorded events.
Br 15	Ephemeral	Small pool, identified in May 2020, but not apparent in satellite imagery. Given location and size, likely to be ephemeral.
De_Br 7	Unknown	Small pool visited May 2020, cannot be seen on satellite imagery.
De1	Ephemeral	Small pool. Dry on 18 of 46 inspections.
De2 Pool 1	Ephemeral	Medium pool. Observed July 2018, satellite imagery 2011, and monitored 20 May 2019 - 8 July 2019, when it went dry.
De2 Pool 8	Ephemeral	Small pool, observed in February 2018, May 2020. Likely ephemeral based on nearby pools.
De3	Ephemeral	Small pool. Dry on 13 of 45 inspections.
De4	Ephemeral	Small pool. Dry on 4 of 36 inspections.
De4 Pool 20	Ephemeral	Small pool below De4, observed in May 2020. Likely ephemeral based on nearby pools (especially De4).
De5	Semi-permanent	Small pool. Dry on 2 of 32 inspections.

Site ID	Persistence	Comments
De5 Pool 14	Ephemeral	Small pool below De5. Appears ephemeral (water observed in July 2018, May 2020, but appears to be dry in satellite imagery – 2011, April and September 2018).
De5 Pool 21	Ephemeral	Small pool adjacent to Deep Creek. Appears ephemeral (water observed in May 2020, but appears to be dry in satellite imagery of 2011, April and September 2018.
DCS	Ephemeral	String of small ephemeral pools, observed in June 2020. Based on surrounding pools and size, appears ephemeral (no data from satellite imagery).
Pool 19A, B	Unknown	Pair of small pools. Water in May 2020. Otherwise satellite imagery inconclusive.
St1	Permanent	Part of large pool. Water at all times during sampling, and in 2011, April and September 2018.
To Pool 10	Permanent	Large pool, observed in May 2020. Appears permanent (water in 2011, April and September 2018, May 2020).
To1	Semi-permanent	Part of large Pool 5 when full (January - February 2018), otherwise medium sized. Dry on 2 of 50 inspections.
To2 Pool1	Permanent	Large pool. Water present on all of 41 inspections, and in 2011, 2018 satellite imagery.
To3	Semi-permanent	Medium sized pool. Dry on 1 of 32 inspections.
ToGS1	Permanent	Medium sized pool. Gauging station, containing water January 2020 onwards, and water in 2011, April and September 2018 satellite imagery.

Water quality sampling of permanent or semi-permanent pools in Tooloombah Creek indicated that in some pools there was increasing salinity over dry periods (ELA 2020a). For example, ToGS1 moves from an EC of <1,500 µS/cm at the start of the dry season, to over 9,000 µs/cm at the end of the dry season. Modelling by WRM (2020a) found that the increase in salinity in this pool could not be explained by evaporation alone and that such increases require the contribution of saline groundwater inputs. ELA (2020a) notes that while the water table aquifer is generally located below the creek bed, intersections between the creek bed and the water table aquifer do occur in some locations on a seasonal basis. As such, there is expected to be variation across the site and from pool to pool.

Monitoring of water level and chemistry in pools with no anticipated groundwater input showed that these pools retained an EC of <1,500 µS/cm and lost approximately 5-10 mm of water per day during the dry season, which can be explained purely by evaporation.

Field studies also identified that there is a weathered clay underlying the alluvium of Tooloombah Creek and that these sediments have a low permeability, reducing the vertical connectivity between the alluvium and Styx Coal Measures, Tooloombah Creek has a high capacity for bank storage (ELA 2020a). In Tooloombah Creek, bank storage is recharged through lateral flow of surface water during the wet season, causing mounding in the water table aquifer. Throughout the dry season, water held in bank storage flows towards the creek, maintaining water levels. Flows from bank storage are predicted to reach Tooloombah Creek for a period of approximately 150 days.

The Groundwater Model and Assessment Report (Appendix A6b) notes that there is the potential for localised upward pressures from the aquifer underlying Tooloombah Creek. This is likely

influenced by surface water recharge of the groundwater system near the Tooloombah Creek 'pinch point', a geographic feature where there is a narrowing of the creek channel between Mount Brunswick and Mount Mamelon, upstream of the Project. It was conjectured that the hydrological pressures associated with the 'pinch point' may provide a mechanism for groundwater from the water table aquifer to flow upwards into Tooloombah Creek at locations downstream of the pinch point, although based on the stable isotope analysis this could be influenced by surface water recharge of the water table aquifer near the pinch point. As noted above the detailed work by ELA (2020c) also indicates that groundwater supply is primarily via bank storage return.

In contrast to Tooloombah Creek, Deep Creek, follows the course of a fault and while the western bank of the creek comprises some clay content, as well as sand, the eastern bank of the creek consists of coarse gravel layers with a high permeability (ELA 2020a). As such, the sediments underlying Deep Creek have a higher permeability than Tooloombah Creek and bank storage is far less feasible along this watercourse. Water from flooding or rainfall is likely to percolate through the coarser sediments and gravels, and flow away from the creek to the east. Groundwater and bank storage therefore plays a lesser role in supporting Aquatic GDEs than it does at Tooloombah Creek. In addition, increases in salinity within pools of Deep Creek can be explained by evaporation.

Based on the above, groundwater is considered more important to sustain the ecological values of Aquatic GDEs in Tooloombah Creek, in particular the persistence of pools, than it is at Deep Creek. Such findings are consistent with field observations of pools.

15.3.4.5 Terrestrial GDEs

GDE mapping on the Bureau of Meteorology's GDE Atlas presented in Figure 15-9 indicates the potential presence of Terrestrial GDEs within and adjacent to the Project Site including the Styx River, Tooloombah Creek, Deep Creek, Barrack Creek, Wetland 1 and 2 and remnant vegetation located to the south and west of the Project Site. Based on the detailed investigations presented in Chapter 14 – Terrestrial Ecology, Terrestrial GDEs associated with the Project include:

- Wetland 1, as *Melaleuca viridiflora* utilises sub-surface groundwater, in the form of a perched aquifer. As *Melaleuca viridiflora* is a key component of the wetland, and its associated RE 11.3.12, the entire wetland is considered a Terrestrial GDE.
- Vegetation communities existing along the riparian corridors of Tooloombah and Deep Creek comprising REs 11.3.4, RE 11.3.25, RE 11.3.12, RE 11.3.27 and RE 11.3.35, where they are accessing groundwater located less than 15 metres below ground level (mbgl) and that has an EC below the conservative tolerance of 10,000 µS/cm.

As stated in 3D Environmental (2020), Wetland 2 is not a Terrestrial GDE as any aquifer located beneath Wetland 2 is deeper than 15 mbgl and beyond the reach of tree roots. Vegetation within Wetland 2, and Wetland 2 itself, is not a Terrestrial GDE.

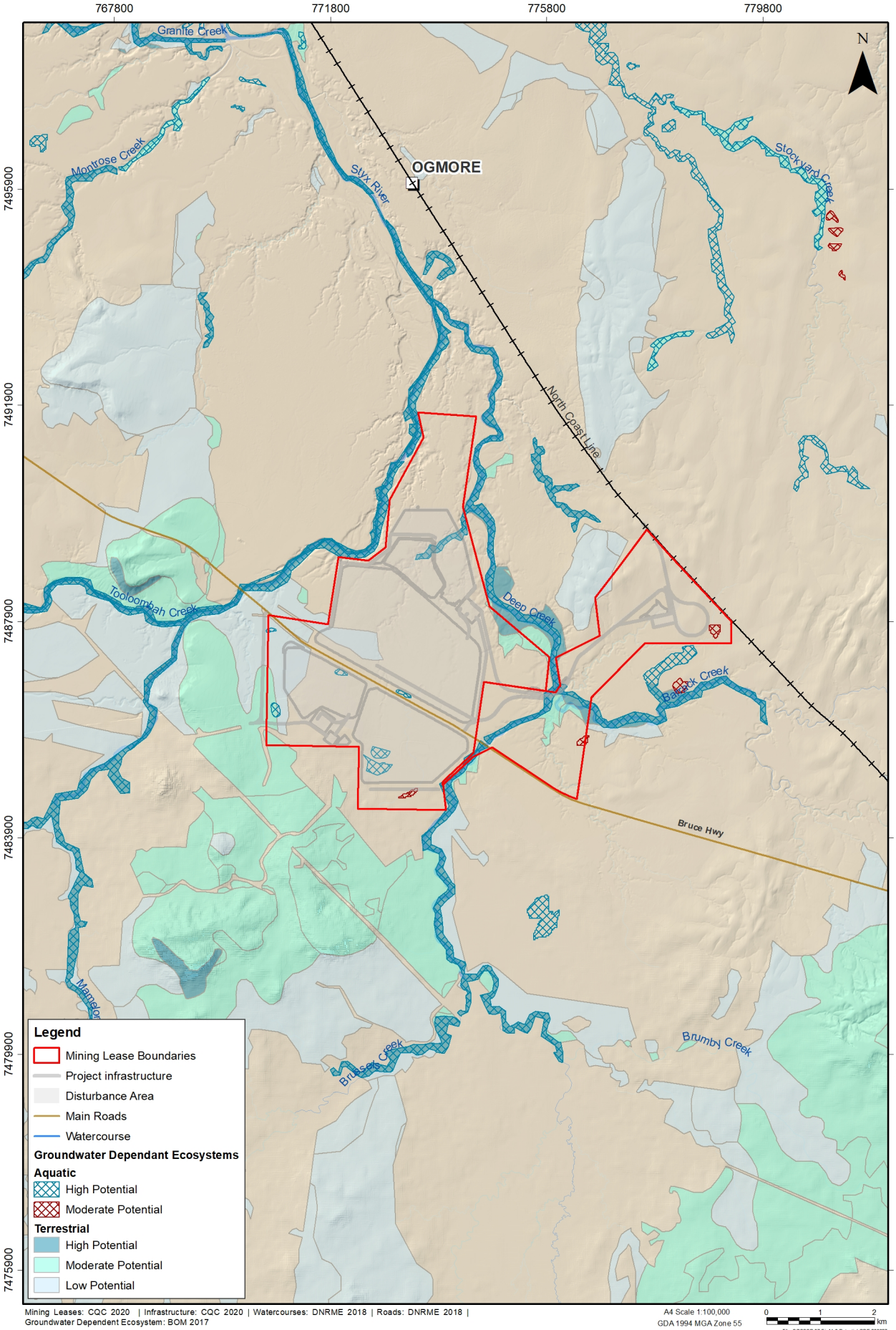

Figure 15-9: Potential GDEs

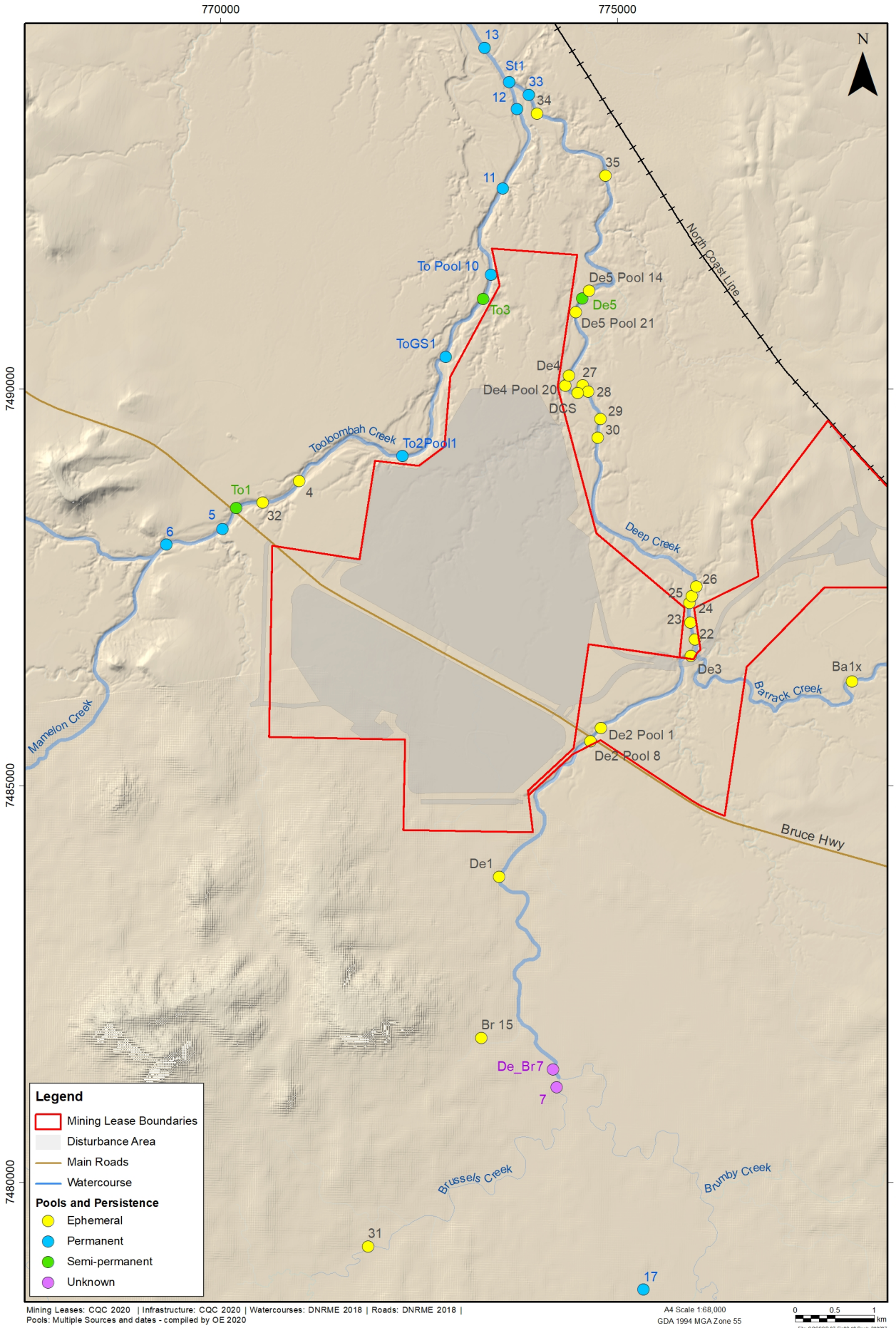

Figure 15-10: Location of pools adjacent to the Project Site

15.3.5 Broad Sound

15.3.5.1 Broad Sound Wetland

The Broad Sound wetland is a large macro-tidal bay located on Australia's east coast approximately 11 km downstream of the northern Project boundary (Figure 15-11). It is listed in the DIWA, and the lower Styx River forms part of the catchment of the wetland. Several ephemeral drainage lines empty into Broad Sound including Herbert Creek (associated with the Torilla Plain), Saint Lawrence and Waverley Creeks, and the Styx River.

The wetland encompasses an area of approximately 2,100 km^2 comprising a complex aggregation of tidal marine and estuarine wetlands. The southern boundary of the wetland lies close to the boundary of the GBRWHA (Figure 15-11). The wetland area includes the Torilla Plain, a large marine plain to the east of the Project formed on the southern side of the Torilla Peninsula. In this area wetlands occur as numerous interconnected pools and channels which may merge into much larger waterbodies in the wet season.

15.3.5.1.1 Aquatic and Marine Habitats

Broad Sound comprises a range of habitats including seagrass beds, lower intertidal and supratidal mudflats, and mangroves. There are also small areas of beach habitat, and brackish and freshwater coastal swamps and lagoons, and open depressions of streams, creeks and estuaries. These have been formed in a sheltered embayment and have a very large tidal range of approximately 9 m. Broad Sound is the largest shallow, macro-tidal bay on Australia's east coast. The area is very shallow, with depths of less than 10 m. Tidal waters supply most of the water to Broad Sound. These saline waters are diluted to brackish by freshwater flooding and stream flows, particularly during extreme rainfall events. Several freshwater waterways discharge into Broad Sound, including the Styx River.

Broad Sound (with adjacent Shoalwater Bay) is considered one of the five main centres within the GBR for saltmarsh and mangrove communities. These are critical habitats for important juvenile marine species such as barramundi (*Lates calcarifer*), mullet and penaeid prawns. In the past, there has been extensive construction of ponded pastures in the Broad Sound area. Bund walls have been constructed to convert saltmarsh into pasture, restricting movements of juvenile fish into these areas (Goudkamp and Chin 2006), but creating additional temporary and brackish wetlands.

Saltpans and saltmarsh communities occupy 372 km^2 of the Broad Sound wetland area (Figure 15-11). Current vegetation mapping indicates large areas of saltpans and mudflats with saltmarsh species are present along the Styx River beginning approximately 14 km downstream of the Project Site. These become extensive further downstream extending 5 km to 6 km inland on the northern bank of the river as the channel splits around Rosewood Island.

Mangroves occupy 216 km^2 within the Broad Sound wetland (Figure 15-11). In some areas these form bands over 1 km wide, largely in the western section (Torilla Peninsula) but also in the lower reaches of the Styx River around Rosewood Island. There are no specific references to the mangrove species occurring in Broad Sound. Based on vegetation mapping, dominant species are expected to be grey mangrove (*Avicennia marina*), *Rhizophora* and *Bruguiera* species, spurred mangrove (*Ceriops tagal*) and black mangrove (*Aegiceras conrniculatum*).

Seagrass mapping data from the past 30 years has been collated across the GBR area (Carter et al. 2016). The only mapped seagrass beds known in the Broad Sound area are small patches located

in the north-east corner of the wetland. There are no seagrass beds mapped in the vicinity of the Styx River estuary or surrounds. Extensive seagrass beds occur to the northwest in the Clairview area (approximately 53 km north of the Project) and in Shoalwater Bay, including small patches near the islands off Stanage Bay approximately 70 km north-east of the Project. Seagrasses require suitable light conditions and appropriate nutrient levels. It is likely the extreme tidal range in Broad Sound influences the lack of seagrass, this is likely to be due to high turbidity levels and prolonged exposure of tidal flats during low tides.

Mapping for the GBRMP area indicates small fringing reefs occur within Broad Sound on Turtle Island and Charon Point approximately 35 km north-northeast of the Project (Figure 15-11). A larger reef area occurs on the southwest edge of Long Island (52 km northeast), a continental island adjacent to the west of the Torilla Peninsula. Several small reefs also occur in the Clairview area to the north of Broad Sound (approximately 55 km north).

The structure of coral reefs in the area surrounding Broad Sound (including offshore islands such as Peak Island) have previously been surveyed to examine the impact of the naturally turbid conditions and tidal range on reef development. Coral richness in the area is lower than in adjacent regions (De'ath and Fabricius 2008). High turbidity inhibits photosynthesis in symbiotic algae (Thompson et al. 2014) and low tides that allow for extended exposure are not suitable for most coral species (Kleypas 1996). Kleypas (1996) examined reef systems surrounding the Broad Sound area, including the Percy Islands and Duke Island (90 km and 120 km north-east of the Project respectively). The study found that reefs within or close to Broad Sound were thinner, in shallower waters and comprised species associated with deeper waters. The effects of elevated turbidity in and surrounding Broad Sound included:

- decreasing hard coral colony size associated with distance to Broad Sound
- decreasing diversity of both soft and hard corals
- shifting coral morphology and
- lack of reef building (or framework) species (Kleypas 1996).

15.3.5.1.2 Condition

The Broad Sound region is a remote and relatively undisturbed area of the GBR. Water within the region is naturally turbid due to the extreme tidal range over a large shallow area, resulting in strong currents and the resuspension of sediments. A turbidity plume extends outwards from Broad Sound to local islands in the Capricorn area of the GBR (such as the Percy Islands group) (Kleypas 1996). Nutrient and chlorophyll concentrations are generally low (De'ath and Fabricius 2008).

Broad Sound experiences a complex and broad range of water quality influences reflecting varying inputs from fresh and marine waters. Widespread clearing of vegetation in low-lying areas for agriculture / cattle grazing increases erosion, mobilisation of sediments, and nutrients entering Broad Sound from within the contributing catchments. Extensive construction of low embankments to create ponded pasture throughout the Broad Sound area have altered freshwater inputs from the catchment (Holmes et al. 2013).

15.3.5.2 Fish Habitat Area

Broad Sound contains a variety of intertidal and estuarine habitats including mangroves and seagrass that provide key spawning and nursery areas for many species of fish. Broad Sound is afforded formal protection for its values to fish via designation as a declared FHA, under the

Fisheries Act. Broad Sound FHA is Australia's largest declared FHA at over 170,000 ha (Figure 15-11). The FHA boundary is located approximately 10 km downstream of the Project Site. Habitats within the FHA include intertidal and estuarine habitats including mangroves and seagrass that provide key spawning and nursery areas for many species of fish and terrestrial areas such as rocky headlands and sand bars.

The Broad Sound FHA is declared a Management A area. Management A areas are afforded a higher level of protection and management as they are considered key fish habitats. FHAs are protected from physical disturbance while allowing legal commercial, recreational and indigenous fishing to take place. Fish species of fisheries value occurring in the FHA include barramundi, blue salmon, bream, estuary cod, flathead, grey mackerel, grunter, mangrove jack, queenfish, sea mullet, school mackerel, whiting, banana prawns and mud crabs (DNPSR 2014).

15.3.6 Great Barrier Reef

The GBR extends along approximately 2,300 km of the Queensland coast and includes intertidal areas such as Broad Sound, as well as coral reefs extending out to the continental shelf. The GBR and its ecological values are protected under the EPBC Act as well as the *Queensland Marine Parks Act 2004*.

15.3.6.1 World Heritage Area

The Great Barrier Reef was inscribed as a World Heritage property in 1981, as it was deemed to meet all the natural heritage criteria for listing. The GBRWHA extends from the low water mark on the coast of Queensland past the continental shelf outside the outer reef, covering an area of approximately 348,000 km^2. The GBRWHA boundary aligns with the boundary of the Broad Sound FHA and is located approximately 10 km downstream of the Project (Figure 15-11).

The EPBC Act provides for the protection of World Heritage values such as the GBRWHA from actions that may have a significant impact on these values. This protection is based upon attributes of Outstanding Universal Value (OUV) outlined in the EPBC Act referral guidelines for the Outstanding Universal Value of the Great Barrier Reef World Heritage Area (DE 2014).

None of the specific locations referred to in the World Heritage listing for the GBR (e.g. Green Turtle breeding on Green Island and the Cod Hole tourist attraction), occur within or near the Project Area. However, Broad Sound and the surrounding region does make a contribution to OUV under the majority of the GBRWHA's listing criteria as the area supports a subset of the features and processes (e.g. natural beauty, biodiversity, coral reef accretion) identified in the listing. However, none of the area's contributions to OUV are critical contributions at the scale of the World Heritage Area (DE 2014).

Of the environmental values present in the Project Area, some can be considered to provide a higher contribution to the OUV of the GBRWHA than others. Broad Sound is considered one of the five main centres within the GBR for mangrove and saltmarsh communities. It is also considered to provide significant habitat for waterbirds including substantial aggregations of migratory shorebirds listed under the EPBC Act (DEE 2017a). Other attributes present in the vicinity of Broad Sound that contribute to the OUV of the GBRWHA include:

- A number of reef communities including a large reef system on the edge of Long Island.
- Extensive seagrass beds in the Clairview area (northwest) and in Shoalwater Bay (only small patches are present within Broad Sound Wetland).

- Inshore dolphin species, Australian hump-back dolphin (*Sousa sahulensis*) and Australian snubfin dolphin (*Orcaella brevirostris*) have been observed in Broad Sound and Shoalwater Bay.
- Multiple sites of flatback turtle nesting occur in areas near Broad Sound, such as Long Island, Avoid Island and Wild Duck Island, and Broad Sound is utilised as inter-nesting habitat by some flatback turtles.

The GBR was placed on the National Heritage List in May 2007 in accordance with the provisions of item 1A of Schedule 3 of the Commonwealth's Environment and Heritage Legislation Amendment Act (No.1) 2003. It was determined by the Minister of the then Department of Environment and Water Resources the GBR should be included on the National Heritage List as the National Heritage values were demonstrated to be achieved through corresponding World Heritage values.

15.3.6.2 Great Barrier Reef Marine Park

The GBRMP was established under the *Great Barrier Reef Marine Park Act 1975* and overlays much of the GBRWHA, covering approximately 344,000 km^2. It is located approximately 41 km downstream the Project (Figure 15-12). The areas of the GBRMP downstream from the Project within the Styx River estuary are zoned General Use under the Great Barrier Reef Zoning Plan 2003, as are other nearshore coastal areas to the north. The area beyond the Styx River estuary/coastal zone and in Broad Sound is zoned Marine National Park ('green zone').

The GBRMP supports a wide variety of habitats, within which there is large variation. The Great Barrier Reef Outlook Report prepared by the Great Barrier Reef Marine Park Authority (GBRMPA) (2019) identifies the key habitats of the GBRMP. Those present within the areas downstream of the Project include:

- coastal habitats (including islands, beaches, mangroves, and seagrass meadows)
- coral communities (e.g. Turtle Island and Long Island)
- seabed including the lagoon floor and
- open water, which connects all of the GBRMP's habitats (GBRMPA 2019).

The GBRMP also supports a number of physical, chemical and ecological processes, along with social and cultural values. Those with potential to be influenced by the Project include:

- aboriginal cultural values (e.g. connection to Sea Country and presence of culturally important species such as dugong)
- recreational and commercial fishing and
- tourism.

15.3.6.3 Great Barrier Reef Coast Marine Park

The GBRCMP is a State marine park administered under the Queensland *Marine Parks Act 2004*. It overlays part of the GBRMP, encompassing the tidal lands and tidal waters (an area of 62,731 km^2). The GBRCMP boundary is located approximately 10 km downstream of the Project (Figure 15-12).

The GBRCMP is a MSES where designated as a 'highly protected area' as defined in Schedule 2 of the *Environmental Offsets Regulation 2014*. The Great Barrier Reef Zoning Plan 2003 maps areas of the marine park in relation to the types of activities that can occur in the various zones. Several zones occur within the Broad Sound area ranging from General Use to Marine National Park. The

section of the park on the Styx River closest to the Project is identified as a General Use zone, providing reasonable use while allowing conservation and is therefore not identified as a 'highly protected area' (Figure 15-12). The Marine National Park zone is located approximately 33 km northeast of the Project (or 40 km downstream).

15.3.6.4 Threats to the Great Barrier Reef

The GBR is subject to a number of threats including land-based runoff, climate change, coastal development and direct human uses such as fishing. In recent years, the overall condition of the GBR has been declining and the latest Outlook Report published as part of the Reef 2050 Long-Term Sustainability Plan (Reef 2050 Plan) (Commonwealth of Australia 2018) states that the current outlook for the GBR is very poor, unless more action is taken to address a range of threats (GBRMPA 2019).

Inshore areas of the GBR, such as Broad Sound, are also under threat, particularly due to decreased water quality. Sedimentation and levels of pollutants are high in many of these inshore areas as a result of coastal development, increased erosion, and run off from agricultural practices. Although some improvements in water quality are occurring, the rate of improvement is slow (GBRMPA 2019).

The Fitzroy Basin Association Natural Resource Management (FBA NRM) body reports that the most significant risk to the entire GBRMP is sediment (Waterhouse et al. 2015). On average, it is estimated that approximately 9.9 million tonnes (t) of sediment as total suspended solids (TSS) is delivered to the GBR lagoon, with approximately 1.8 million t per year from the Fitzroy region, amounting to 18% of the total sediment load that reaches the GBR (Bartley et al. 2017). The leading land use source of sediment is grazing land which accounts for 75% of the extra sediment entering the GBRMP (Bartley et al. 2017). It is estimated that the Styx Basin contributes approximately 0.1 million t per year of TSS, equating to around 5% of the total Fitzroy region (Bartley et al. 2017).

A sediment budget assessment undertaken for the Project by Engeny Water Management, provided in Appendix 15b, estimates that under average climatic conditions, a total baseline sediment export rate of 5,037 t/year for the Project Area, comprising the Mamelon Property and ML 700022. This equates to 0.72 t/ha/year based on the predominant grazing land use for the area.

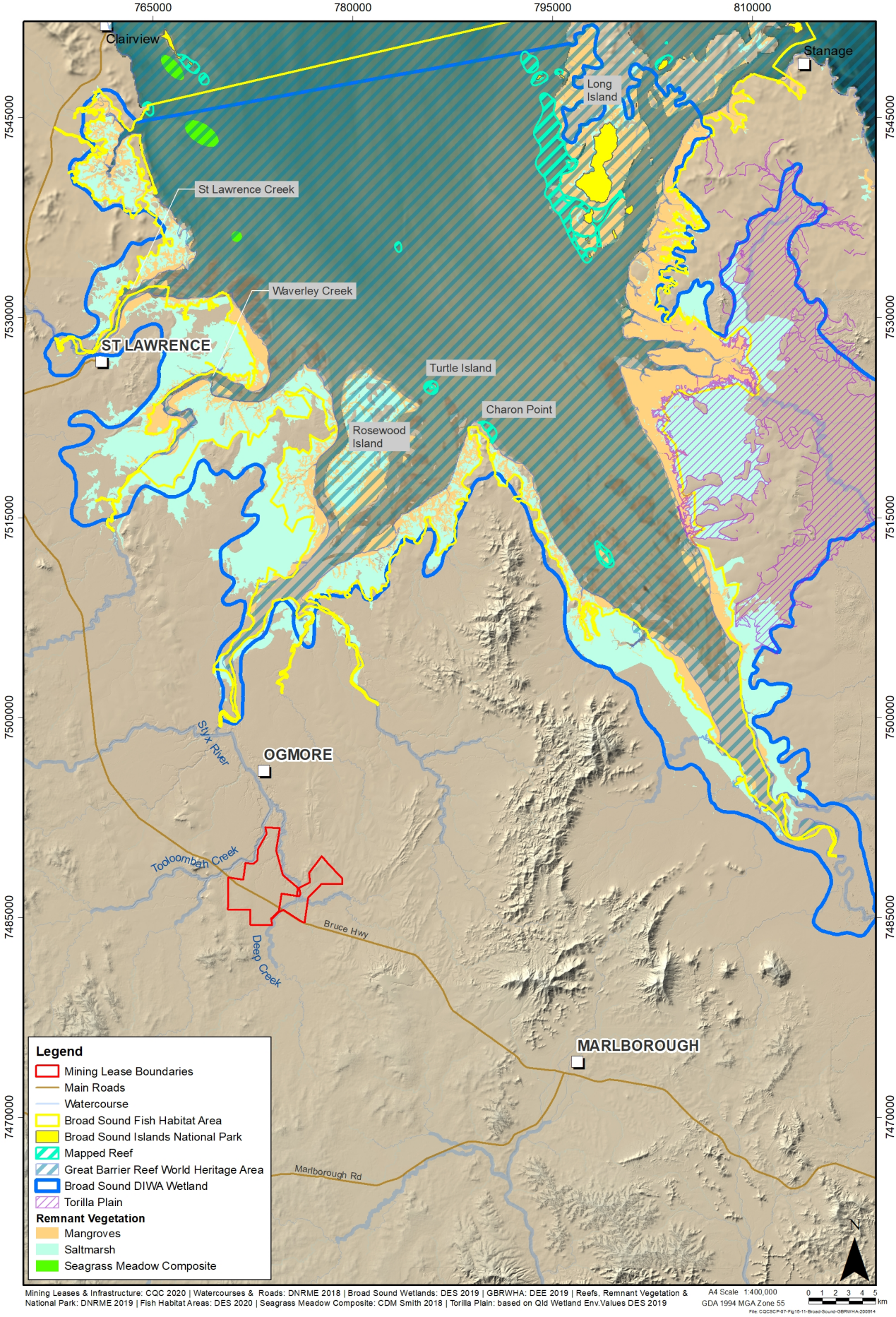

Figure 15-11: Broad Sound and the GBRWHA

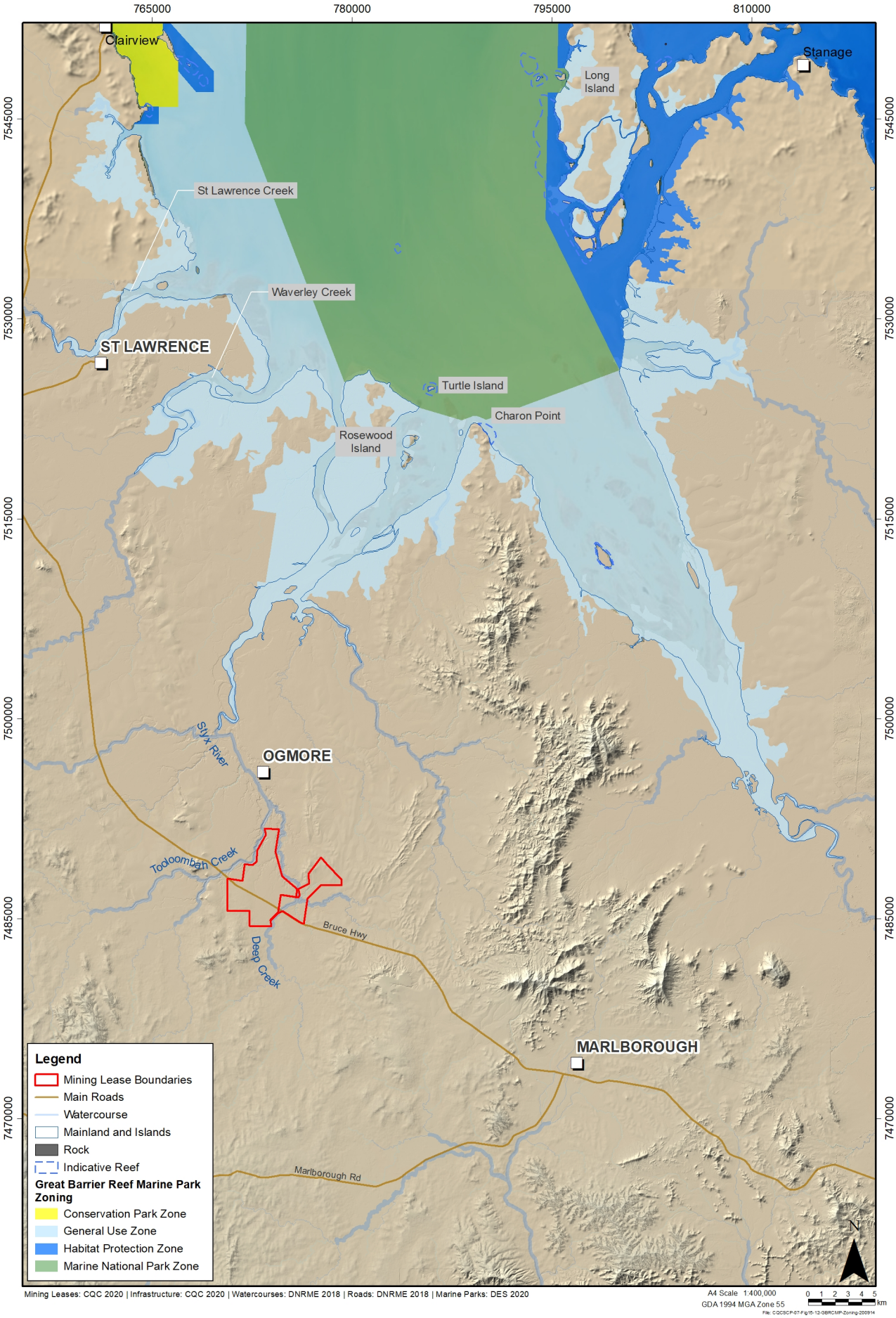

Figure 15-12: Great Barrier Reef Marine Park and Coast Marine Park

15.3.7 Aquatic and Marine Flora

No native aquatic flora was identified through the database search (DSITIA 2020). No native aquatic flora listed under the EPBC Act and NC Act was recorded during field surveys.

Observations during wet and dry season surveys across the wider area in 2011 recorded a number of sedge / wetland plants associated with ephemeral wetlands including *Eleocharis blakeana* and *Juncus polyanthemus*. Aquatic flora species were relatively sparse during the February 2017 survey, although dense aquatic algae occurred at the Tooloombah Creek sites. Water snowflake, a floating species, was relatively common on the large pool at Tooloombah Creek site To2. Swamp lily occurred in isolated patches along the edge of Deep Creek site De2.

Several species of plants defined as marine plants under the Fisheries Act occur in the tidal and intertidal areas downstream of the Project Site. Marine couch (*Sporobolus virginicus*) was identified along the edge of the Styx River approximately 2.5 km downstream of the Project. These sparse occurrences most likely represent the peak tide limit associated with king tides and storm surges. Marine couch was most abundant along the banks of the Styx River from approximately 4 km downstream of the Project, which is considered to represents the normal high tide limit. Extensive stands of saltmarsh and mangrove species occur downstream of the Project (14 km and 21 km downstream respectively) along the margins of the Styx River and Broad Sound.

15.3.8 Aquatic Weeds

No aquatic weeds were identified through database searches (DSITIA 2020). The semi-aquatic weed, olive hymenachne, was observed on several field surveys. Olive hymenachne is a large semi-aquatic grass species that can reproduce from small fragments of the plant stem. It forms dense stands crowding out native plant species and degrading habitat for aquatic fauna including commercial and recreational fish species. It was observed in the northern extent of the Project Site at a farm dam in February 2017 and in a water-filled gilgai in May 2017 (Figure 15-13). It was also observed in several wetlands and dams in January 2018 having expanded its occurrence in the area. Olive hymenachne is listed as a Category 3 Restricted Matter (under the Queensland *Biosecurity Act 2014*) and a Weed of National Significance.

Parthenium (*Parthenium hysterophus*) was observed in the creek bed at Tooloombah Creek site To2 during the 2017 survey and was commonly observed along the creek banks adjacent to the site following heavy rains later in the year. This is listed as a Category 3 Restricted Matter (under the State's Biosecurity Act) and a Weed of National Significance, although is not an aquatic plant.

Rubber vine (*Cryptostegia grandiflora*) and lantana are common, often forming dense infestations (up to 4m in height) along the creeks (Figure 15-13). Bellyache bush (*Jatropha gossypifolia*) also occurs in patches along the margins of both creeks. Parthenium (*Parthenium hysterophorus*) was only observed along Tooloombah Creek and not within the Project Site itself. Both species are listed under Biosecurity Act and as Weeds of National Significance.

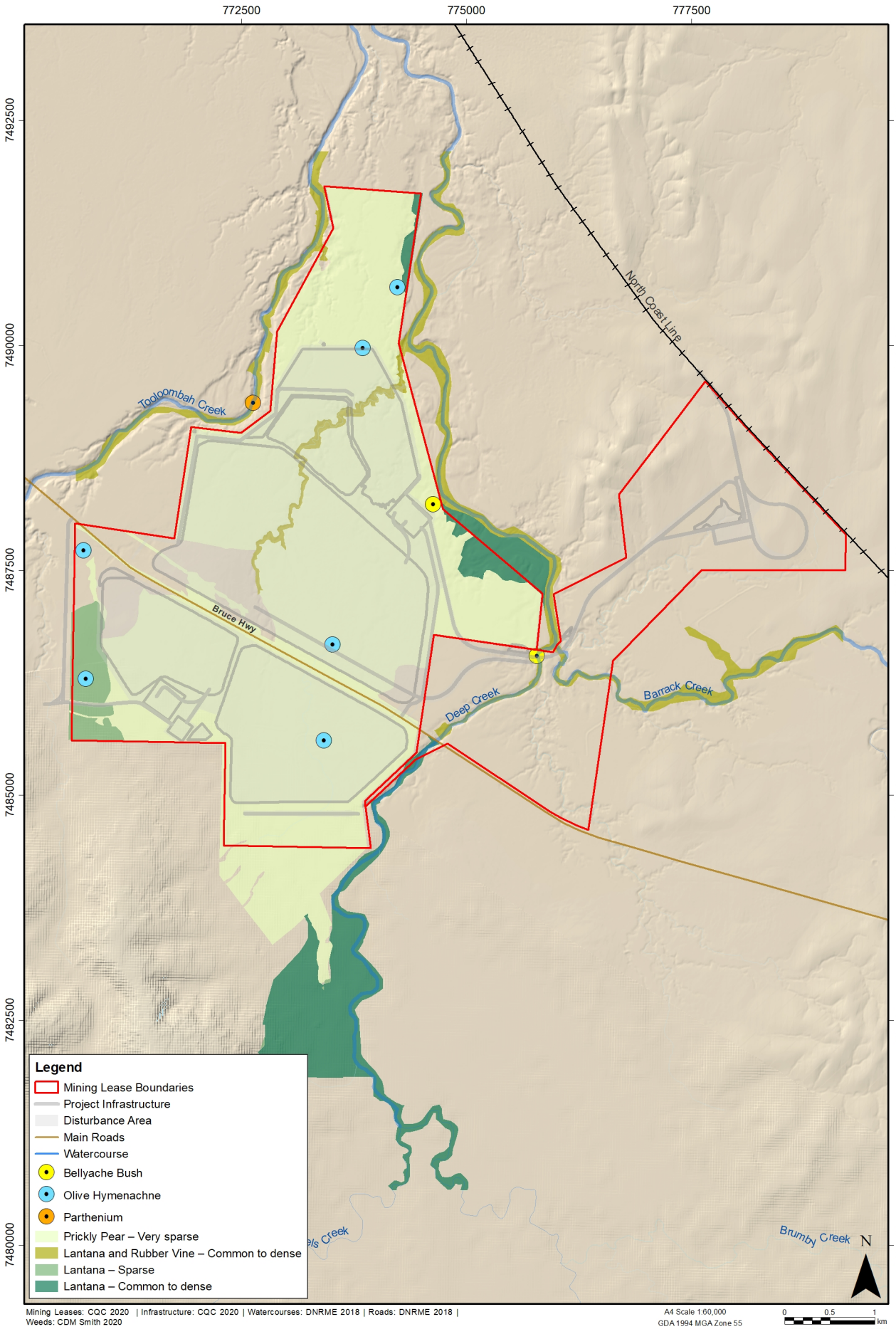

Figure 15-13: Distribution of weed species across the Project Site

15.3.9 Aquatic and Marine Fauna

The results of the desktop and field surveys as presented below indicate that the aquatic ecosystems present within the Project Area provide habitat for a range of aquatic fauna including native fish, turtles, mammals and macroinvertebrates that are tolerant of poor water quality and periods of static or low flow.

15.3.9.1 Desktop Assessment

The Wildlife Online report identified 38 species as known to occur within the search area (DSITIA 2020) including:

- 29 fish species (24 freshwater, four estuarine and one marine species). None of the fish species identified are listed as conservation significant under the NC Act or EPBC Act.
- Five freshwater turtle species including Krefft's river turtle (*Emydura macquarii krefftii*), Fitzroy turtle (*Rheodytes leukops*), southern snapping turtle (*Elseya albagula*), snake-necked turtle (*Chelodina longicollis*) and saw-shelled turtle (*Wollumbinia latisternum*) (DSITIA 2020). The Fitzroy turtle is listed as Vulnerable under the NC Act and EPBC Act. The southern snapping turtle is listed as Endangered under the NC Act and Critically Endangered under the EPBC Act.
- The estuarine crocodile (*Crocodylus porosus*) listed as Vulnerable under the NC Act and Migratory under the EPBC Act.
- Three mammals including platypus (*Ornithorhynchus anatinus*), blue whale (*Balaenoptera musculus*) and water rat (*Hydromys chrysogaster*). The platypus is listed as Special Least Concern under the NC Act and the blue whale is listed as Endangered and Migratory under the EPBC Act.

The PMST Report identified 21 listed threatened and/or migratory species with the potential to occur within a 25 km radius of the Project, noting that some species, such as green turtle (*Chelonia mydas*), are listed as both threatened and migratory (DAWE 2020a) (Table 15-5). Species listed solely as marine under the EPBC Act do not constitute MNES, as such, they are not considered in this chapter. The complete list of species identified through the desktop assessment is presented in Appendix A9f – 2016 and 2020 Database Searches.

Based on the results of the desktop assessment 23 aquatic and marine fauna species listed under the NC Act and/or the EPBC Act are known, or have the potential, to occur within the Project Area (Table 15-5). This includes nine reptiles, 10 mammals and four rays or sharks.

Table 15-5: Desktop results – conservation significant aquatic and marine species

Species	EPBC Status[1]	NC Act[1]	Data source	
			Wildlife Online	PMST
Reptiles				
Estuarine crocodile (*Crocodylus porosus*)	M	V	x	x
Fitzroy turtle (*Rheodytes leukops*)	V	V	x	x
Flatback turtle (*Natator depressus*)	V, M	V		x
Green turtle (*Chelonia mydas*)	V, M	V		x
Hawksbill turtle (*Eretmochelys imbricata*)	V, M	E		x

[1] E: Endangered, V: Vulnerable, CE: Critically Endangered, M: Migratory, LC: Least Concern and SLC: Special Least Concern

Species	EPBC Status[1]	NC Act[1]	Data source	
			Wildlife Online	PMST
Leatherback turtle (*Dermochelys coriacea*)	E, M	E		x
Loggerhead turtle (*Caretta caretta*)	E, M	E		x
Olive ridley turtle (*Lepidochelys olivacea*)	E, M	E		x
White-throated snapping turtle / southern snapping turtle (*Elseya albagula*)	CE	CE	x	
Mammals				
Australian humpback dolphin (*Sousa sahulensis*)	M	V		x
Australian snubfin dolphin (*Orcaella heinsohni*)	M	V		x
Blue whale (*Balaenoptera musculus*)	E, M	LC	x	x
Bryde's whale (*Balaenoptera edeni*)	M	LC		x
Dugong (*Dugong dugon*)	M	V		x
Humpback whale (*Megaptera novaeangliae*)	V, M	V		x
Indo-Pacific humpback dolphin (*Sousa chinensis*)	M			x
Killer whale (*Orcinus orca*)	M	LC		x
Platypus (*Ornithorhynchus anatinus*)		SLC	x	
Water mouse (*Xeromys myoides*)	V	V		x
Rays and sharks				
Giant manta ray (*Manta birostris*)	M			x
Green sawfish (*Pristis zijsron*)	V, M			x
Porbeagle (*Lamna nasus*)	M			x
Reef manta ray (*Manta alfredi*)	M			x

15.3.9.2 Field Surveys

15.3.9.2.1 Habitat Types and Condition

Table 15-6 provides locations and descriptions of the survey sites. Aquatic habitat is variable throughout the creeks, with pools common, through drying out or becoming isolated during periods of low rainfall. Some pools are fed by groundwater, resulting in their persistence during the dry season for longer than other pools. Other habitat features include occasional riffles, large woody debris and undercut banks. Key aquatic habitats observed during field surveys included rocky pools, sandy pools, rocky runs, sandy runs, riffles, large woody debris, and undercut banks.

Large woody debris was found at all sites, indicating there has been little if any de-snagging in the catchment. Most sites monitored during baseline studies had multiple physical habitat features, indicating a robust environment for aquatic fauna and a healthy ecosystem. All sampling sites scored high in terms of physical habitat assessment indicating high structural integrity at both a site and catchment level.

However, some natural and human-related aspects of the existing aquatic ecosystem limit the ecological condition of waterways. During dry periods surface water pools have highly variable water chemistry, influenced by evaporation, disconnection from adjacent waterways, and in some cases, saline groundwater inputs. Pools only provide refugial habitat for aquatic fauna that are able to tolerate the highly variable water quality conditions. In addition, trampling of instream habitats by cattle and associated declines in water quality (increase in suspended sediments and

nutrients) creates fluctuations and declines in water quality at certain times of the year. Observations from the 2017 survey indicate that substantial cattle access occurs at Deep Creek site De2 which likely reflects the poor water quality indicators recorded at this site. There was also some evidence of cattle access at Tooloombah Creek site To2. The remaining sites appear to be relatively inaccessible for cattle although signs of access by feral pigs was evident at Tooloombah Creek and Deep Creek sites (To2 and De4). These factors result in an aquatic environment that is highly variable, and mostly utilised by species that either have short life cycles, are mobile or are tolerant of a wide range of environmental conditions.

Despite the dominant agricultural landscape and widespread erosion, riparian vegetation persists along the waterways and ranges in condition from poor to good. Infestations of weeds and pest activity significantly reduce ecological condition in some riparian corridors, affecting the quality of their associated aquatic habitats. Riparian vegetation was in relatively poor condition along virtually all of the Styx River, with noogoora burr (*Xanthium occidentale*) dominating riparian vegetation downstream at site St2. Rubber vine and lantana are common, often forming dense infestations (up to 4m in height) along the creeks.

Estuarine and marine habitats located downstream of the Project Site provide habitat for fish, sharks, turtles and dugong (*Dugong dugon*). The estuarine and intertidal areas in this region are substantially different to the upstream habitat within and surrounding the Project Site and have been described in preceding sections.

The main existing impact to aquatic ecosystems adjacent to the Project Site is agriculture, with the surrounding land used predominantly for cattle grazing. This activity poses a significant threat to the aquatic ecosystems, especially when cattle access waterways, causing bank erosion, disturbing stream beds, trampling aquatic habitat and increasing nutrient loads via defecation. Erosion can reduce the condition of aquatic habitat, with many areas within the Styx Catchment prone to erosion, particularly during extreme rainfall events.

Table 15-6: Location of aquatic ecology survey sites and dates sampled

Site	Site Coordinates	Date Sampled	Macroinvert. Signal Score	Approx. Channel Size/Mean Depth	Location and Description
De2.1	-22.71803, 149.67018	June 2011 and February 2017	Riffle – 4.76	3 m (riffle) to 6 m (pool) / 0.2 m (riffle) to >0.5 m (pool)	Adjacent to eastern boundary of Project Site. Substrate comprised small cobbles, gravel and sand. Well vegetated riparian zone at all levels with lantana (*Lantana camara*) dominant in shrub layer. Channel well shaded. Some cattle access evident but likely minor due to steep banks. Pool dries out after prolonged dry weather.

Site	Site Coordinates	Date Sampled	Macroinvert. Signal Score	Approx. Channel Size/Mean Depth	Location and Description
De2	-22.71272, 149.67582	June 2011 and February 2017	Riffle – 5.25	7 m (riffle) to 14 m (pool) / 0.2 m (riffle), uncertain depth of pool – likely to retain water for extended periods	Located just north of highway. Substantial pool present. Substrate comprised small cobbles, gravel and sand. Bank height approx. 2.5 m above channel. Thin riparian zone with moderate shade cover. Vehicle / cattle crossing point evident. Cattle access evident. Pool dries out after prolonged dry weather.
De5.1	-22.66108, 149.67363	June 2011	Riffle – 5.71	1.8 m (riffle) to 10 m (pool) / 0.3 m (riffle), uncertain depth of pool at time of sampling	Adjacent to north-east corner of Project Site. Evidence of recent flooding – debris noted approx. 6-8 m above channel. Steep incised banks 8 m above water level. Substrate comprised largely gravel and sand. Well vegetated riparian zone at all levels. Rubber vine (*Cryptostegia grandiflora*) dominant in some areas. Channel well shaded. Abundant woody debris observed in channel. Cattle access evident despite presence of exclusion fencing. Pool dries out after prolonged dry weather.
De4	-22.664023, 149.672344	February 2017	NA	8 m (pool) / Uncertain – likely to retain water for extended periods	Located approximately 700 m upstream of De3. De4 was sampled due to lack of site access to De3. Steep incised banks, 8 m above water level on west side. Substrate comprised largely gravel and sand. Well vegetated riparian zone at all levels (Rubber vine dominant on lower

Site	Site Coordinates	Date Sampled	Macroinvert. Signal Score	Approx. Channel Size/Mean Depth	Location and Description
					east bank). Channel well shaded. Woody debris observed in channel. No obvious cattle access evident but evidence of pig presence observed.
To1	-22.68923, 149.62985	June 2011 and February 2017	Riffle – 5.77	5 m (riffle) to 17 m (pool) / 0.3 m (riffle) to >1.5 m (pool)	Located adjacent to bridge over highway (downstream). Evidence of recent flooding – debris noted approx. 6 m above channel. North bank steep (>15 m above channel), gentle slope on south bank. Rocky creek with areas of substrate dominated by bedrock, as well as cobbles / gravel / sand. Well vegetated riparian zone. Channel moderately shaded. Evidence of cattle activity recorded at site. Pool extends well upstream of sample site and maintains water through extended dry weather.
To2	-22.68083, 149.6535	June 2011 and February 2017	Riffle – 5.37	2.5 m (riffle) to 35 m (pool) / 0.3 m (riffle), uncertain depth of pool – likely to retain water for extended periods, creek may be permanent some years	Located adjacent to western boundary of Project Site. Moderate flow at time of 2011 survey. North bank relatively steep (7 m above channel), gentle slope on south bank. Substrate dominated cobbles / gravel / sand with large rocks sometimes present. Well vegetated riparian zone in good condition although occurrences of Rubber Vine present. Evidence of cattle activity recorded at site. Channel moderately shaded.

Site	Site Coordinates	Date Sampled	Macroinvert. Signal Score	Approx. Channel Size/Mean Depth	Location and Description
St1	-22.64, 149.6624	June 2011	Riffle – 3.65	5 m (run) to 40 m (pool) / 0.3 m (riffle area in Tooloombah Creek), main channel uncertain – 0.6 m at edge	Just downstream of merge of Deep Creek and Tooloombah Creek. Shallow banks 5-7 m above water level. Substrate comprised largely gravel and sand. Very disturbed riparian zone with few tall trees and weed species common (Rubber Vine dominant in some areas). Poor channel shading. Aquatic vegetation present.
St1b	-22.6232, 149.65187	June 2011	Riffle – 3.5	6 m to 12 m (pool) / Up to 2.5 m in main channel	Located upstream of bridge on Ogmore Connection Road. Substrate dominated by silt / clay. Riparian zone shows evident of infrequent tidal inundation (marine couch present close to channel). Clearing evident with few tall trees present and weed species common. No channel shading. Aquatic vegetation present. Cattle access evident.
St2b	-22.62018, 149.64848	June 2011	Riffle – 3.52	4 m to 10 m (pool) / Up to 1.2 m in main channel	Located immediately downstream of the Ogmore Road Bridge crossing. Furthest downstream sampling point. Right bank heavily incised (6 m above channel), left bank floodplain less than 3 m above channel. Substrate dominated by silt / clay. Regular tidal inundation of site and few tall trees present as a result. Weed species common (heavy cover of noogoora burr (*Xanthium*

Site	Site Coordinates	Date Sampled	Macroinvert. Signal Score	Approx. Channel Size/Mean Depth	Location and Description
					occidentale)). No channel shading. Aquatic vegetation present.
Gr1	-22.60893, 149.54475	June 2011	Riffle – 6.06	3 m (riffle) to 25 - 45 m (pool) / 0.3 m (riffle), 3.8 m in deep section of pool – likely to retain water for extended periods	Located downstream of highway and 13 km north-west of Project Site. Series of large pools joined by riffle areas. Banks gently sloped, north bank approx. 5 m above channel. Substrate dominated by cobbles / gravel / sand. Riparian zone disturbed and substantially narrowed in sections. Weeds common. Channel poorly shaded. Aquatic vegetation present.

15.3.9.2.2 Reptiles

Most sightings of aquatic reptiles were of turtles at sites on Granite Creek (Gr1), Deep Creek (De2 and De3) and Tooloombah Creek (To1 and To2). Three species were recorded during the 2011 and 2017 surveys; krefft's river turtle, snake-necked turtle and saw-shelled turtle. Turtles were most abundant in large pools at Granite Creek (Gr1) and Tooloombah Creek (To1) with a total of 26 turtles recorded at these two sites. In 2017 turtles were trapped at a single site (To1) with nine saw-shelled turtles caught across two sampling events.

During the June 2011 survey, evidence of estuarine crocodile slides was observed at two Styx River sites (St1b and St2). Anecdotal evidence for the presence of estuarine crocodile was also noted for Deep Creek, Granite creek, and the Styx River. Local amateur fishermen observed four crocodiles downstream of St2 in June 2011. It is considered likely that estuarine crocodiles are also present in parts of Tooloombah Creek. No evidence of their presence was observed during the February 2017 survey.

15.3.9.2.3 Mammals

No aquatic or marine mammals were observed in the Project Area during any of the survey events.

15.3.9.2.4 Fish

A total of 736 fish comprising 28 common native species were collected across all sites during the 2011 survey. None of the species collected are listed under the NC Act or EPBC Act. The fish taxa recorded during the June 2011 sampling round are generally typical of what would be expected to occur in a Central Queensland coastal catchment. The most abundant catches were in Deep Creek and Granite Creek. The highest fish diversity for individual sites was recorded from a Styx River site and a Tooloombah Creek site, which both recorded 15 species. Both sites had large pools that

enabled sampling from a boat. The lowest diversity sites were a Deep Creek site (De1), and a Tooloombah Creek site (To2). Both sites were sampled with a back-pack electrofishing unit only. The highest diversity of fish overall was recorded from the Styx River where 22 species were caught over the three sites, followed by Tooloombah Creek (15 species from two sites), Granite Creek (12 species from a single site) and Deep Creek (11 species from three sites).

The taxa recorded were a mix of freshwater and estuarine / marine species. Eastern rainbowfish (*Melanotaenia splendida*) and empire gudgeon (*Hypseleotris compressa*) were the most common species caught in terms of both abundance and distribution across all sites. Agassizs glassfish (*Ambassis agassizii*), spangled perch (*Leiopotherapon unicolour*), purple spotted gudgeon (*Mogurnda adspersa*) and barramundi (*Lates calcarifer*) were also relatively common although did not occur across all sites.

Two commercially targeted fish taxa were recorded during 2011 field surveys - the sea mullet (*Mugil cephalus*) and barramundi (*Lates calcarifer*). Sea mullet was predominantly caught at the two downstream Styx River sites (St1b and St2b). These sites are in the upper reaches of the estuary and made up of pools over 200 m in length which provide ideal habitat for this species.

A total of 51 barramundi were caught during the 2011 survey. Barramundi were caught in all creeks sampled except Deep Creek. This is most likely due to the fact that barramundi were only captured in large pools and no large pools were sampled within Deep Creek. Barramundi ranged in size from 150 mm to 610 mm with smaller fish (< 500 mm) accounting for 86% of the catch. A key finding is that where barramundi was recorded, a range of size classes were represented. This indicates that the Project Area is a nursery area for juvenile barramundi and that there have been successive cohorts utilising the Project Area.

Two specimens of an unidentified eel were recorded during the 2011 survey. These were tentatively identified as swamp eels of the genera *Ophisternon* (Family: Synbranchidae). At that time, there was no record of this genus or family occurring in the Styx River or the wider region. However, this group of eels has been poorly studied and there is limited taxonomic information available. Swamp eels spend their life living and feeding in burrows within soft sediments and are rarely recorded as a result. Recent information suggests that the Synbranchidae occur as far south as the Moreton Bay region and there are up to three undescribed species from the southern and central coast of Queensland (pers. comm. Dr Jeff Johnson).

Multivariate analysis of the 2011 fish community data indicated that Deep Creek had a distinct community from that of the other creek systems assessed reflecting the strong average similarity for Deep Creek sites (73.68 %). Fish community composition was more variable in the Styx River and Tooloombah Creek. Further analysis indicated that this related to shallow stream versus deep pool habitat, though further sampling would be required to confirm this. Granite Creek fish fauna most closely matched that of site To1, though this is based on only one sample from that creek system. Further analysis is provided in Appendix A10b – 2011 Baseline Monitoring Program.

Fish sampling in 2017 was limited to bait traps and did not take place at the estuarine sites on the Styx River as occurred during the 2011 survey. A total of 274 fish, comprising four species, were collected across the five sites sampled including Agassizs glassfish, fly-speckled hardyhead (*Craterocephalus stercusmuscarum*), empire gudgeon and eastern rainbowfish. None of the species collected are listed under the NC Act or EPBC Act.

15.3.9.2.5 Aquatic Macroinvertebrates

Aquatic macroinvertebrate communities were sampled in June 2011 and February 2017 and were represented by 48 taxa (CDM Smith 2018). Fewer taxa were collected from the Styx River than from the creek sites sampled, possibly because invertebrates are more concentrated in the smaller water bodies, and habitat diversity was higher in the creeks (CDM Smith 2018). The taxa collected are tolerant of poor water quality and periods of static or low flow. According to the AusRivAS Model for Central Queensland for riffle habitats, three sites had more taxa than reference sites, two sites had similar numbers of taxa as reference sites, and one site had significantly fewer taxa and was assessed as 'significantly impaired'.

Although the Styx River sites had fewer taxa than nearby creeks, they had permanent pools and were characterised by different invertebrate groups than the ephemeral pools. Styx River had higher abundances of the swimming families Dytiscidae and Corrixidae, as well as the snail Thiaridae. Three caddisfly (Trichopteran) families were relatively abundant in Tooloombah and Deep Creeks, but not in the Styx River. These were Hydrobiosidae, Hydropsychidae and Philipotomidae, which prefer flowing water. The blackfly family Simuliidae also requires flowing water, and while present in high numbers at the Tooloombah and Deep Creeks, was rarely detected in the Styx River. Similar patterns of occurrence were recorded for the mayfly (Ephemeroptera) families Baetidae and Caenidae. Such results highlight the variability of the aquatic ecosystems of the Project Area between the upper creeks and lower Styx River ecosystems.

15.3.9.2.6 Introduced Species

No introduced species were collected during field surveys indicating that the aquatic environments of the Project Area may be relatively free of introduced taxa.

15.3.9.3 Likelihood of Occurrence – Conservation Significant Species

Based on the results of the desktop assessment and field surveys a likelihood of occurrence assessment was undertaken for all conservation significant species identified as having the potential to occur in the waterways surrounding the Project Site and/or the downstream environments. Four categories were used to classify the likelihood of species being present including:

- Known - confirmed during field surveys
- Likely - known distribution, records within or around the assessment area, and suitable habitat observed during field surveys
- Potential - known distribution, limited records of the species occurring in the wider area and limited possibility of suitable habitat occurring and
- Unlikely - no suitable habitat presence, or not known to occur within the local region.

The results of this assessment are presented in Table 15-7.

Table 15-7: Conservation significant aquatic and marine species – likelihood of occurrence

Species	EPBC Act Status[2]	NC Act Status[2]	Database Search		Habitat preference	Likelihood of occurrence
			Wildlife Online	PMST Report		
Reptiles						
Estuarine crocodile *(Crocodylus porosus)*	M	V	x	x	The estuarine crocodile inhabits coastal and inland waterways from Gladstone to Cape York and through the Gulf of Carpentaria to the Queensland/ Northern Territory boarder (Read et al. 2004) with the majority of the population occurring in tidally influenced areas. The habitat of the estuarine crocodile includes marine habitats such as mangroves, but they also commonly occur in freshwater habitats such as rivers, lakes and swamps.	Known. During the June 2011 aquatic ecology survey evidence of the presence of estuarine crocodile slides was observed at two Styx River sites. Estuarine crocodile is also anecdotally considered to occur in a large waterhole located downstream of the confluence of Deep Creek and Tooloombah Creek (2.2 km north of the Project boundary). However, it has not been observed during Project surveys on any occasion. There are no WildNet database records of the species from the wider area. The nearest ALA database records are from the Fitzroy River approximately 50 km south of the Project. The species known to occur in low numbers in the Shoalwater Bay area (DoD 2009). Habitat throughout the Styx River estuary and Broad Sound is considered suitable for this species.
Fitzroy turtle (*Rheodytes leukops)*	V	V	x	x	The Fitzroy turtle is endemic to the Fitzroy River and its tributaries, with the known species' distribution extending from the Fitzroy Barrage at Rockhampton to at least Theodore Weir on the Dawson River, and within the lower reaches of the Nogoa River and upper reaches of the Connors River (GHD 2015). It is primarily known to occur in the Fitzroy, Connors,	Unlikely. As it not known from outside of the Fitzroy River and tributaries, it is considered highly unlikely that the Fitzroy turtle would occur in the waterways in the vicinity of the Project. The Styx River is isolated from the Fitzroy River basin and the species is not known to occur in the area. Furthermore, even if it were to occur, the waterways around the Project do not represent suitable habitat for this species.

[2] E: Endangered, V: Vulnerable, CE: Critically Endangered, M: Migratory, LC: Least Concern and SLC: Special Least Concern

Species	EPBC Act Status[2]	NC Act Status[2]	Database Search		Habitat preference	Likelihood of occurrence
			Wildlife Online	PMST Report		
					Dawson, and Mackenzie Rivers, Widah Creek and Develin or Marlborough Creek (Cogger 2000). The species occurs within permanent freshwater riverine reaches and large, isolated permanent waterholes (DES 2016). The species prefers large pools and connecting flowing riffle habitats with clear water. It generally does not move far within its home range. It is known to feed on aquatic insect larvae, freshwater sponges and Ribbonweed (*Valisneria* spp.) (Tucker et al. 2001). The species maintains a home range of between 400 m to 700 m and generally remains sedentary.	No individuals were recorded within the Project Area at any of the sites investigated. The nearest records for the species are located 30 km to the west (Mackenzie River) and 30 km to the south-west (Marlborough Creek). Both of these areas lie within the Fitzroy Basin. The nearest potential habitat for the species based on current information is in Marlborough Creek to the south.
Flatback turtle *(Natator depressus)*	V,M	V		x	Flatback turtle is the only marine turtle species that is endemic to the Australian continental shelf and only nests in Australia. It prefers soft-bottomed habitats in shallow waters and rarely occurs in seagrass or coral reef habitats. Trawl fishery data indicates the species occurs largely from 6 to 35 m depth in the GBR region (Limpus 2007). It feeds on soft-bodied invertebrates such as jellyfish, soft corals and sea pens.	Known. Flatback turtles are known to nest throughout the Broad Sound region, with large nesting aggregations at Wild Duck and Avoid Islands, which are both located ~75 km north of the Project. It is not expected that marine turtles occur upstream in the Styx River estuary much further than Rosewood Island (where the river meets the wider Broad Sound inlet). This is likely due to the shallow nature of the river (particularly at low tides) and the lack of suitable instream habitat for marine turtles.
Green turtle *(Chelonia mydas)*	V,M	V		x	Green turtles occur on reefs, seagrass meadows and algal mats on sand or mud substrates (Limpus 2008). This is a widespread species. Major nesting rookeries in the southern GBR occur in the Capricorn-Bunker group of islands, with minor nesting areas on several other islands as well as the mainland coast. Adult green turtles eat seagrasses, a wide range of algae, as well as mangrove fruits. They will occasionally eat	Known. This is a widespread and common species that may transiently occur during foraging movements. There are several ALA records within the Styx River estuary (Figure 15-14). However, these are all attributable to a single radio-tracked individual released by the Cairns turtle rehabilitation and reef

Species	EPBC Act Status[2]	NC Act Status[2]	Database Search		Habitat preference	Likelihood of occurrence
			Wildlife Online	PMST Report		
					other items such as jellyfish and sponges (Read and Limpus 2002 and Arthur et al. 2007).	HQ facility in 2010. There is no suitable seagrass foraging habitat in the estuary. There are many ALA records in the wider Broad Sound area (Figure 15-14). Low-level nesting has been recorded on several offshore islands in the wider region including the Percy Islands group, Curlew Island and islands and mainland beaches in Shoalwater Bay. The Shoalwater Bay sites are the nearest known nesting sites to the Project (66 km north-east) (Limpus et al. 2002).
Hawksbill turtle *(Eretmochelys imbricata)*	V,M	E		x	Hawksbill turtles are generally associated with reef habitats (tidal and sub-tidal). Nesting in Queensland occurs on northern Cape York Peninsula. They have been recorded as far south as northern New South Wales. They feed principally on various species of sponge, but they may also feed on algae, soft corals and macro-zooplankton such as jellyfish and comb-jellies (Limpus 2009a).	Unlikely to occur in the Styx River estuary as there is no suitable habitat present. Potential to occur in the wider Broad Sound area. Three ALA database records – one of indeterminate origin from Mackay, and two records (1985 and 2010) offshore of Yeppoon. The nearest sizeable reef habitat to the Project is located on the western side of Long Island (approx. 53 km north). Aerial surveys for large marine turtles in the broader region (including Broad Sound) in 2016 recorded only one marine turtle (species not identified) within the Broad Sound DIWA area (Sobtzick et al. 2017).
Leatherback turtle (*Dermochelys coriacea)*	E,M	E		x	Leatherback turtles occur in both oceanic waters and over the Australian continental shelf. There are no major nest sites in Australia. Scattered minor nesting has been recorded along the Northern Territory coast and southern Queensland / New South Wales (Limpus 2009b).	Unlikely. A single ALA database record (1985) from the Mackay region. Circumstances of record are not given. Given the species occurs in open waters the area of Broad Sound does not constitute habitat for this species.

Species	EPBC Act Status[2]	NC Act Status[2]	Database Search		Habitat preference	Likelihood of occurrence
			Wildlife Online	PMST Report		
Loggerhead turtle *(Caretta caretta)*	E,M	E		x	In Australia, the loggerhead turtle occurs in the waters of coral and rocky reefs, seagrass beds and muddy bays throughout eastern, northern and western Australia (Limpus et al. 1992). Nesting is concentrated in southern Queensland and from Shark Bay to the North West Cape in Western Australia, foraging areas are more widely distributed. Loggerhead turtle occurs over a wide range of habitats in tidal and sub-tidal waters including reefs, seagrass and soft-bottomed sand or mud. Loggerhead turtles specialise in foraging for slow-moving shelled invertebrates including gastropods, bivalves and some crab taxa. Nesting females feed close to nesting beaches. Hatchlings disperse to pelagic waters, then returning to inshore waters at an estimated age of 13 years (Limpus 2008).	Unlikely to occur in the Styx River estuary. No suitable habitat likely to be present due to shallow waters. Potential to occur in the wider Broad Sound area. Single ALA database record from the broader region located 107 km east of the Project in the Port Clinton area. Targeted nesting surveys in the region found low level nesting activity (1 – 10 females per year) on the Percy Islands (approx. 120 km north-east of the Project) and Bushy Island (offshore from Mackay). Aerial surveys for large marine turtles in the broader region (including Broad Sound) in 2016 recorded only one marine turtle (species not identified) within the Broad Sound DIWA area (Sobtzick et al. 2017). Potentially occurs in the wider Broad Sound area but habitat downstream of the Project is likely to be less suitable for this species.
Olive ridley turtle *(Lepidochelys olivacea)*	E,M	E		x	It is likely that Australia has the largest remaining breeding population of olive ridley turtles in the southeast Asia–western Pacific region (Limpus 2008). Nesting occurs in the Northern Territory and the western coast of Cape York Peninsula. There are no nesting records from the east coast of Queensland. The species prefers soft-bottomed habitats in shallow waters as far south as south-east Queensland. It rarely occurs in seagrass or coral reef habitats. Trawl fishery data indicates the species occurs largely from 6 to 35 m depth in the GBR region (Limpus 2008). It feeds on gastropods and crabs.	Unlikely to occur in the Styx River estuary as no suitable habitat likely to be present due to shallow waters. Potential to occur in the wider Broad Sound area. There are no ALA database records from the wider Broad Sound region. Aerial surveys for large marine turtles in the broader region (including Broad Sound) in 2016 recorded only one marine turtle (species not identified) within the Broad Sound DIWA area (Sobtzick et al. 2017). Although there are no records for this species in the wider area, there is potential habitat in the Broad Sound area.

Species	EPBC Act Status[2]	NC Act Status[2]	Database Search		Habitat preference	Likelihood of occurrence
			Wildlife Online	PMST Report		
White-throated snapping turtle / southern snapping turtle (*Elseya albagula*)	CE	CE	x		The white-throated snapping turtle is only found in drainage systems of the Fitzroy, Burnett and Mary River catchments (DES 2017). It prefers permanently flowing water habitats where there are suitable shelters and refuges (e.g. fallen trees) and is not thought to occur within farm dams, ephemeral swamplands or brackish waters (Hamann et al. 2007).	Unlikely. As this species is not known from the Styx catchment, it is considered highly unlikely that the white-throated snapping turtle would occur in the waterways in the vicinity of the Project. Furthermore, even if it were to occur, the waterways around the Project do not represent suitable habitat for this species, as the species has a marked preference for permanently flowing fresh water, and the waterways in the vicinity of the Project only flow for around 24% of the time. It is noted that in the original EIS submission southern snapping turtle was listed as having been encountered close to site. This was based on a recorded capture of the species in Deep Creek during aquatic ecology surveys in June 2011. This was despite the species not being known to occur in the Styx River catchment and the presence of unsuitable habitat (i.e. the species prefers flowing waters whereas the catchment streams are ephemeral with sporadic flow events). CDM Smith requested the photo records of the captured individual (as noted in the report) from the original survey by ALS Water Resources Group. The photos were located and passed on to an expert with experience of the species (Dr. Col Limpus) for verification. The photos depicted a juvenile Saw-shelled Turtle (*Wollumbinia latisternum*) (Plate 15-5 and Plate 15-6) which is not listed as threatened under the NC Act or EPBC Act.

Species	EPBC Act Status[2]	NC Act Status[2]	Database Search		Habitat preference	Likelihood of occurrence
			Wildlife Online	PMST Report		
Mammals						
Australian humpback dolphin *(Sousa sahulensis)*	M	V		x	Species occurs as local populations along the Queensland coast that are small in number and discrete in geographic range (Hale et al. 2000). Habitat preference is for shallow turbid estuarine and coastal waters (Lin et al. 2013) and in particular shallow channels.	Known. During boat-based surveys of Broad Sound carried out over two weeks in 2013 low numbers of both species were detected north of the Styx River in the channel on the western side of Rosewood Island. There are several ALA records of Australian snubfin dolphin (only) in the wider area to the north of Broad Sound. Given the shallow nature of the Styx River, particularly at low tides, suitable habitat for these species in the river is not expected to extend upstream beyond Rosewood Island.
Australian snubfin dolphin *(Orcaella brevirostris)*	M	V		x	The species habitat preference in the Keppel Bay area is shallow waters ranging from 2 to 15 m depth (Cagnazzi et al. 2013). Populations occur sporadically along the Queensland coast through to northern Western Australia.	
Blue whale *(Balaenoptera musculus)*	E,M	LC		x	Blue whale sightings are widespread around the continental shelf of Australia although much of this area is likely to be used for migratory movements and incidental foraging. The only known areas of significance in Australian waters are feeding areas around the southern continental shelf, notably the Perth Canyon, off Western Australia, and the Bonney Upwelling and adjacent upwelling areas of South Australia and Victoria.	Unlikely. Four ALA database records from the surrounding region including offshore of Yeppoon approximately 140 km east of the Project area (record described as sighted 'off Maryborough'). Two of these are strandings: one recorded in the Shoalwater Bay area in 1928; and another at Saint Lawrence in 1994 (DoD 2009). The species likely occurs offshore of the local mainland at times but the shallow waters of Broad Sound are not suitable for the species.
Bryde's whale (*Balaenoptera edeni)*	M	LC		x	Bryde's whale is pelagic (i.e. occurs in open waters) and is a rarely recorded species that may occur off all Australian states where it prefers waters above 16°C in temperature. Specific identification in the field may be difficult due to confusion with Sei Whales (*B. borealis*). There are two forms of Bryde's whale: the coastal form of Bryde's whale is smaller and appears to be limited to the 200 m depth isobar, moving along the coast in response to availability of suitable prey. The offshore form is found in deeper	Unlikely. No database records from region and the marine habitat located downstream of the Project does not represent suitable habitat for this species.

Species	EPBC Act Status[2]	NC Act Status[2]	Database Search		Habitat preference	Likelihood of occurrence
			Wildlife Online	PMST Report		
					water (500 m to 1000 m). Unlike other baleen whales the species is known to feed all year round. There are no specific feeding or breeding grounds known in Australia.	
Dugong *(Dugong dugon)*	M	V		x	Dugong is widespread across northern Australia and specialises in feeding on seagrasses in shallow inshore areas. There are several concentrations of Dugong along the eastern Queensland coast. The Shoalwater Bay area is considered the most important site south of Cooktown due to the large population and controls on impacts due to the presence of the Shoalwater Bay Training Area (DoD 2009). Other areas known to support the species includes Moreton Bay, Hervey Bay, Port Curtis, Cleveland Bay, Upstart Bay, and Hinchinbrook Island. Movements appear highly idiosyncratic with variations of less than 15 km up to 560 km recorded during monitoring of individuals.	Known. Given the lack of seagrass in most of Broad Sound it is unlikely the area immediately downstream of the Project provides suitable habitat for the species however the seagrass beds to the northwest of Broad Sound (around the township of Clairview) are known to support populations of dugong. There is a Dugong Protection Area (DPA) associated with extensive seagrass beds extending from Carmilla Creek south to Clairview Bluff which is approximately 55 km north of the Project in the Broad sound region. A second DPA occurs in the Shoalwater Bay area to the north-west of the Project. Shoalwater Bay DPA is considered the most important Dugong site in the southern area of the GBRMP. In a review of dugong sighting data by Marsh and Penrose (2001) there are no reported sightings in the Broad Sound area. More recently extensive aerial transect surveys for dugong and marine turtles, which included Broad Sound, recorded no individuals in Broad Sound itself. The nearest reported sightings were individuals in the Clairview and Stanage Bay areas (Sobtzick et al. 2017).
Humpback whale *(Megaptera novaeangliae)*	V,M	V		x	Large baleen whale species are well known for winter migrations along the east and west coast of Australia where the species breeds. Core areas off Queensland include resting areas off Moreton Bay and Hervey Bay and calving habitat in the	Known. The humpback whale is known to utilise the sheltered coastal waters of central and southern Queensland, particularly while on its southern migration. Broad Sound is not ideal habitat for the species, due to its large tidal range and associated

Species	EPBC Act Status[2]	NC Act Status[2]	Database Search		Habitat preference	Likelihood of occurrence
			Wildlife Online	PMST Report		
					Whitsunday Islands area. Feeding largely occurs in Antarctic waters during the southern hemisphere summer. Migratory habitat off the Australian coast is usually within 20 km of the mainland and less than 200 m deep.	turbid waters. However, the deeper waters at the northern entrance to Broad Sound are likely to be utilised by humpback whales for short periods during the southern migration. This is particularly so for whales that have recently calved, with a core calving area located to the north of Broad Sound off the coast of Mackay (DAWE 2020c).
Indo-Pacific humpback dolphin (*Sousa chinensis*)	M			x	The delphinid genus Sousa underwent a major revision in 2014 in which *Sousa sahulensis* was differentiated from the original taxon *Sousa chinensis*. *S. chinensis* does not occur in Australian waters – it ranges from eastern India to central China and throughout Southeast Asia (Jefferson and Rosenbaum 2014). *S. sahulensis* occurs in the waters of the Sahul Shelf from northern Australia to southern New Guinea. It is separated from *S. chinensis* by a wide distributional gap that coincides with Wallace's Line (Jefferson and Rosenbaum 2014). However, under the EPBC Act, the migratory and cetacean listings for S *sahulensis* still refer to *S. chinensis.* Therefore, although *S. chinensis* would not occur in the waters downstream of the Project Site, it is still included in the database searches, but reference to discussion on this species should be made to *S. sahulensis*.	Unlikely. Does not occur in Australian waters.
Killer whale *(Orcinus orca)*	M	LC		x	Killer whales are recorded off the coast of all Australian states although they are more common in the cooler waters of the southern states as well as Antarctic and sub-Antarctic waters. Preferred habitat for the species is difficult to define given its	Unlikely. No database records from the wider region. The shallow marine habitat of Broad Sound is very unlikely to represent suitable habitat for this species.

Species	EPBC Act Status[2]	NC Act Status[2]	Database Search		Habitat preference	Likelihood of occurrence
			Wildlife Online	PMST Report		
					widespread distribution and ability to inhabit all parts of the oceans. In Australia they are generally seen on the continental shelf and edge, particularly where seal colonies occur. Feeding is varied and dependent on local conditions. In Australia they are known to feed on a range of marine mammal species (including larger whale species) as well as smaller marine fauna including fish and cephalopods.	
Platypus (*Ornithorhyn-chus anatinus*)		SLC	x		The platypus is widely distributed in small streams and rivers ranging from tropical to alpine environments along the east of Australia. The range extends from Tasmania to the base of the Cape York Peninsula. The platypus prefer habitat near freshwater creeks, slow-moving rivers, lakes joined by rivers, and built water storages such as farm dams. They build a simple burrow in a river bank, just above water level and often among a tangle of tree roots. Platypuses are cryptic, and predominantly nocturnal and crepuscular, thereby impeding their detection in fauna surveys.	Potential. Although not previously detected in the Styx River catchment, they are known from the adjacent Fitzroy River catchment. Suitable habitat for this species does exist in the vicinity of the Project Site, and given this, as well as the elusive nature of this species and the low survey effort, it is considered possible that this species occurs in the Project area.
Water mouse (*Xeromys myoides*)	V	V		x	The water mouse had been documented in three distinct locations (Northern Territory, central south Queensland, south-east Queensland) within habitat including mangroves and associated saltmarsh, sedgelands, clay pans, heathlands and freshwater wetlands (DAWE 2020d). In central south Queensland, the water mouse has only been captured in the high inter-tidal zone in tall, closed fringing mangrove forest containing only *Ceriops tagal* and/or *Bruguiera* sp (Ball 2004). Although not considered core habitat, the water	Potential. Potentially suitable habitat is present downstream of the Project in mangrove forests. Mangrove communities occur along the banks of the Styx river beginning 21 km downstream of the Project boundary. Mangroves occupy 216 km^2 within the Broad Sound DIWA boundary, becoming more extensive near Rosewood Island. Based on vegetation mapping dominant species are expected to be grey mangrove (*Avicennia marina*), Rhizophora and Bruguiera species, spurred mangrove (*Ceriops tagal*).

Species	EPBC Act Status[2]	NC Act Status[2]	Database Search		Habitat preference	Likelihood of occurrence
			Wildlife Online	PMST Report		
					mouse has also been captured in saline grassland adjacent to a closed forest of *Ceriops tagal* and Bruguiera sp and in closed forest of *Avicennia marina* (DAWE 2020d).	However, there are no database records from the wider area.
Rays and sharks						
Giant manta ray *(Manta birostris)*	M			x	The giant manta ray lives mostly in the open ocean, traveling with the currents and migrating to areas where upwellings of nutrient-rich water increase prey concentrations.	Unlikely. No database records from the region and the marine habitat located downstream of the Project does not represent suitable habitat for this species.
Green sawfish *(Pristis zijsron)*	V,M			x	The green sawfish has a preference for sand and mud flats outside of river mouths (Peverell 2005) and frequently utilises very shallow water. It has been recorded in inshore marine waters, estuaries, river mouths, embankments and along sandy and muddy beaches. It has been historically recorded as far south as Jervis Bay in New South Wales but likely habitat is now considered to occur from the Whitsunday Islands in Queensland across northern Australian waters to Shark Bay in Western Australia.	Unlikely. There are no database records in the wider region and no recent records south of Port Douglas in north Queensland. The Project area is located south of the species likely habitat distribution.
Porbeagle *(Lamna nasus)*	M			x	The species occurs in temperate, arctic and subantarctic waters and is known from southern Queensland through to south-west Western Australia. Porbeagle generally occurs in open water off the continental shelf.	Unlikely. No database records from region and the marine habitat located downstream of the Project does not represent suitable habitat for this species.
Reef manta ray *(Manta Alfredi)*	M			x	The reef manta ray is commonly sighted inshore, around coral reefs and rocky reefs in coastal areas (Marshall et al. 2011) and within areas of upwelling which provide nutrient rich waters supporting high plankton abundance. The species predictably	Unlikely to occur in the Styx River estuary as there is no suitable habitat present. Potential to occur in the wider Broad Sound area. Suitable reef habitat located in the wider Broad Sound area (downstream of the Project) is limited and

Species	EPBC Act Status[2]	NC Act Status[2]	Database Search		Habitat preference	Likelihood of occurrence
			Wildlife Online	PMST Report		
					aggregates to particular locations such as Lady Elliot Island, North Stradbroke Island and Byron Bay in eastern Australia, for which they display a high degree of site fidelity (Couturier et al. 2011). Aggregation sites are strongly believed to represent critical habitats for this species.	likely restricted to the inshore islands located adjacent to the Torilla Peninsula. There are no database records for the species within the region.

Plate 15-4: Saw-shelled turtle - plastron (ALS Water Sciences 2011)

Plate 15-5: Saw-shelled turtle (ALS Water Sciences 2011)

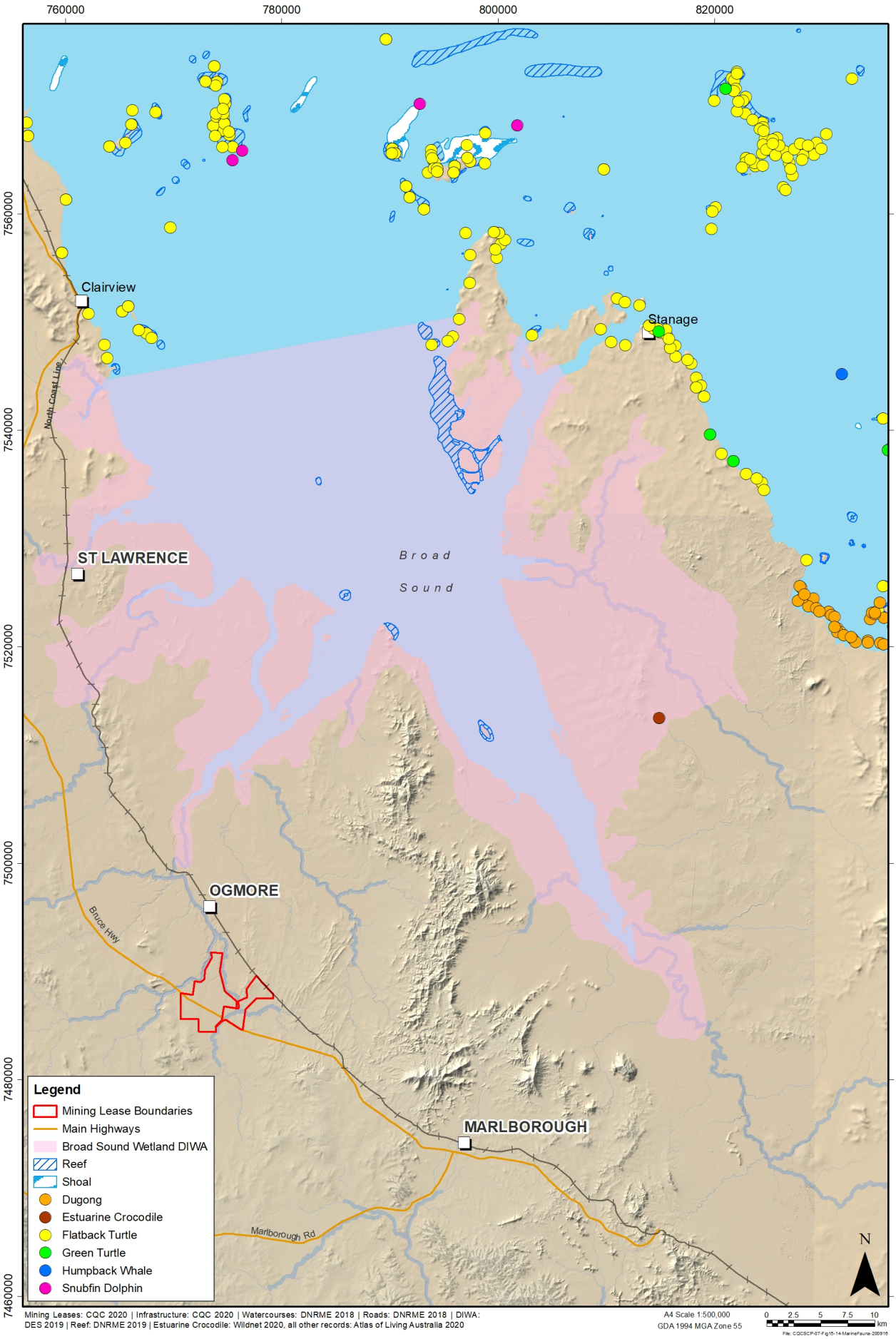

Figure 15-14: Conservation significant aquatic and marine fauna records

15.3.9.4 Conservation Significant Species Known or Likely to Occur

The assessment presented above identifies seven conservation significant species which are known or likely to occur in the waterways surrounding the Project Site and/or the downstream environments of the Styx River estuary and Broad Sound. These species are:

- Estuarine crocodile
- Green turtle
- Flatback turtle
- Australian hump-back dolphin
- Australian snubfin dolphin
- Dugong and
- Humpback whale.

The presence or potential presence of species, and species habitat, was used to assess the potential risk of impacts from the Project. Only species considered known or likely to occur are further described below and considered in the impact assessment presented in Section 15.6.5. With the exception of the estuarine crocodile, these species are not expected to occur close to the Project due to the very low water levels in the Styx River during the low tidal phase, the ephemeral nature of the creeks and the general lack of suitable habitat present.

15.3.9.4.1 Estuarine Crocodile

EPBC Act – M, NC Act – V

The estuarine crocodile is the largest species of crocodile and the largest living reptile in the world. The upper body is grey, brown or almost black above, with irregular darker mottling; they are generally whitish on the underside. The tail is highly muscular and is the main propulsion mechanism used in the water. An adult estuarine crocodile is believed to have the greatest bite pressure of any living animal. The estuarine crocodile is widespread throughout northern Australia and in Queensland it inhabits reef, coastal and inland waterways from Gladstone on the east coast, throughout the Cape York Peninsula and west to the Queensland-Northern Territory border (DAWE 2020e). Despite the species' common name, the estuarine crocodile can persist in freshwater bodies (DAWE 2020e). Threats to the species include mortality due to fishing nets and habitat destruction.

The species has not been observed during Project surveys on any occasion. However, evidence of this species in the form of crocodile slides was observed at two Styx River sites in 2011. The species is also anecdotally considered to occur in a large waterhole located downstream of the confluence of Deep Creek and Tooloombah Creek (2.2 km north of the Project boundary). There are no WildNet database records of the species from the wider area. The nearest ALA database records are from the Fitzroy River approximately 50 km south of the Project. The species known to occur in low numbers in the Shoalwater Bay area (DoD 2009). Habitat throughout the Styx River estuary and Broad Sound is considered suitable for the estuarine crocodile.

15.3.9.4.2 Green Turtle

EPBC Act – V,M, NC Act – V

The Green turtle has an olive green, nearly circular or heart-shaped carapace (upper shell) up to 1 m in length. The carapace is usually variegated with brown, reddish-brown and black on the top and

whitish or cream underneath. Green turtles nest, forage and migrate across tropical northern Australia (DAWE 2020f).

Green turtle has been recorded nesting on several offshore islands in the region including the Percy Islands group (120 km north-east), Curlew Island (116 km north) and islands and mainland beaches in Shoalwater Bay (68 km north-east). Records from the ALA database (Figure 15-14) show several records of green turtle in Broad Sound including the Styx River estuary, however these are all attributable to a single radio-tracked individual released by the Cairns turtle rehabilitation and reef HQ facility in 2010. The Shoalwater Bay sites are the nearest known nesting sites to the Project (66 km north-east) (Limpus et al. 2002).

Extensive aerial transect surveys for marine turtles which included Broad Sound recorded one individual in the Broad Sound DIWA area (on the south-west side of Long Island). Individuals were recorded north of Broad Sound adjacent to the north-west side of Long Island and in the Clairview area. Much higher densities were recorded in Shoalwater Bay (Sobtzick et al. 2017). Green turtle is known to forage on seagrasses which do not occur in the majority of Broad Sound. The lack of marine turtle observations in the area may be an indicator that the tidal regime in Broad Sound provides low habitat value for marine turtles in general. Given the shallow nature of the river (particularly at low tides) and the lack of suitable instream habitat for marine turtle species in the river, it is not expected that marine turtles occur upstream in the Styx River estuary much further than Rosewood Island.

15.3.9.4.3 Flatback Turtle

EPBC Act – V,M, NC Act – V

The Flatback turtle has a low domed carapace (shell), is grey, pale grey-green or olive in colour and is found only in the tropical waters of northern Australia, Papua New Guinea and Irian Jaya. There are four genetic stocks of flatback turtles in Australia: Queensland east coast, Torres Strait/Gulf of Carpentaria, Northern Territory and Western Australia (Limpus 2007). It is one of only two species of sea turtle without a global distribution (DAWE 2020f).

The species nests only in Australia and is the most common nesting species in the marine area surrounding Broad Sound. There are large nesting aggregations of flatback turtles at Wild Duck Island (74 km north north-east of the Project) and Avoid Island (75 km north of the Project). The species nests at lower levels on many of the islands in the local region and selected mainland beaches (Limpus et al. 2002). Targeted nesting surveys in the region indicate the nearest nest sites for this species were the Clairview area (55 km north including mainland beach sites and nearby Flock Pigeon Island), north-east side of Long Island (67 km north north-east), and in the Stanage Bay area (70 km north-east including mainland sites and Quail Island) (Limpus et al. 2002). There are many ALA database records in the wider area and islands but no records within the Broad Sound area itself.

15.3.9.4.4 Australian Hump-back Dolphin and Australian Snubfin Dolphin

EPBC Act – M, NC Act – V

Protected marine species recorded from the region include inshore dolphin species including Australian hump-back dolphin and Australian snubfin dolphin. Australian snubfin dolphin's habitat preference in the Keppel Bay area is shallow waters ranging from 2 to 15 m depth (Cagnazzi et al. 2013). Populations occur sporadically along the Queensland coast through to northern Western Australia. Australian hump-back dolphin occurs as local populations along the Queensland coast that

are small in number and discrete in geographic range (Hale et al. 2000). Habitat preference is for shallow turbid estuarine and coastal waters (Lin et al. 2013) and in particular shallow channels.

Past surveys indicate that both species occur in the Shoalwater Bay area although Australian snubfin dolphin occurs in low numbers compared to those recorded further south in the Fitzroy River estuary (Cagnazzi 2010 and Cagnazzi et al. 2013). During boat-based surveys of Broad Sound carried out over two weeks in 2013 low numbers of both species were detected (seven separate pods detected including two pods of Australian snubfin dolphins). All records were located north of the Styx River. Both species were detected in the channel on the western side of Rosewood Island (CCP 2013). There are several ALA database records of Australian snubfin dolphin (only) in the wider area to the north of Broad Sound (Figure 15-14). Given the shallow nature of the Styx River, particularly at low tides, suitable habitat for these species in the river is not expected to extend upstream much further than Rosewood Island.

15.3.9.4.5 Dugong

EPBC Act – M

The seagrass beds to the northwest of Broad Sound (around the township of Clairview) support populations of dugong. There is a Dugong Protection Area (DPA) (administered under the *Great Barrier Reef Marine Park Regulations 1983*) extending from Carmilla Creek south to Clairview Bluff approximately 55 km north of the Project). A second DPA occurs in the Shoalwater Bay area to the north-west of the Project. Shoalwater Bay DPA is considered the most important dugong site in the southern area of the GBRMP. Sightings of dugong are rare in most of Broad Sound. In a review of dugong sighting data by Marsh and Penrose (2001) there are no reported sightings in the Broad Sound area. More recently, extensive aerial transect surveys for dugong and marine turtles which included Broad Sound, recorded no individuals in the Sound itself. The nearest reported sightings were individuals in the Clairview and Stanage Bay areas (Sobtzick et al. 2017). Given the lack of seagrass in most of Broad Sound it is unlikely the area immediately downstream of the Project provides suitable habitat for the species however the seagrass beds to the northwest of Broad Sound (around the township of Clairview) are known to support populations of dugong.

15.3.9.4.6 Humpback Whale

EPBC Act – V,M, NC Act – V

Humpback whale is a large baleen whale species that can grow to 16 m in length and are well known for winter migrations along the east and west coast of Australia where the species breeds. The population of Australia's east coast migrates from summer cold-water feeding grounds in Subantarctic waters to warm-water winter breeding grounds in the central GBR (OEH 2017).

Humpback whale is known to utilise the sheltered coastal waters of central and southern Queensland, particularly while on its southern migration. Broad Sound is not ideal habitat for the species, due to its large tidal range and associated turbid waters. However, the deeper waters at the northern entrance to Broad Sound are likely to be utilised by humpback whales for short periods during the southern migration. This is particularly so for whales that have recently calved, with a core calving area located to the north of Broad Sound off the coast of Mackay (DAWE 2020c).

15.3.10 MSES and MNES

The EPBC Act establishes a process for assessment and approval of proposed actions that have, or are likely to have, a significant impact on MNES including listed threatened species, ecological communities and listed migratory species. MSES are listed in Schedule 2 of the Queensland Environmental Offsets Regulation 2014. Any significant residual impacts on MNES and MSES must be offset in accordance with the EPBC Act Environmental Offsets Policy and the QEOP. A summary of all aquatic and marine MSES and MNES and their applicability to the Project is presented in Table 15-8.

Table 15-8: Summary of aquatic and marine MSES and MNES and applicability to the Project

MSES/MNES	Description	Project Applicability
MSES		
Wetlands and watercourses	Includes: • wetlands in a WPA • wetlands of HES shown on the map of Queensland wetland environmental values and • a wetland or watercourse in high ecological value (HEV) waters.	Wetland 1 is both a wetland of HES and a wetland in a WPA. It is mapped as RE 11.3.12. There are no wetlands or watercourses in HEV waters located near the Project. Wetland REs that are MSES are addressed in Chapter 14.
Protected wildlife habitat	Includes habitat for an animal that is endangered or vulnerable, or special least concern wildlife under the NC Act.	There are seven species which are listed as vulnerable under the NC Act and are known or likely to occur in the waterways surrounding the Project Site and/or the downstream environments. These species are: • Estuarine crocodile (Vulnerable - NC Act; Migratory – EPBC Act) • Green turtle (Vulnerable - NC Act; Vulnerable/Migratory – EPBC Act) • Flatback turtle (Vulnerable - NC Act; Vulnerable/Migratory - EPBC Act) • Australian hump-back dolphin (Vulnerable - NC Act; Migratory - EPBC Act) • Australian snubfin dolphin (Vulnerable - NC Act; Migratory EPBC Act) • Dugong (Vulnerable - NC Act; Migratory EPBC Act) and • Humpback whale (Vulnerable - NC Act; Vulnerable/Migratory - EPBC Act).
Highly protected zones of State Marine Parks	Includes highly protected areas of relevant Queensland Marine Parks. Relevant Queensland marine parks include any of the following listed under the *Marine Parks Act 2004*: • the Great Barrier Reef Coast Marine Park • the Moreton Bay Marine Park and	The GBRCMP is considered as a MSES where designated as a 'highly protected area' as defined in Schedule 2 of the Environmental Offsets Regulation 2014. Highly protected area means: (a) a zone classified, under the Marine Parks Act 2004, as a conservation park zone, marine national park zone or preservation zone; or

MSES/MNES	Description	Project Applicability
	• the Great Sandy Marine Park.	(b) another area prescribed under a regulation or zoning plan, under the Marine Parks Act 2004, as a highly protected area. Only the areas of the GBRCMP zoned Marine National Park or Conservation Park Zone are considered MSES. The Marine National Park zone is located approximately 33 km northeast of the Project (or 40 km downstream).
Fish habitat areas	Includes areas declared as a Fish Habitat Area under the Fisheries Act.	Broad Sound FHA boundary is located approximately 10 km downstream of the Project.
Waterway providing for fish passage	Includes any part of a waterway that provides for passage of fish only if the construction, installation or modification of waterway barrier works will limit the passage of fish along the waterway.	There are several watercourses of varying stream orders located within the Project area that have the potential to provide fish passage.
Marine Plants	Marine plants are defined under the Fisheries Act and include the following: • a plant (a tidal plant) that usually grows on, or adjacent to, tidal land, whether it is living, dead, standing or fallen • material of a tidal plant, or other plant material on tidal land • a plant, or material of a plant, prescribed under regulation or management plan to be a marine plant.	Marine couch was identified along the edge of the Styx River approximately 2.5 km downstream of the Project, however, was most abundant along the banks of the Styx River from approximately 4 km downstream of the Project. Extensive stands of saltmarsh and mangrove species occur downstream of the Project (14 km and 21 km downstream respectively) along the margins of the Styx River and Broad Sound.
MNES		
World Heritage Properties	An area that has been included in the World Heritage list or declared by the minister to be a World Heritage property. World Heritage properties are places with natural or cultural heritage values which are recognised to have outstanding universal value.	The GBRWHA is located approximately 10 km downstream of the northernmost Project boundary.
National Heritage Places	Places or groups of places with outstanding heritage value to Australia – whether natural, Indigenous or historic or a combination of these.	The GBR was placed on the National Heritage List in May 2007. It is located approximately 10 km downstream of the northernmost Project boundary.
Wetlands of international importance (listed under the Ramsar Convention)	A 'declared Ramsar wetland' is an area that has been designated under Article 2 of the Ramsar Convention or declared by the minister to be a declared Ramsar wetland under section 16 of the EPBC Act.	No Ramsar Wetlands under the EPBC Act are located within the Project Area. The closest Ramsar wetlands are the Shoalwater and Corio Bays which are adjacent to the Broad Sound wetland.
Listed threatened species	An action will require approval if the action has, will have, or is likely to have a	There are seven listed threatened and/or migratory species which are known or likely to occur in the waterways

MSES/MNES	Description	Project Applicability
	significant impact on a species listed in any of the following categories: • extinct in the wild • critically endangered • endangered or • vulnerable.	surrounding the Project Site and/or the downstream environments. These species are: • Estuarine crocodile (Vulnerable - NC Act; Migratory - EPBC Act) • Green turtle (Vulnerable - NC Act; Vulnerable/Migratory - EPBC Act) • Flatback turtle (Vulnerable - NC Act; Vulnerable/Migratory - EPBC Act) • Australian hump-back dolphin (Vulnerable - NC Act; Migratory - EPBC Act) • Australian snubfin dolphin (Vulnerable - NC Act; Migratory EPBC Act) • Dugong (Vulnerable - NC Act; Migratory EPBC Act) • Humpback whale (Vulnerable - NC Act; Vulnerable/Migratory - EPBC Act).
Listed Migratory Species	An action will require approval if the action has, will have, or is likely to have a significant impact on a listed migratory species. Some migratory species are also listed as threatened species. The Significant impact criteria for migratory species are relevant to migratory species that are not threatened.	
Commonwealth marine areas	A 'Commonwealth marine area' is defined in section 24 of the EPBC Act. Marine protected areas are marine areas which are recognised to have high conservation value. Actions in or near marine protected areas, or other areas with high conservation value, have a greater likelihood of significant impacts on the Commonwealth marine environment.	Coral Sea Marine Park is the closest Commonwealth marine area. It covers 989,836 square kilometres and lies off the coast of Queensland, and is one of the world's largest marine parks. The Coral Sea Marine Park boundary is located approximately 330 km north-east of the Project Area.
Great Barrier Reef Marine Park	The Great Barrier Reef Marine Park is established under the Great Barrier Reef Marine Park Act 1975. The Great Barrier Reef Marine Park is an area recognised to have high conservation value. Other protected matters potentially relevant to the Great Barrier Reef and the Project include: • The Great Barrier Reef is a World Heritage property • The Great Barrier Reef is a National Heritage place • Listed threatened species and ecological communities • Listed migratory species.	The GBRMP is located approximately 41 km downstream of the Project.

15.4 Potential Impacts of the Project

The Project has the potential to result in direct and indirect impacts on aquatic and marine values as a result of:

- establishment of Project infrastructure
- groundwater drawdown
- surface water changes
- erosion of stream banks
- increased abundance or diversity of pest and weeds and
- increased dust.

The following sections provide a discussion of these potential impacts, describing how they can impact aquatic and marine values, and the potential for these impacts to arise as a result of the Project. A detailed assessment for each of the relevant aquatic and marine values is then provided in Section 15.6, including significant impact assessments where required for MNES and MSES.

15.4.1 Establishment of Project Infrastructure

Construction of Project infrastructure can result in direct impacts to aquatic and marine habitat. There will be no direct disturbance in the downstream environment and the Disturbance Footprint does not intersect any natural freshwater wetlands. However, establishment of critical Project infrastructure will result in direct impacts to a number of waterways and riparian vegetation within the Project Site including at Deep Creek, Barrack Creek and unnamed tributaries of Tooloombah and Deep Creek.

Two unnamed tributaries of Deep Creek will be permanently removed through the establishment of Dam 1 and the mine pits, resulting in the permanent loss of aquatic habitat and riparian vegetation. Small extents of two tributaries of Tooloombah Creek will also be permanently removed. A haul road crossing will be established over Deep and Barrack Creek.

Direct mortality of aquatic fauna may occur due to construction activities associated with establishment of creek crossings and dams. However, construction works will be completed in the dry season, when in-stream aquatic ecology values are generally not present or are limited in geographic scale and abundance. Spotter catchers will be present during all clearing activities and clearing procedures will be developed to relocate native wildlife to adjacent areas and rehabilitate any injured wildlife.

15.4.2 Groundwater Drawdown

Mine dewatering and depressurisation will result in groundwater drawdown near the mine and extending below parts of Deep, Tooloombah, Barrack and Mamelon Creeks. Pit progression and associated groundwater drawdown will move in a south-easterly direction, and drawdown will extend to beneath Tooloombah Creek within the first three years of operation. Drawdown will not extend below Deep Creek until three to five years after Project commencement. Within the water table aquifer the model predicts water levels will fall by a maximum of approximately 60 m beneath Deep Creek, and 4.7 m below Tooloombah Creek and Barrack Creek at some locations. Groundwater drawdown is not predicted to occur beneath the Styx River and therefore loss of potential baseflow in downstream areas is not considered to be a potential impact of the Project.

Groundwater drawdown can potentially impact aquatic ecosystems through reduction in water availability and alterations to water quality. Groundwater drawdown has the potential to reduce connectivity along waterways, causing streams to dry up faster during the dry season than occurs under baseline conditions. There is the potential for loss of baseflow / enhanced leakage from reduced groundwater inflows into pools (Aquatic GDEs). Groundwater drawdown can also directly impact habitat for subterranean fauna.

Groundwater drawdown can impact Terrestrial GDEs which may provide important ecological functions for aquatic ecosystems, such as providing shade to waterways which regulates temperature, and supporting bank stability. If the water table aquifer is at an accessible depth to vegetation, and of a suitable quality for use, the drawdown of the aquifer through mine dewatering and depressurisation has the potential to directly reduce water availability for Terrestrial GDEs.

Reductions in groundwater quantity can have flow-on effects on groundwater quality. Changes in groundwater quality can occur in a number of ways including:

- evaporative concentration of salts in temporarily open mine voids whilst they remain open (noting that all Project voids will be backfilled)
- possible induced flow of groundwater of different quality towards depressurised parts of the groundwater system
- infiltration of water containing elevated concentrations of metals, sulphate and salinity from waste rock stockpiles and mine water storages (Dams 1 to 4)
- accidental release of chemicals (such as unintended fuel spills, leakage of sewage effluent, or infiltration of stormwater from disturbed areas) and
- movement in the location of the ‘saltwater-freshwater’ interface.

With the exception of a few shallow groundwater bores located immediately adjacent to watercourses, the groundwater quality within the Project Site and surrounding areas is generally poor, and of limited human use, due to high salinity. Given the similarity of higher and variable salinity for the various source groundwaters, no appreciable change in groundwater salinity is expected as a consequence of mining. There is also limited potential for groundwater contamination to occur as a result of spills of hydrocarbons or other contaminants, due to the depth of groundwater typically being greater than 10 m below ground level.

Waste rock characterisation, detailed in Chapter 8 – Waste Rock and Rejects, determined that the overwhelming majority of the waste rock and coal reject materials have a low reactive sulphur content, excess acid neutralising capacity, and are classified as non-acid forming. While a small fraction of the waste rock and coal reject materials may have some potential to generate acidity, the bulk materials will have excess acid neutralising capacity and will therefore generate alkaline surface runoff and seepage. Leachate testing also indicated a low salinity and typically low levels of trace metals/metalloids other than aluminium, arsenic and selenium which were elevated in some of the samples.

Despite the salinity evident in some of the groundwater samples collected at the Project Site and surrounding areas, it has been determined that the salinity in the groundwaters intersected by the Project is derived from regional geochemistry, and not an oceanic saltwater interface (the fresh-seawater interface). As described in detail in Chapter 10 - Groundwater, if any interface between oceanic saltwater and freshwater does exist within the groundwater in the vicinity of the Project, it will be hundreds of meters below sea level at the location of the pits, or beyond the extent of any

drawdown influence from the Project, and would therefore not result in any movement of any interface between seawater and groundwater.

15.4.3 Surface Water Changes

Control of erosion on and off-site will largely be managed under the site Erosion and Sediment Control Plan (ESCP) (see Appendix 15a). Water will be managed on site via a number of dams, catchment diversion drains, levees and pipes, with water captured on the site used to supply site water demands.

Dam 1 is the main storage for runoff from active mining areas and groundwater inflows to the open cut pits, and for bulk operational water supply for the site. Dam 1 will also collect undisturbed catchment runoff in the early stages of the Project to provide water supply for mining operations. It will operate with a capacity of 1,800 ML, but will be capable of holding 2,783 ML, and will provide water for the Coal Handling and Preparation Plant (CHPP), haul road dust suppression, vehicle washdown and fire water. The Project also includes a number of Environmental Dams to collect and contain runoff from various areas and sediment dams to collect and treat runoff from overburden emplacements.

The two major mine pits (Open Cut 1 and Open Cut 2) will require the construction of two catchment diversion drains to divert water runoff around the site to Deep Creek. These will be constructed in a progressive manner as the pits expand, with the drain to the north of the Bruce Highway constructed first. The second drain, to the south of the Bruce Highway, will be constructed around nine years later in the latter half of the Project. The full details of the mine site water management system are given in Chapter 9 – Surface Water.

The general potential impacts to surface water systems as a result of the Project are discussed below and can be summarised as follows:

- Point source discharges to waterways – from controlled dam releases, uncontrolled dam releases, localised erosion and sedimentation, and spills and leaks, including from waste rock storages or groundwater affected by mining operations.
- Area sources – altered loads from larger catchment areas as a result of land use change, including increases in erosion and sedimentation of waterways, broad based leakage from groundwater and waste rock storages.
- Changes to flow patterns from concentration of flows due to constrictions in flow passages, alterations of floodplain areas, and the like, resulting in changes to erosion, sedimentation and bed load.

These impacts have the potential to affect habitat and / or resources for a range of aquatic and marine values reliant on the availability of surface water resources.

15.4.3.1 Controlled and Uncontrolled Releases

During wet climatic conditions, controlled releases from Dam 1 to Deep Creek may be required to prevent excessive accumulation of water within the site storages and minimise the risk of uncontrolled discharges to the receiving environment. The controlled release point will be located on the northern boundary of Dam 1 and water directed along an existing drainage line into Deep Creek. The release point will be armoured and fitted with energy dissipation structures to prevent erosion and scour.

Flow based controlled release rules have been developed using the water balance model for the Project (provided in Appendix 5b - Flood Study and Water Balance), requiring release only during flow in Deep Creek, with the flow rate and maximum EC and sulfate levels determining when and how releases can occur. The predicted annual controlled release volumes from Dam 1 are:

- for very wet climatic conditions (1%ile), predicted annual controlled releases range between 2,790 and 2,930 ML/a
- for wet climatic conditions (10%ile), predicted annual controlled releases range between 780 and 1,430 ML/a
- for median climatic conditions (10%ile), predicted annual controlled releases range are up to 40 ML/a and
- no controlled releases are projected to occur in dry and very dry climatic conditions.

The mine-affected water dams that could potentially overflow directly to the receiving environment through uncontrolled overflows if rainfall exceeded the storage design criteria include:

- Dam 1 – spilling to Tooloombah Creek
- Environmental Dams 2D1 and 2D2 – spilling to Deep Creek
- Environmental Dam 1B – spilling to Tooloombah Creek and
- Dam 4 – spilling to Deep Creek.

The water balance model (Appendix 5b) was used to assess the risk of uncontrolled offsite spills from the proposed water management system. Across all storages the annual risk of overflow is considered to be low (between 1 – 10%) and would only occur under wet conditions. The predicted annual overflows from these dams are:

- Dam 1 overflows:
  - During the first 10 years of the Project, there is only a very small (around 1%) risk of an overflow from Dam 1 occurring, with a maximum annual overflow volume of 320 ML/a.
  - From Year 11 to Year 18, the annual risk of overflows from Dam 1 increases to around 10% due to the increase in upstream natural catchment draining to the dam. Under very wet climatic conditions (1%ile), the maximum annual overflow volume is around 2,500 ML/a. Under wet climatic conditions (10%ile), the maximum annual overflow volume reduces to around 65 ML/a.
  - During median and drier climatic conditions, there are no modelled overflows from Dam 1.
- Environmental Dams 2D1 and 2D2 overflows:
  - There is only a very small (around 1%) risk of an overflow from Dams 2D 1&2 occurring over the life of the Project, with a maximum annual overflow volume of 22 ML/a.
- Environmental Dam 1B overflows:
  - The modelling predicts no overflows in the first 10 years of the mine life. From Year 11 to Year 18, the annual risk of overflows increases to around 10%. Under very wet climatic conditions (1%), the maximum annual overflow is predicted is around 700ML/a. Under wet climatic conditions (10%), the maximum annual overflow volume reduces to around 100ML/a.
- Dam 4 overflows:
  - There is only a very small (around 1%) risk of an overflow from Dam 4 occurring over the life of the Project, with a maximum annual overflow volume of 130 ML/a.

15.4.3.1.1 Water Quality Impact Assessment

To assess the water quality impacts of controlled releases and uncontrolled overflows six parameters, including EC, Arsenic (As), Molybdenum (Mo), Selenium (Se), Vanadium (V) and Sulphate (SO_4^{2-}), were modelled within the water management system and consequent discharges from the site. These parameters were chosen on the basis of geochemistry analysis for the site, which indicates that they are among the key parameters most likely to be present in high concentrations.

Modelling realisations representative of 1%ile (very wet), 10%ile (wet), and 50%ile (median) climatic conditions were undertaken. For each of these three realisations, the modelled water quality of the receiving waters (Tooloombah Creek, Deep Creek and downstream of the Tooloombah/Deep Creek confluence) on each day that a controlled release or uncontrolled overflow occurred was statistically analysed. For each of the six parameters analysed, the predicted concentrations in the downstream waterways was compared against the known historic concentrations. For each of the parameters analysed the predicted concentrations were well within the range of the typical historical receiving water concentrations. The highest predicted concentrations for all heavy metals that were modelled are also an order of magnitude lower than thresholds set out in model mining EA conditions for water releases.

This assessment indicates that the risks to downstream environments from high concentrations of water quality parameters contained in controlled or uncontrolled releases from the mine are low. Downstream water quality is expected to be within the range of natural variability under all release scenarios, and hence is not expected to cause adverse impacts to the aquatic and marine environment. The full details regarding the assessment are in Chapter 9 - Surface Water.

15.4.3.2 Accidental Release of Pollutants

The release of pollutants into the surrounding environment and waterways has the potential to degrade stream habitat quality and water quality near the site. Without mitigation, potential exists for contaminants to enter waterways including: contaminated mine dewatering runoff; contaminated runoff from waste rock stockpiles; aqueous waste streams including oily waste water (from heavy equipment cleaning); contaminated runoff from chemical storage areas; potentially contaminated drainage from fuel oil storage areas; and general washdown water. However, standard containment facilities for the storage of fuel, oils and other chemicals will ensure that leaks and spills of these contaminants does not occur. Runoff from Project facilities such as the CHPP/Mine Infrastructure Area and waste rock stockpiles will also be captured in a number of environmental dams (and Dam 1 for Waste Rock Stockpile 2) for re-use or treatment, and therefore will not flow directly to nearby waterways. As such the risk of accidental releases of pollutants into the aquatic and marine environment is considered to be low.

15.4.3.3 Flooding and Hydrology

A flood impact assessment found that the impacts of the Project on flood extents are generally minor with flooding patterns predicted to remain largely unchanged, and the majority of the flood extent continuing to be confined within the banks of Tooloombah and Deep Creeks. Small increases in flood level, up to about 0.20 m, are caused by the proposed haul road crossing, the diversion of local catchment runoff by the Northern Drain and overflows from Dam 1. The study also found that impacts of the Project on flow velocities in the creeks are very small. The full details of the flood impact assessment are provided in Chapter 9 – Surface Water.

The Project is not expected to result in any major changes to the natural hydrological conditions of Tooloombah and Deep Creeks, and therefore to the Styx River. While some runoff within the creek catchments will be captured and retained on site within the mine footprint, the amount of water involved is minimal compared with that entering the creeks as runoff from the broader catchment during rain events. Surface water modelling shows that there will be no substantial change to the number of no flow days in the system under a mining scenario. Flow currently occurs approximately 24% of the time and this will not be affected by the Project. As such, the ephemeral nature of the creeks and the current flow regime will remain unchanged, and connectivity along the creek systems and into the downstream environments will not be affected. Downstream areas will continue to be primarily influenced by the tidal regime of the Styx River estuary and Broad Sound marine environment.

15.4.3.4 Changes to the Freshwater – Saltwater Interface

The tidally influenced portion of the Styx River is located up to approximately the Ogmore Road Bridge crossing with a transitional zone extending during peak tides (i.e. tidal bore) to the Tooloombah and Deep Creek confluence. Surface water modelling for the Project indicates that this will not change as result of the Project. This, combined with the negligible changes to the hydrological regime, suggests there will be no change in the location of the freshwater – saltwater interface within surface waters of the Styx River.

15.4.3.5 Erosion and Sedimentation

Vegetation clearing, mining operations and earthworks required during both construction and operation will expose the land to varying levels of erosion based on a number of factors including soil type, surface slopes and extent of ground coverage, runoff potential and rainfall intensity. Sediment can be mobilised and transported by surface water during rainfall events ultimately discharging into drainage lines which can result in negative impacts on water quality and downstream aquatic habitats. Specifically, increased quantities of suspended sediments can reduce light penetration, decreasing the photosynthesis of aquatic flora and lowering dissolved oxygen concentrations.

A conceptual ESCP (see Appendix 15a) has been prepared for the Project to manage the risk of erosion from the Project Site. It describes the proposed strategies and controls for management of erosion and sedimentation based on the site conditions, proposed mine features, seasonal influences, management controls and mitigation measures. Risks associated with the erosion of stream banks will also be managed through the engineering design of diversion channels, drains and spillways, and through minimising the disturbance to riparian vegetation.

The risk of erosion and consequent loss of sediment has been calculated for the Project for both the existing pre-mine condition (baseline) and operationally which accounts for waste rock material, mine water management and the layout of the proposed mine. Based on average climatic conditions the assessment shows that the Project will result in a reduction in the estimated baseline sediment generation rate of 5,037 t/year to approximately 2,297 t/year, due to the proposed water management system, destocking of the undisturbed Project Site and Mamelon offset areas and the subsequent managed regeneration of native vegetation on the majority of the Mamelon property. Based on this assessment the Project will reduce the sediment load to the downstream environment by approximately 2,740 t/year. This equates to a reduction in the total Styx Basin sediment load of 2.74 % and a reduction in the total Fitzroy Basin sediment load of 0.15%.

The assessment also considered non-average, very wet, climatic conditions when sediment might be expected to mobilise more readily and found that, even under non-average wet and very wet conditions, the sediment load from the Project will be less than that of current baseline conditions. An assessment against the Reef 2050 Water Quality Targets also indicates that the Project will result in a positive contribution through the expected reduction in sediment load reporting to the Styx River.

15.4.4 Erosion of Stream Banks

Tooloombah and Deep Creek are highly incised waterways that are likely to be partially reliant on the retention of riparian vegetation for streambank stability. The loss of riparian vegetation in some areas, either through direct clearing or indirect impacts associated with changes in hydrology, has the potential to compromise the stability of the banks and lead to collapse. Controlled and uncontrolled releases also have the potential to cause local erosion of stream beds and banks, if not managed appropriately.

A description of the geomorphological values of the Project Area is provided by Gippel (2020) in Appendix A5d - Fluvial Geomorphology. The geomorphology assessment concluded that while there could be isolated areas subject to somewhat higher risk of scour compared with baseline conditions, the overall risk of rapid and significant geomorphic change in Tooloombah and Deep creeks and the Styx River due to the proposed mining activity is low. Impacts from the Project on hydraulic variables will be small enough that a rapid geomorphic response would not be expected. Rather, the channel will slowly adjust over the life of the mine to the altered hydraulic conditions through minor changes in bed and floodplain levels, or channel widths.

15.4.5 Weeds

The movement of earthmoving machinery and other plant and construction materials increases the risk of weed introduction. In addition, the use of that machinery on site can contribute to the spread of existing weeds within the site. Where the soil seed bank on site already has a weedy component, further movement of those seeds within the site by earthmoving equipment can be impossible to avoid.

Whilst there is potential for introduction and spread of weed species as a result of the Project, it is considered unlikely that the Project would contribute to a significant further change to existing threats given the current prevalence of weeds in the area and the land use history for the Project Site and surrounding area. The Project will involve the implementation of a comprehensive suite of best-practice prevention strategies through the EMP, both within the Project Site and in adjacent areas of the Mamelon Station to minimise the risk of weed introduction and spread. Furthermore, the implementation of weed control measures within and adjacent to the Project Site is likely to relieve the pressure of introduced flora on ecological values, improving the quality of vegetation and habitats within and adjacent to the Project Site.

15.4.6 Pests

No aquatic pest animals were recorded in database searches or during field surveys indicating that the aquatic environments of the Project Area may be relatively free of introduced taxa. There is considered negligible potential for introduction of aquatic pest animals as a result of construction or operation of the Project. The Project will involve the implementation a comprehensive suite of best-practice prevention strategies through the EMP, including measures for pest animal control both

within the Project Site and in adjacent areas of the Mamelon Station, although with a focus on terrestrial pest fauna. In addition, the Project will involve the reduction of grazing within the Project Site and surrounding areas of Mamelon Station, relieving the pressure of pastoralism on ecological values, including waterways, and improving the quality of vegetation and habitats within and adjacent to the Project Site.

15.4.7 Dust

Increased dust resulting from excavations, topsoil stripping, vehicle movement, open cut mining activities, construction of infrastructure and roads, coal transport and from coal stockpiles has the potential to impact aquatic habitats within the Project Site and surrounds.

Coal dust can result in adverse impacts on plant photosynthesis and productivity (Chaston and Doley 2006), changes in soil properties ultimately impacting plant species assemblages' (Farmer 1993 and Spencer and Tinnin 1997) and mortality and/or decrease in health of aquatic communities from the toxicity of poor water quality. Naidoo and Naidoo (2005) found coal dust on mangroves located within 3 km of a coal terminal in South Africa impaired the productivity of two out of four species tested by reducing photosynthetic activity. However, only leaves that were 'extensively covered and appeared black' were tested.

Chronic exposure to high and localised concentrations of fine coal particles (as associated with bulk coal marine transport spills) have been found to have lethal effects on coral and impact the growth rates of tropical fish and seagrass (Berry et al. 2016). Coal contains potential contaminants such as metals and polycyclic aromatic hydrocarbons which may pose a risk to aquatic organisms including marine species. However, recent research indicates the risk of these contaminants leaching into seawater is low (Jaffrennou et al. 2007; Lucas and Planner 2012; Berry et al. 2016). The risks of fine coal particles in water are likely to be physical processes where there is a concentrated point source or plume of particles. This may have effects such as the physical smothering of benthic fauna, and attenuation of light inhibiting algae (Jaffrennou et al. 2007) or seagrass growth.

The deposition of road dust on nearby freshwater wetlands caused by heavy traffic increases due to energy development projects found minimal impact on water quality or soils (Creuzer et al. 2016). However, the actual impacts on wetlands or wetland vegetation from coal dust deposition, as (opposed to increased atmospheric dust) appear little studied.

Modelling of potential dust particle deposition resulting from both Project construction and operation showed that there is no exceedance of any air quality criteria at any sensitive receptor. Sensitive receptors included Tooloombah and Deep Creek, as well as Wetland 1 and 2. All predicted modelled concentrations were below the relevant air quality criteria set by the State under the Environmental Protection (Air) Policy 2019 (EPP (Air)). The complete assessment is presented in Chapter 12 – Air Quality.

Aquatic and marine values associated with Broad Sound and the GBR include extensive areas of mudflats, saltmarsh flats and mangroves. Coral communities and seagrass meadows do not occur to any great extent in the vicinity of the Styx River. Given the distance these habitats are away from the Project Site, the implementation of the erosion and sediment control plan and the relatively minor extent of the modelled impacts as described above, it is considered that coal dust deposition from Project activities will not impact downstream marine habitats, including those associated with the GBR and Broad Sound.

15.5 Avoidance and Mitigation through Project Design

An options analysis was undertaken to evaluate the relative social, economic and environmental advantages and disadvantages of different Project scenarios, and to identify opportunities for avoidance of environmental impacts. The analysis included consideration of a range of environmental factors such as:

- the location of protected or declared environmental areas
- mapped areas of biodiversity significance
- the presence of MNES and MSES including, but not limited to, remnant vegetation, wetlands and fauna habitat
- the location of surface water features and
- maximising the use of existing infrastructure such as power supply, telecommunications infrastructure and transportation options, including proximity of mine site to existing ports.

The outcomes of this analysis were used to select the final Project location in the context of the location of coal deposits within EPC 1029, Mineral Development Licence (MDL) 468 and later ML 80187. The final Project Site is located in close proximity to both the Bruce Highway and the North Coast Rail Line, which the Project will utilise to transport coal to the existing Dalrymple Bay Coal Terminal at the Port of Hay Point. It also has direct access to a 22kv powerline and telecommunications cabling located within the Bruce Highway road corridor.

At the site level, Project infrastructure has been preferentially sited to avoid impacts on threatened ecological communities, environmentally sensitive areas, wildlife corridors and mapped wetlands, and to minimise impacts to regulated and riparian vegetation. Existing disturbed areas (such as farm access tracks or clearings) have been used to site infrastructure and reduce impacts to MNES and MSES to the greatest extent possible. Of the total Disturbance Area (1,372.50 ha) approximately 90% is located within non-remnant vegetation which has been previously cleared for cattle grazing (1,231.13 ha).

Through the EIS and SEIS process, refinement of Project design has sought to further avoid and minimise impacts on environmental values. Since the finalisation of SEIS v2, additional changes made to avoid impacts on environmental values include:

- excising 349 ha from the southern extent of ML 80187 to reduce the overall size of the Project Site
- complete removal of Dam 2 to avoid impacts on least concern RE 11.3.27 (freshwater wetlands) and of concern RE 11.4.2
- relocating Environmental Dam 2D from within an area of concern RE 11.3.4 into non-remnant areas adjacent to the Haul Road
- retracting the Open Cut 2 pit northern end wall by 40 m to the south to increase the buffer between the mine and endangered RE 11.3.11
- redesigning, reconfiguring or removing the Waste Rock Stockpiles in order to reduce the stockpile slopes and locating them out of the flood zone to the greatest extent possible and
- consolidating water storages and increasing the size of Dam 1 within areas of non-remnant vegetation to increase storage capacity and reduce the potential for controlled and uncontrolled releases to the receiving environment.

In addition to the location and design of Project infrastructure, the technology used in mining processes can greatly influence the level of environmental impact of an activity and ensure operations are conducted as efficiently as possible. This efficiency can translate to a smaller footprint (the amount of surface area disturbed), less waste generated and cleaner and safer operations. Technologies that have been factored into the Project design to reduce impacts on the environment include:

- designing and constructing the final rehabilitated landform to integrate with the surrounding environment, with no final void to remain
- the avoidance of tailings storages through the implementation of paste thickeners and filter pressing technology, allowing process water to be recycled (approximately 60%), reducing water losses, process chemical losses, seepage and reducing processing plant water demand, as well as eliminating the risk of potential leaks or releases to the receiving environment from tailings storages and
- installing an overhead bin and train loading facility from the start of the operations to minimise coal dust and the potential loss of coal during train transit.

15.6 Impact Assessment

Based on the potential impacts described in Section 15.4, the Project has the potential to impact aquatic and marine EVs within the Project Area, including:

- wetlands of the Project Site
- aquatic, subterranean and terrestrial GDEs
- Broad Sound and the GBR
- aquatic and marine flora and fauna
- the coastal environment and
- MNES and MSES.

The following sections describe the impact of the Project on each of these values. For MNES and MSES significant impact assessments are presented in accordance with the relevant guidelines.

15.6.1 Wetlands of the Project Site

Wetlands located within the Project Site include Wetland 1 and 2, areas of mapped RE 11.3.27 and artificial wetlands such as turkeys nest dams. These wetlands have the potential to be impacted by the establishment of Project infrastructure, surface water changes, dust, weeds and pest animals. Wetlands are also at risk of impact through groundwater drawdown if they are groundwater dependent. As presented in Section 15.3.4 , wetlands within the Project Site are not supported by the surface expression of groundwater and are therefore not Aquatic GDEs. Wetland 1 is a Terrestrial GDE as *Melaleuca viridiflora* utilises sub-surface groundwater, in the form of a perched aquifer.

15.6.1.1 Establishment of Project Infrastructure

The Disturbance Footprint does not intersect any natural freshwater wetlands and consequently direct impacts on wetlands within the Project Site and their aquatic ecology values are not anticipated. Waste Rock Stockpile 1 will intersect the eastern side of the WPA associated with

Wetland 1, however, will not impact the wetland itself. A buffer from this wetland to the Project footprint of over 200 m will continue to be maintained.

A number of artificially created turkeys nest dams will be permanently removed following the construction of Open Cut 1. These artificially created waterbodies are ephemeral and provide limited value for aquatic fauna and flora. They are also widespread in the landscape and as such their removal is considered to have a very low impact on aquatic values.

15.6.1.2 Surface Water Changes

Wetlands have the potential to be impacted by Project related surface water changes through reductions in catchment areas, changes to natural hydrological conditions and reductions in water quality. As described in Section 15.4.3, the magnitude of Project-related changes to the existing surface water regime is very minor. Apart from a reduction in catchment size for two wetlands (discussed below) the Project is not expected to result in any major hydrological changes and flooding patterns are predicted to remain largely unchanged. A conceptual ESCP will be implemented to manage the risk of erosion from the Project Site.

During mining operations, the mine water management system will capture runoff from areas that would have previously flowed to a number of natural freshwater wetlands. A daily water balance was undertaken to assess the impact of these changes on the wetland catchments. The complete detail of the assessment is available in Appendix A5b - Flood Study and Water Balance. The impacts on wetland catchment areas are summarised as follows:

- the Wetland 1, Wetland 2 and Wetland 5 catchment areas will not be affected by mining operations
- the Wetland 3 catchment area will be reduced by up to 41% due to mining operations and
- the Wetland 4 catchment area will be reduced by up to 39% due to mining operations.

Water level duration curves were developed for each of the five wetlands to determine the impact of the wetland catchment excision on wetland water levels. The results of this assessment show that the wetland catchment excision due to mining operations will have a negligible impact on water level behaviour in the wetlands. As such there is not expected to be any impact on these wetlands as a result of catchment excisions.

15.6.1.3 Groundwater Drawdown

Wetland 1 is a Terrestrial GDE. There is a low risk of impact from groundwater drawdown on groundwater dependent vegetation at Wetland 1. Field studies have identified that *Melaleuca viridiflora* at Wetland 1 is accessing water in a perched aquifer located at 8 mbgl, well above the underlying water table aquifer which is located at 13.5 m. Maximum groundwater drawdown of 2.7 m at bore WMP25 near Wetland 1 is considered unlikely to affect the groundwater held in the perched aquifer and it is expected that access to this groundwater source will persist throughout the life of the Project.

15.6.1.4 Dust

There are no air quality objectives for the deposition of dust for the protection of the health and biodiversity of ecosystems in the EPP (Air), or any other statutory limit regarding vegetation, creeks or wetland protection. In the absence of readily available information or assessment criteria for dust deposition on wetlands, criteria for this Project have been adopted from the Cumulative Impact Assessment (CIA) for air quality for Abbot Point (Katestone 2012), for which the former Queensland

Department of Environmental and Heritage Protection (now DES) provided design guidance for dust deposition for the avoidance of dust nuisance. This study investigated, in part, the effects of coal dust on vegetation, with particular emphasis on assessment for vegetation in marshes and wetland, at Abbot Point (Katestone 2012). The operational goal of a 120-day rolling average deposition rate of 200 mg/m^2/day was recommended as a result of the CIA air quality assessment. This goal is adopted here for the assessment of dust deposition impacts on vegetation, including wetlands.

The Project's impact assessment has considered the deposition rates on a number of sensitive receptors including Tooloombah Creek, Deep Creek, Wetland 1 and Wetland 2. The maximum predicted dust deposition rates for each of these sensitive receptors and a comparison against the adopted goal are presented in Table 15-9. As shown, the model predictions are all below the criteria. As a result, there is not expected to be any impact on wetlands within the Project Site as a result of dust deposition.

Table 15-9: Maximum predicted dust deposition rates

Receptor	UTM Coordinates (km)		120-day rolling average deposition rate (mg/m^2/day)		Criteria
	Easting	Northing	Isolation	Cumulative	
Tooloombah Creek	769.689	7488.548	20.28	79.28	200 mg/m^2/day
Deep Creek	775.226	7486.022	3.11	62.11	
Western Boundary Wetland 1	770.787	7486.254	17.41	76.41	
Western Boundary Wetland 2	770.743	7487.605	26.49	85.49	

15.6.1.5 Weeds and Pests

As described in Section 15.4.5 and 15.4.6, it is considered unlikely that the Project would contribute to increases in weeds and pests within the aquatic environment. Implementation of weed and pest control measures within and adjacent to the Project Site is likely to relieve the pressure on ecological values, improving the quality of aquatic environments. The reduction of grazing within the Project Site and surrounds will also help to improve the quality of aquatic and marine habitats.

15.6.1.6 Significant Impact Assessment

Wetland 1 is a MSES because it is both a wetland of HES and a wetland in a WPA. As such, a significant impact assessment for Wetland 1 must be undertaken in accordance with the QEOP Significant Residual Impact Guidelines (DEHP 2014a). A project is likely to have a significant residual impact on wetlands listed as MSES if it is likely that it will result in environmental values being affected as per the criteria listed in Table 15-10. The assessment demonstrates that the Project will not result in a significant residual impact on Wetland 1.

Regional ecosystems that intersect with an area shown as a wetland on the vegetation management wetlands map (to the extent of the intersection) are also MSES. However, the impacts on RE that intersect with an area shown as a wetland on the vegetation management wetlands map are addressed in Chapter 14 – Terrestrial Ecology.

Table 15-10: Significant impact assessment – Wetland 1

Significant impact criteria	Response	Significant impact?
Areas of the wetland or watercourses being destroyed or artificially modified	There is no Project infrastructure planned to intersect the wetlands within the Project Site, including Wetland 1. Consequently, this wetland will not be destroyed or artificially modified.	No
A measurable change in water quality of the wetland or watercourse – for example a change in the level of the physical and/or chemical characteristics of the water, including salinity, pollutants, or nutrients in the wetland or watercourse, to a level that exceeds the water quality guidelines for the waters	All the areas of the Project Site that are affected by Project operations, and hence have the potential to affect the quality of surface water runoff within the catchments of wetlands, are contained within the mine site and drain to the mine site water management system – no water will discharge to these wetlands. In addition, the Project ESCP will be implemented to manage the risk of erosion from the Project Site. Predicted changes to wetland water balance is negligible, and therefore no change to the water quality of the Wetland 1 within the Project Site are anticipated.	No
The habitat or lifecycle of native species, including invertebrate fauna and fish species, dependent upon the wetland being seriously affected	No native species dependent on the wetland were identified during baseline assessments. Wetland 1 would only provide suitable habitat for fauna that are common and widespread in the local area and adapted to the ephemeral nature of the wetland and its drying and wetting cycles. In addition, the Project will not directly impact any wetlands within the Project Site and is highly unlikely to result in demonstratable indirect impacts to the wetland.	No
A substantial and measurable change in the hydrological regime or recharge zones of the wetland e.g. a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland	Groundwater drawdown as a result of mining operations will not affect Wetland 1. Wetland 1 is not an Aquatic GDE. Whilst Wetland 1 is a Terrestrial GDE it will not be affected by groundwater drawdown as a result of the Project as the vegetation is accessing water in a perched aquifer located at 8 mbgl, well above the underlying water table aquifer which is located at 13.5 m, and drawdown at this site is only 2.7. With reference to surface water hydrological regimes, the catchment of Wetland 1 will not be affected by mining operations.	No
An invasive species that is harmful to the environmental values of the wetland being established (or an existing invasive species being spread) in the wetland	There is no evidence of harmful invasive species detrimental to wetlands being present in the Project Site. The Project will not create mechanisms that allow for any invasive species detrimental to wetlands to become established or spread. A weed and pest management plan will be developed and implemented for the Project, and strict hygiene measures will be utilised during Project construction activities.	No

15.6.2 Groundwater Dependent Ecosystems

15.6.2.1 Subterranean GDEs

The main aspect of the Project impacting aquifer ecosystems is the dewatering required prior to and during excavation. This has the potential to remove areas of stygofauna habitat, and as the drawdown cone extends across the width of most of the alluvial water table aquifer, to isolate communities south of the mine from those in the more extensive sediments to the north. This may have a localised impact on the stygofauna community of the central Styx River alluvium, and could also reduce diversity in the southern part of the aquifer over the life of the mine, since migration pathways will be severed.

The risk assessment for impacts on stygofauna concludes that the drawdown in alluvium from aquifer dewatering is likely to result in direct disturbance to stygofauna habitat. Stygofauna will be lost from the area of impact around the mine, and communities upslope of the mine will be isolated from downstream communities. It is the lower reaches of the Styx alluvium, and areas adjacent to the main creeks where stygofauna diversity is likely to be highest. Any taxa living in the area modelled for drawdown are likely to also occur in the downstream reaches which will remain unaffected by drawdown.

Overall, impacts on stygofauna are considered to be acceptable, as they will result in the localised loss of assemblages that are likely to be well represented in adjacent areas. Extensive monitoring of GDEs including stygofauna will be undertaken as part of the adaptive management approach outlined in the GDEMMP. Stygofauna sampling will occur ahead of groundwater drawdown occurring, targeting the upper freshwater sections of aquifers. Samples will also be collected from locations outside of groundwater drawdown areas to understand stygofauna distribution patterns across the broader Styx River basin.

15.6.2.2 Aquatic GDEs

As outlined in Section 15.3.4.4, Aquatic GDEs present within the Project Area include groundwater fed pools of Tooloombah and, to a lesser extent, Deep Creek. *Melaleuca leucadendra* occurring along the riparian fringe of Tooloombah and Deep Creek, and near groundwater-fed pools, are also consistent with the definition of an Aquatic GDE. The majority of pools in Deep Creek are ephemeral, while those in Tooloombah Creek in proximity to the Project are permanent or semi-permanent. The greater prevalence of persistent pools along Tooloombah Creek when compared with Deep Creek is consistent with the findings that the alluvial sediments of Deep Creek are generally permeable and not supportive of groundwater inflows to the creek system from bank storage.

The key potential impact relevant to Aquatic GDEs as a result of the Project is groundwater drawdown through mine dewatering and depressurisation. A reduction or elimination of groundwater inputs to the creek systems during dry periods may have the resultant effect of reducing the time over which some of the pools persist, however, this depends on the level of connectivity a given pool has with groundwater, and it is known that not all pools have this connection. Changes to the water chemistry of pools is also likely to occur, resulting in a more consistent salinity profile in the absence of saline groundwater inputs, which have a more pronounced effect on pool salinity in the dry season. Pools that have a connection to groundwater can be expected to retain their freshwater chemistry <1,500 µS/cm while they persist during the dry season in the event that saline groundwater inflows are reduced or cease as a result of the Project. Each pool is likely to be affected in a different way, as a function of its size (length, width and depth), habitat features and types of fauna it supports, amount of groundwater drawdown predicted to

occur in its location, and the degree to which groundwater currently supports the pool under baseline conditions. There may also be a potential reduction of water available to *Melaleuca leucadendra* trees, which have been found to be utilising groundwater fed stream pools and fluvial sands.

Groundwater modelling has predicted a 1.5 m or more drawdown in the water table aquifer along 4.4 km of Tooloombah Creek, and 11.5 km of Deep Creek, with maximum drawdown reaching 4.7 m in Tooloombah Creek, and 60 m in Deep Creek at some locations. To assess the potential impact of groundwater drawdown on pools within Tooloombah and Deep Creek, the persistence of ToGS1, a permanent pool with known connectivity to groundwater, was modelled using a range of groundwater drawdown scenarios, including:

- continuation of existing conditions (small groundwater input of 4.5kL/day at EC 15,000 µS/cm)
- zero groundwater inflow to pool and
- leakage of surface water from the pool, at a rate of 1 L per second per km [3], which is equivalent to the enhanced leakage estimated by HydroAlgorithmics (2020) (worst case scenario).

As illustrated in Figure 15-16 and Figure 15-16, the results show that:

- Under existing conditions, the ToGS1 is perennial, containing water for 100% of the time.
- With zero groundwater inflow, the pool would continue to contain water about 96% of the time, only drying out during major drought conditions.
- With a groundwater outflow (assumed to be double the rate of the estimated current inflow), the pool would dry out more often. The pool water level would be within 0.5 m of the overflow level about 40% of the time and would be dry about 30% of the time.
- Reductions in baseflow input ToGS1 will reduce pool salinity. Under existing conditions, median pool salinity is about 3,500 µS/cm. This would drop to between 200 and 300 µS/cm for the alternative baseflow cases.

[3] The 1 L/s/km leakage was based on an assumed constant 1 m depth of water in the creek, and connectivity along the entire reach (at the assumed level of streambed conductivity). Given the ephemeral nature of the waterways, this should be assumed as an upper limit based on the modelling.

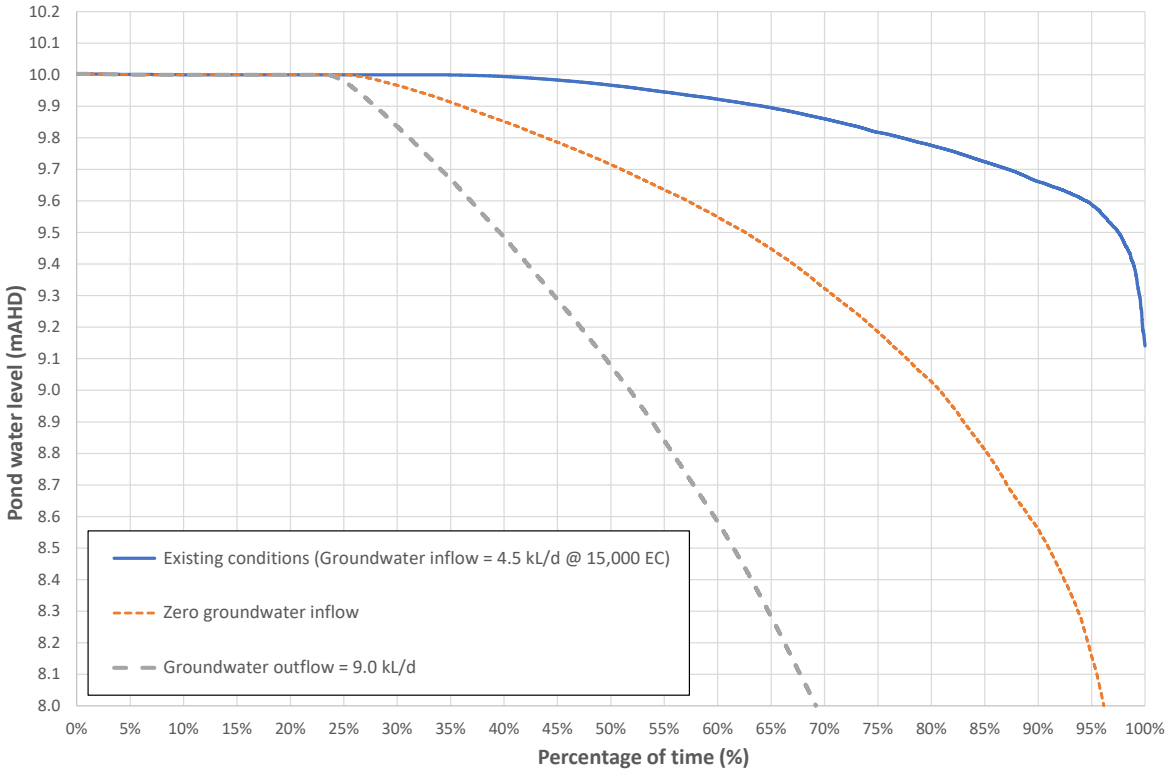

Figure 15-15: Modelled changes of ToGS1 water level

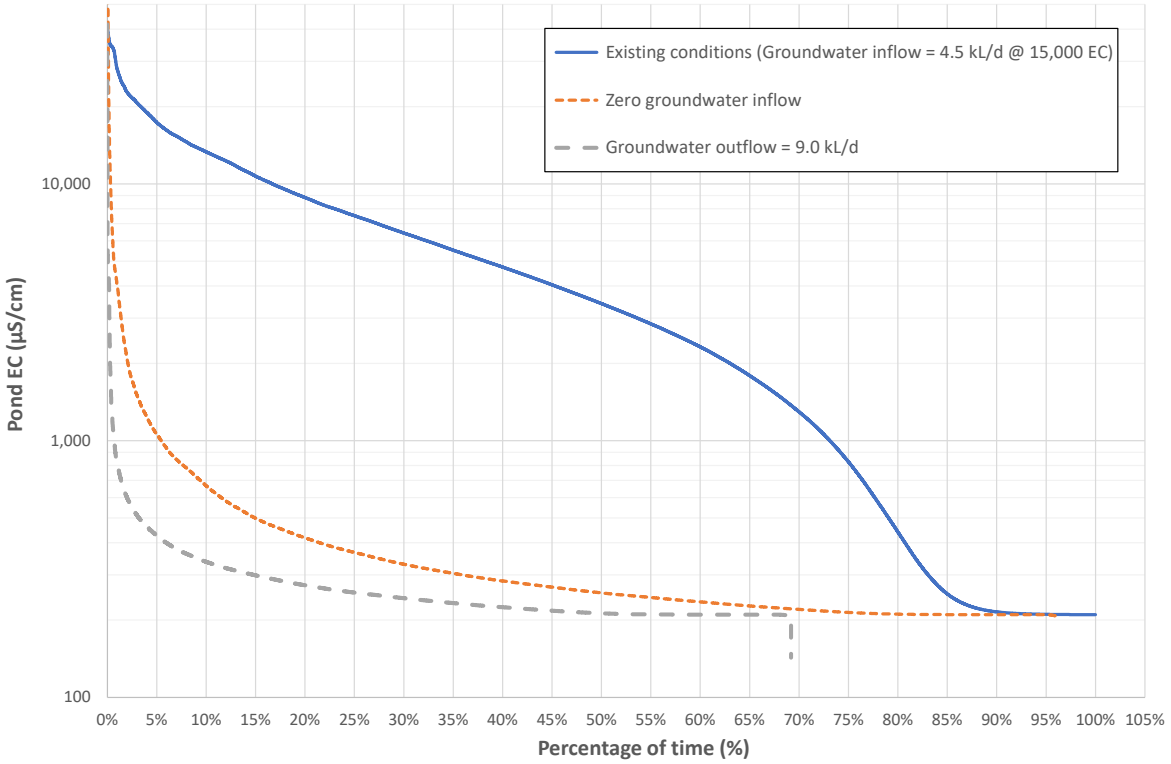

Figure 15-16: Modelled changes of ToGS1 EC

The impact assessment found that the impacts of groundwater drawdown on Aquatic GDEs is expected to be relatively minor because:

- Drawdown at Tooloombah Creek is relatively small (<4 m) and the sediments in these locations have a low permeability (reducing the potential for enhanced leakage).
- Bank storage at Tooloombah Creek is unlikely to be significantly affected by groundwater drawdown. This is because any downward movement of water held in bank storage is restricted, to some extent, by the impermeable layer of weathered clay underlying the alluvium of Tooloombah Creek. In addition, because drawdown of the water table aquifer at Tooloombah Creek is relatively small and sediments at these locations have a low permeability, the potential for enhanced leakage is reduced.
- The persistence of bank storage and associated return flows to Tooloombah Creek are likely to provide safeguards to mitigate impacts on pool persistence from drawdown of the water table underneath the creek. Flows from bank storage were predicted to reach the creek for a period of approximately 150 days.
- Permanent pools are likely to still persist throughout most of the dry season, even under the worst-case scenario, with improvements in water quality (less variation in salinity).
- Most pools at Deep Creek are ephemeral. Whilst ephemeral pools are likely to dry up more quickly and for longer than under existing conditions, especially in the middle reaches of Deep Creek, these pools experience a natural cycle of drying under existing baseline conditions, and the aquatic ecosystem is adapted to these cycles.
- Recolonisation of pools will occur naturally as it currently does under existing conditions following rainfall, once the creeks begin flowing again. Flow currently occurs approximately 24% of the time and will not be affected by the Project. In addition, aquatic fauna recorded in pools during field surveys are all common species considered typical of a Central Queensland coast catchment.
- Groundwater drawdown is not predicted to occur beneath the Styx River and therefore loss of potential baseflow from Aquatic GDEs in downstream areas is not considered to be a potential impact of the Project.

In addition, there will be minimal physical impact to Aquatic GDEs as a result of the Project. Some localised areas of disturbance will occur due to the construction of road crossings, discharge structures and other infrastructure. Such works are likely to involve the clearing of a small area of riparian vegetation, and the placement of new structures within the in-stream habitats. These works will be small in scale, with the locations generally chosen to avoid critical features of aquatic ecology value, such as groundwater fed pools. The risk of Project impacts from physical disturbance is therefore considered to be low.

15.6.2.3 Terrestrial GDEs

Based on the results of the impact assessment presented in Chapter 14 – Terrestrial Ecology, it is concluded that groundwater drawdown would result in at least a 'Possible' likelihood of there being a 'Minor' impact on vegetation within three stream reaches along Deep Creek. These impacts are considered likely to manifest through a reduction in the condition of structural elements of the vegetation communities, such as forest red gums and melaleuca species. In these areas BioCondition scores, canopy cover and canopy height could be expected to decline over time and the vegetation may no longer meet the RE description.

These impacts can be expected to commence over timeframes of 10 to 20 years after commencement of the Project. The area predicted to be affected consists of 165.23 ha of riparian

vegetation, comprising RE 11.3.25, RE 11.3.27, RE 11.3.35, and RE 11.3.4. It should be noted that in identifying potential groundwater dependent RE, only areas with a groundwater level deeper than 15 mbgl were excluded from the assessment (see complete details in Chapter 14 – Terrestrial Ecology). This approach is considered to be conservative, as known depths to water table in published sources are generally reported as a maximum of 10 m for the vegetation species present within the Project Site (IESC 2018) In addition, it was assumed that the maximum EC of groundwater that may sustain terrestrial vegetation at the site is 10,000 µS/cm. Whereas, the upper soil salinity tolerance of key vegetation species present in the Project Area is generally equivalent to an EC of 4,000 to 8,000 µS/cm (DoA 2020). Therefore, it is possible that the area to be affected may be substantially less than 165.23 ha. Vegetation with the potential to be impacted is shown in Figure 15-17.

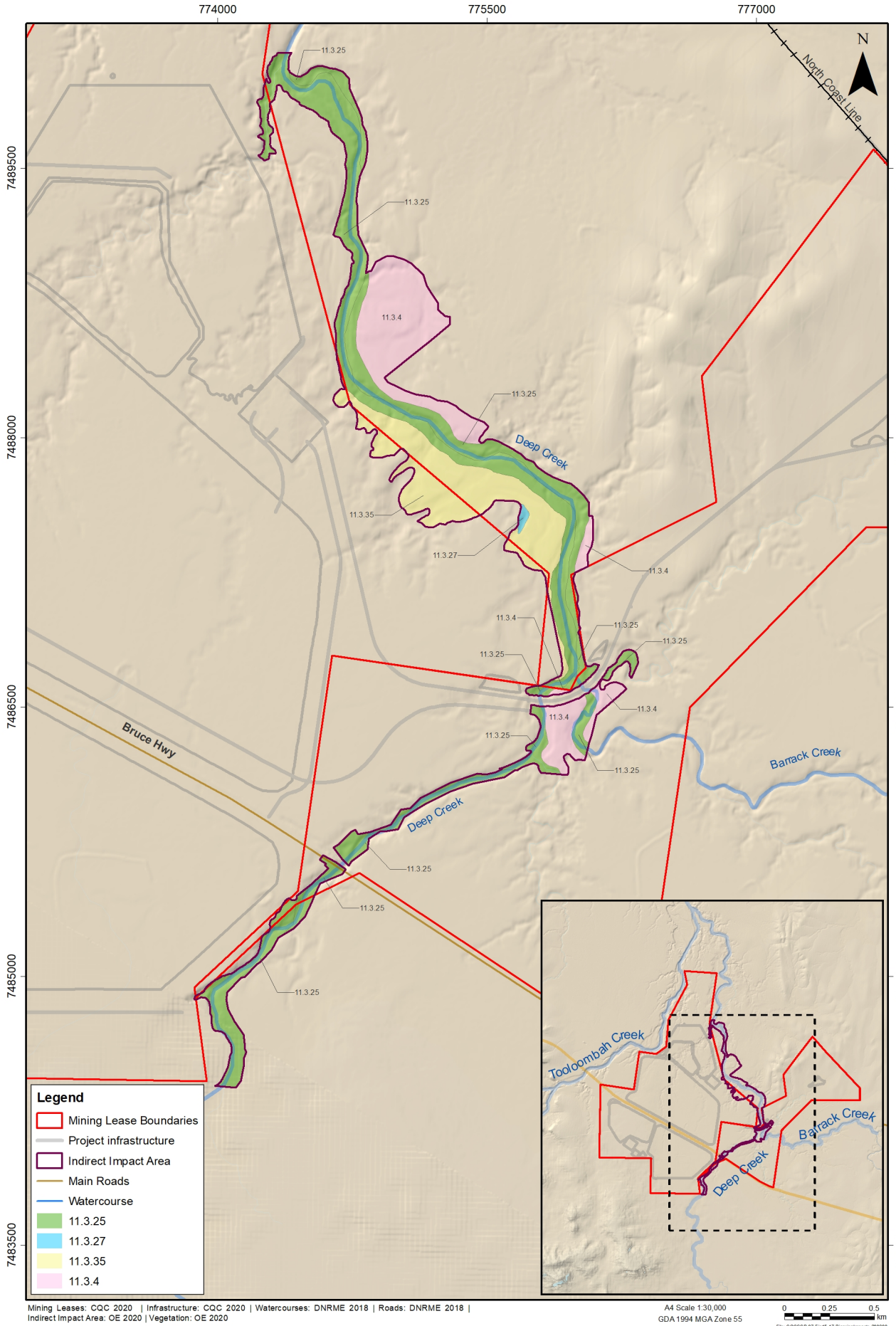

Figure 15-17: Riparian vegetation predicted to be impacted by groundwater drawdown

15.6.3 Broad Sound and the Great Barrier Reef

Broad Sound and the GBR are located approximately 10 to 11 km downstream of the Project and as such the Project will not result in direct impacts on these areas. Due the connectivity between the Project Site and downstream environment via the Styx River, the ecological values of Broad Sound and the GBR have the potential to be indirectly impacted by Project related activities including surface water changes, groundwater drawdown and erosion of stream banks. These potential impacts are discussed below. Section 15.6.3.4 also provides additional information in relation to the GBR including a description of the consistency of the Project with the activities that are allowed in each of the GBR Marine Park Zones, and an assessment of the Project against the Reef 2020 Water Quality Targets. A significant impact assessment for the Broad Sound FHA, GBRWHA, GBRCMP and the GBRMP is presented in Section 15.6.3.5.

15.6.3.1 Surface Water Changes

As described in Section 15.4.3, surface water changes as a result of the Project pose a low risk to environmental values downstream. Impacts of the Project on flow velocities in the creeks are very small and the Project is not expected to result in any major changes to the natural hydrological conditions of Tooloombah and Deep Creeks, and therefore nor to the Styx River or Broad Sound. Surface water modelling shows that there will be no substantial change to the number of no flow days in the system under a mining scenario. Flow currently occurs approximately 24% of the time and this will not be affected by the Project. The ephemeral nature of the creeks and the current flow regime will remain unchanged, and connectivity along the creek systems and into the downstream environments will not be affected. Downstream areas will continue to be primarily influenced by the tidal regime of the Styx River estuary and Broad Sound marine environment. There will be no change in the location of the freshwater – saltwater interface within surface waters of the Styx River.

Changes to surface water quality as a result of the Project present a potential risk to downstream values. This is particularly relevant in a GBR catchment, where sediment and other contaminants are known to present a significant risk to inshore biodiversity values. Increased sediment loads are a significant issue for nearshore environments within the GBR. The FBA NRM body reports that the most significant risk to the entire GBRMP is sediment (Waterhouse et al. 2015).

A number of assessments have been undertaken to consider the risks to downstream environments from changes to water quality (see Section 15.4.3). These assessments indicate that the risks to downstream environments from sediments and/or high concentrations of water quality parameters contained in controlled or uncontrolled releases from the mine are low. The sediment load assessment using average climatic conditions indicates that the Project will reduce the estimated baseline sediment generation rate of 5,037 t/year to approximately 2,297 t/year. This is primarily due to the water management and sediment and erosion control systems for the Project being designed such that sediment-laden water is captured and treated on site. Additionally, current land use practices (cattle grazing) will cease across a large area, both on the Project Site and within upstream areas, thereby also reducing existing sediment and nutrient loads to downstream waters. Based on this assessment the Project will reduce the sediment load to the downstream environment by approximately 2,740 t/year. This equates to a reduction in the total Styx Basin sediment load of 2.74 % and a reduction in the total Fitzroy Basin sediment load of 0.15%. The assessment also considered non-average, very wet, climatic conditions when sediment might be expected to mobilise more readily and found that, even under non-average wet and very wet conditions, the sediment load from the Project will be less than that of current baseline conditions. An assessment against the

Reef 2050 Water Quality Targets (see Section 15.6.3.4.2 below) indicate that the Project will result in a positive contribution through the expected reduction in sediment load reporting to Tooloombah and Deep Creek.

15.6.3.2 Erosion of Stream Banks

The geomorphology assessment concludes that while there could be isolated areas subject to somewhat higher risks of scour compared with the existing situation, the overall risk of rapid and significant geomorphic change in Tooloombah and Deep creeks and the Styx River due to the proposed mining activity is low. Impacts from the Project on hydraulic variables would be small enough that a rapid geomorphic response would not be expected. Rather, the channel will slowly adjust over the life of the mine to the altered hydraulic conditions, through minor changes in bed and floodplain levels or channel widths.

15.6.3.3 Groundwater Drawdown

Groundwater drawdown is not predicted to occur beneath the Styx River and therefore loss of potential baseflow from groundwater sources in downstream areas is not considered to be a potential impact of the Project.

Further upstream, there is the potential for loss of baseflow / enhanced leakage from reduced groundwater inflows into pools in Tooloombah Creek, and to a lesser extent Deep Creek. Loss of baseflow or enhanced leakage upstream is only relevant to downstream environments while there is connectivity between the pools and downstream areas (i.e. when the rivers have streamflow). As impacts to pools from groundwater drawdown is limited to dry periods of no flow, any impacts from groundwater drawdown are likely to be limited in extent to the particular pools that are affected in the upstream environment, rather than to larger regional areas.

As described in detail in Chapter 10, if any interface between oceanic saltwater and freshwater does exist within the groundwater in the vicinity of the Project, it will be hundreds of meters below sea level and/or beyond the extent of any drawdown influence from the Project, and would therefore not result in any movement of any interface between seawater and fresh groundwater.

Based on the application of conservative assumptions and a worst-case scenario impact assessment, groundwater drawdown is predicted to result in at least a ‘Possible’ likelihood of there being a ‘Minor’ impact on 165.23 ha of riparian vegetation associated with Deep Creek. Riparian vegetation plays a key role in stabilising banks and therefore its loss may contribute to localised instream erosion and increased sediment loads. These impacts can be expected to commence over timeframes of 10 to 20 years after commencement of the Project and are likely to manifest through a gradual reduction in the condition of structural elements of the vegetation communities. In the long term, loss of riparian vegetation may include the loss of large trees as their access to groundwater resources is diminished over time. However, it is expected that shrubs and grassy vegetation will remain. In addition, potential impacts on riparian vegetation will be mitigated through the active management of vegetation within the riparian corridor of Deep Creek, including the implementation of a revegetation program using suitable, non-groundwater dependent, vegetation. This will ensure that ecosystem processes relating to bank stability are retained, and risks of increased sedimentation in Broad Sound and the GBR through loss of riparian vegetation is low.

15.6.3.4 Additional Considerations for the Great Barrier Reef

15.6.3.4.1 Consistency with Marine Park Zoning

The Styx River portion of the GBRMP is mapped as a General Use Zone. East of the entrance of the river extending into Broad Sound, the area is zoned as Marine National Park and bordering this zone to the west is Habitat Protection Zone adjacent to Long Island. Actions occurring within the GBRMP need to be evaluated in regard to their consistency with the activities that are allowed in each of the Marine Park Zones. As the Project occurs more than 10 km upstream from the GBRMP, the Marine Park Zoning is not relevant to any actions taking place. The existing environmental values of the GBR are not expected to be impacted by the Project.

15.6.3.4.2 Net Benefit to Downstream Water Quality

The Great Barrier Reef Ministerial Forum approved the Reef 2050 Cumulative Impact Management Policy and the Net Benefit Policy on 20 July 2018. These two documents, along with the Good Practice Management for the Great Barrier Reef document, are part of a suite of guidance materials to support implementation of the Reef 2050 Plan.

Net benefit is defined in the Net Benefit Policy as an overall improvement in the condition and/or trend of a Great Barrier Reef value, or those actions which result in the net improvement (GBRMPA 2018).

The objective of the Policy is to ensure decisions and actions to reduce pressures and impacts on the GBR deliver a positive change in the condition and trend of GBR values, regardless of whether they occur within or outside the GBR, including internationally.

Decreased water quality is a significant threat to the GBR, highlighted in the Outlook Report (GBRMPA 2019); particularly for inshore areas such as Broad Sound. Sedimentation and levels of pollutants are elevated in many of these inshore areas as a result of coastal development, increased erosion and run off from agricultural practices. Although some improvement in water quality is occurring, the rate of improvement is considered to be too slow (GBRMPA 2019).

The Project has been considered in regard to the potential impact it may have on downstream values including the GBR as a result of decreased water quality via sediment run-off (erosion and ground disturbance) and increases in certain water quality parameters, that may become elevated as a result of mining, in the surrounding waterways which flow into downstream habitats. As described in the preceding sections, impacts of the Project on water quality in the downstream environment are considered to be low. Conversely, the Project is predicted to provide net benefit to water quality in the downstream areas, including the GBR, with a quantifiable reduction in the existing sediment loads to the Styx River estuary. In addition, cessation of cattle grazing would be expected to result in a reduction in nutrient loads. This is consistent with the objectives of the Reef 2050 Plan (Commonwealth of Australia 2018) which guides the overarching protection and management of the GBR.

A sediment budget has been prepared for the Project (see Appendix A15b - Styx Catchment Sediment Budget for the Great Barrier Reef) and an assessment of the Project against the Reef 2050 Water Quality Targets has been undertaken (Table 15-11). Based on this assessment the Project is consistent with the Water Quality Target of achieving at least a 20% reduction in anthropogenic end-of-catchment loads of sediment, on the way to achieving up to a 50% reduction by 2025. A reduction in cattle grazing associated with the Project and adjacent offset areas is also likely to result in reduced concentrations of nutrients in local waterways, which flow to Broad Sound and the GBR.

Table 15-11: Assessment of Reef 2050 Water Quality Targets

Water Quality Target	Assessment
At least a 20% reduction in anthropogenic end-of-catchment loads of sediment in priority areas, on the way to achieving up to a 50% reduction by 2025.	Under average climatic conditions it has been determined that the Project will result in a positive contribution to this target through the expected reduction in sediment load reporting to Tooloombah Creek and Deep Creek in comparison to baseline (current) conditions. Under average climatic conditions it was determined that the Project will result in a reduction of sediment load reporting to Tooloombah and Deep Creek of about 50%. Specifically, the operation of the proposed water storages, in addition to the destocking of the undisturbed Project Site and Mamelon offset areas, will reduce the estimated baseline sediment generation rate of 5,037 t/year to approximately 2,297 t/year. The assessment also considered non-average, very wet, climatic conditions when sediment might be expected to mobilise more readily and found that, even under non-average wet and very wet conditions, the sediment load from the Project will be less than that of current baseline conditions.

15.6.3.5 Significant Impact Assessment

Significant impact assessments are required to be undertaken for MNES and MSES which may be impacted by the Project. Significant impact assessments for the values of Broad Sound and the GBR that are classified as MNES and MSES are provided below.

15.6.3.5.1 Great Barrier Reef Coast Marine Park and Broad Sound Fish Habitat Area

Only the areas of the GBRCMP zoned Marine National Park or Conservation Park Zone are considered MSES. The entire Broad Sound FHA is also a MSES. As per the QEOP Significant Residual Impact Guidelines (DEHP 2014a), works are considered to result in a significant residual impact to a highly protected zone of a marine park or a declared FHA if:

- the works are not for a specific purpose or structure as specified in the guidelines and
- the works will result in a residual disturbance footprint within the declared FHA and/or highly protected zone of a marine park of 40 m^2 or greater in area.

The Marine National Park zone is located approximately 33 km northeast of the Project (or 40 km downstream). The Broad Sound FHA boundary is located approximately 10 km downstream of the Project Site. The Project will not have a direct impact on a highly protected zone of the GBRCMP or Broad Sound FHA as it does not involve any direct disturbance within the boundary of these areas. The Project will not result in a residual disturbance footprint of 40 m^2 or greater, and the Project will not cause a significant residual impact on these MSES.

15.6.3.5.2 Great Barrier Reef World Heritage Area and Great Barrier Reef Marine Park

The GBRWHA and the GBRMP are MNES. As outlined in the MNES Significant Impact Guidelines 1.1 (DE 2013) an action is likely to have a significant impact on the World Heritage values of a declared World Heritage property if there is a real chance or possibility that it will cause:

- one or more of the World Heritage values to be lost
- one or more of the World Heritage values to be degraded or damaged or
- one or more of the World Heritage values to be notably altered, modified, obscured or diminished.

An assessment of the Project has been undertaken against the significant impact criteria applicable to the GBRWHA, and considering advice provided in EPBC Act referral guidelines for the Outstanding Universal Value of the Great Barrier Reef World Heritage Area (DE 2014). This assessment is presented in Table 15-12. The GBR is also a National Heritage place. National Heritage values of the GBR are the same values attributable to the GBRWHA. Therefore, the impacts on the GBR National Heritage Place are also assessed in Table 15-12 through the assessment of the GBRWHA. The application of the Significant Impact Guidelines, consideration of the referral guidelines and the impact assessment presented in the preceding sections demonstrates that the Project will not result in a significant impact on the GBRWHA or the National Heritage Place.

Significant impacts on the GBRMP are also assessed through the application of the MNES Significant Impact Guidelines 1.1 (DE 2013). Assessment against the applicable criteria is provided in Table 15-13. The Project is not expected to result in a significant impact to the GBRMP.

Table 15-12: Significant impact assessment - Great Barrier Reef World Heritage Area

Values	Significant impact considerations	Response	Significant impact?
Criteria from EPBC Act Significant Impact Guidelines 1.1 (DE 2013)			
Values associated with geology or landscape	An action is likely to have a significant impact on natural heritage values of a World Heritage property if there is a real chance or possibility that the action will: • damage, modify, alter or obscure important geological formations in a World Heritage property • damage, modify, alter or obscure landforms or landscape features, for example, by excavation or infilling of the land surface in a World Heritage property • modify, alter or inhibit landscape processes, for example, by accelerating or increasing susceptibility to erosion, or stabilising mobile landforms, such as sand dunes, in a World Heritage property • divert, impound or channelise a river, wetland or other water body in a World Heritage property and • substantially increase concentrations of suspended sediment, nutrients, heavy metals, hydrocarbons, or other pollutants or substances in a river, wetland or water body in a World Heritage property.	As the Project does not occur directly within the GBRWHA, it will not: • damage, modify, alter or obscure important geological formations • damage, modify, alter or obscure landforms or landscape features, for example, by excavation or infilling of the land surface and • modify, alter or inhibit landscape processes, for example, by accelerating or increasing susceptibility to erosion, or stabilising mobile landforms, such as sand dunes in the GBRWHA. The Project will not divert, impound or channelise a river, wetland or other water in the GBRWHA. If not managed properly, the Project has the potential to increase concentrations of suspended sediment and other contaminants in the GBRWHA via inputs from the mine site and adjacent areas flowing from Deep and Tooloombah Creeks. However, these inputs will be managed in such a way as to ensure sediment and contaminant loads remain within acceptable levels at all times. In particular, with the implementation of the site water management system and release conditions that have been devised for the Project, the overall sediment budget for the Project is expected to decrease sediment inputs from the catchment into the downstream GBR, thereby delivering a net benefit from the Project. If water is required to be released, any releases will be appropriately managed and timed to coincide with high flow events. Assessment of the potential impacts of controlled and uncontrolled releases on downstream water quality has demonstrated that, under release scenarios, the water quality of the receiving environment will be well within the range of the typical historical receiving water concentrations for each element examined (see Section 15.4.3.1)15.4.3. As such there will be no impacts on water quality in the downstream environment as a result of water discharges.	No

Values	Significant impact considerations	Response	Significant impact?
Biological and ecological values	An action is likely to have a significant impact on natural heritage values of a World Heritage property if there is a real chance or possibility that the action will: • reduce the diversity or modify the composition of plant and animal species in all or part of a World Heritage property • fragment, isolate or substantially damage habitat important for the conservation of biological diversity in a World Heritage property • cause a long-term reduction in rare, endemic or unique plant or animal populations or species in a World Heritage property and • fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in a World Heritage property.	As discussed in preceding sections of this chapter, as well as Chapter 14 and 16, there are a number of biological and ecological values present in the downstream environment, including threatened and migratory species and marine plant communities. Of particular note are the aggregations of migratory shorebirds within the nearshore environments of Broad Sound (see Chapter 14), which are considered important in both a national and international context. Importantly, there will be no direct impacts to these ecological values from the Project. There is potential for these values to be indirectly impacted by the Project, via potential reductions in water quality, which may in turn reduce habitat values. However, as described above, with erosion and sediment controls, the mine site water management system and water release operating rules in place (see Section 15.4.3.1)15.4.3, the potential for impact to downstream habitats and species within the GBRWHA is considered very low.	No
Wilderness, natural beauty or rare or unique environment values	An action is likely to have a significant impact on natural heritage values of a World Heritage property if there is a real chance or possibility that the action will: • involve construction of buildings, roads, or other structures, vegetation clearance, or other actions with substantial, long-term or permanent impacts on relevant values • introduce noise, odours, pollutants or other intrusive elements with substantial, long-term or permanent impacts on relevant values	As the Project is located approximately 10 km upstream of the GBRWHA and does not involve works directly within the GBRWHA, construction works will not result in any significant impact to the values of the GBRWHA. Nor will there be any effects of noise or odours. The key potential risk of the Project to the GBRWHA is increasing concentrations of suspended sediment and other contaminants in the GBRWHA via inputs from the mine site and adjacent areas flowing from Deep and Tooloombah Creeks. However, this is unlikely to occur as these inputs will be managed in a such as way as to ensure sediment and water quality parameter loads remain within acceptable levels at all times. If water is required to be released, any releases will be appropriately managed and timed to coincide with high flow events. Water quality analysis shows metals, sulphate and EC will be well within the range of the typical historical	No

Values	Significant impact considerations	Response	Significant impact?
		receiving water concentrations for each element examined. As such there will be no impacts on water quality in the downstream environment as a result of water discharges. Importantly, the overall sediment budget for the Project is expected to decrease sediment inputs from the catchment into the GBR, thereby delivering a net benefit from the Project.	
Criteria from EPBC Act referral guidelines for the *Outstanding Universal Value of the Great Barrier Reef World Heritage Area*			
Attributes	Will the proposed action of itself, or in combination with other relevant impacts, result in loss or degradation of areas that are essential for maintaining the beauty of the property? Will the proposed action of itself, or in combination with other relevant impacts, impact on the key interrelated and interdependent elements in their natural relationships? Will the proposed action of itself, or in combination with other relevant impacts, result in the loss of necessary elements that are essential for the long-term conservation of the area's ecosystems and biodiversity? Will the proposed action of itself, or in combination with other relevant impacts, result in the loss or degradation of habitats required for maintaining the diverse fauna and flora of the region?	The nearshore areas of the GBRWHA that are downstream of the Project do not include areas that are essential for maintaining the beauty of the property. However, there are a number of important ecological features. Importantly, there will be no direct impacts to these ecological values from the Project given the Project is located at least 10 km upstream. However, they do have the potential to be indirectly impacted by the Project, via reductions in water quality, which could, in turn, reduce habitat values. However, erosion and sediment controls will be in place, as well as a mine site water management system and water release operating rules which have been designed to ensure that quality of water releases are within acceptable levels (see Section 15.4.3.1)15.4.3. As such, the risk of indirect impacts resulting from reduced water quality occurring is considered low, and alterations to habitat or population level impacts to values are highly unlikely.	No
Wholeness	Will the proposed action of itself, or in combination with other relevant impacts, result in the loss of any elements necessary for the property to express its Outstanding Universal Value?	The Project will not result in the loss of any elements, features or processes necessary for the GBRWHA to express its OUV, nor will there be any reductions in size or boundaries of the property.	No

Values	Significant impact considerations	Response	Significant impact?
	Will the proposed action of itself, or in combination with other relevant impacts, reduce the size or change the boundary of the property? Will the proposed action of itself, or in combination with other relevant impacts, impact on any of the features and processes that convey its Outstanding Universal Value?		
Intactness	Will the proposed action of itself, or in combination with other relevant impacts, result in a 'greenfield' development or the fragmentation, loss and/or degradation of any ecological, physical or chemical processes or of the key features, processes and attributes of the property that express its Outstanding Universal Value? Will the proposed action of itself, or in combination with other relevant impacts, impact on the key interrelated and interdependent attributes or their natural relationships within the property?	The Project is located outside of the GBRWHA and will not result in a 'greenfield' development or fragmentation of key features of the property. Water quality is a key attribute that underpins the overall health of the GBRWHA and therefore requires consideration in terms of interrelatedness and interdependence of natural values. The Project has the potential to increase concentrations of suspended sediment and other water quality parameters in the GBRWHA via inputs from the mine site and adjacent areas flowing from Deep and Tooloombah Creeks. However, erosion and sediment controls will be in place, along with a mine site water management system and water release operating rules (see Section 15.4.3.1). These15.4.3 will ensure that sediment and water quality parameter loads within water releases from the site will remain within acceptable levels at all times.. This will ensure the intactness of the GBRWHA is not affected by the Project.	No
Threats	Will the proposed action of itself, or in combination with other relevant impacts, result in increased adverse effects of development, neglect or any other degrading process? Will the proposed action of itself, or in combination with other relevant impacts, result in an increase in processes that may cause deterioration?	Increased sediment and water quality parameter loads are a significant issue for nearshore environments within the GBRWHA. In the context of the Project, additional sediment/water quality parameters may enter the marine environment either as a result of increased instream erosion and/or directly within mine site runoff and discharges. Therefore, without the appropriate management regimes in place, there is a risk the Project will exacerbate threats to the GBRWHA. However, the erosion and sediment controls, as well as the mine site water management system and water release operating rules (see Section 15.4.3.1)15.4.3 will ensure that sediment and water quality parameter loads within water releases from the site will remain within acceptable levels at all	No

Values	Significant impact considerations	Response	Significant impact?
		times. In particular, in an average year, the overall sediment budget for the Project is expected to decrease sediment discharges from the catchment into the downstream GBR by approximately 50% , thereby delivering a net benefit from the Project.	

Table 15-13: Significant impact assessment - Great Barrier Reef Marine Park

Significant impact criteria	Response	Significant impact?
An action is likely to have a significant impact on the environment of the Great Barrier Reef Marine Park if there is a real chance or possibility that the action will: • Modify, destroy, fragment, isolate or disturb an important, substantial, sensitive or vulnerable area of habitat or ecosystem component such that an adverse impact on marine ecosystem health, functioning or integrity in the Great Barrier Reef Marine Park results.	The nearshore areas of the GBRMP that are downstream of the Project include areas that contain important ecological features and sensitive environments e.g. migratory shorebird roosting areas. Importantly, there will be no direct impacts to these ecologically sensitive areas from the Project. However, these areas do have the potential to be indirectly impacted by the Project, via potential reductions in water quality, which may in turn reduce habitat values and/or ecosystem health. However, erosion and sediment controls will be in place, and a mine site water management system and water release operating rules have been designed to ensure that the quality of water releases are within acceptable levels (see Section 15.4.3.1)15.4.3. As such, the risk of indirect impacts to habitats or components of the ecosystem that would affect health, functioning or integrity in the Great Barrier Reef Marine Park is considered low.	No
An action is likely to have a significant impact on the environment of the Great Barrier Reef Marine Park if there is a real chance or possibility that the action will: • Have a substantial adverse effect on a population of a species or cetacean including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution.	A number of species are known to occur within the area downstream of the Project, including migratory shorebirds, inshore dolphins, humpback whale and marine turtles. Of these species, migratory shorebirds have the most extensive habitat and undertake key lifecycle activities (i.e., overwintering and building condition for the northern migration). Other species are less common and generally only utilise the areas close to the Styx River estuary for foraging. Importantly, there will be no direct impacts to these species from the Project (see chapter 14 and 16 for impact assessment for migratory birds). However, these species do have the potential to be indirectly impacted by the Project, primarily via potential reductions in water quality, which may in turn reduce habitat values and/or ecosystem health. However, erosion and sediment controls will be in place, and a mine site water management system and water release operating rules have been designed to ensure that the quality of water releases are within acceptable levels (see Section 15.4.3.1)15.4.3. As such, the risk of these impacts occurring is considered low and alterations to habitat or population level impacts to species are highly unlikely.	No

Significant impact criteria	Response	Significant impact?
An action is likely to have a significant impact on the environment of the Great Barrier Reef Marine Park if there is a real chance or possibility that the action will: • Result in a substantial change in air quality or water quality (including temperature) which may adversely impact on biodiversity, ecological health or integrity or social amenity or human health.	The Project's impact assessment has considered the dust deposition rates on a number of sensitive aquatic receptors (see Section 15.6.1.4 and Chapter 12 – Air Quality). The maximum predicted dust deposition rates for each of the sensitive aquatic receptors were all below the relevant air quality criteria. Given the distance of the GBRMP from the Project Site, the implementation of the erosion and sediment control plan and the relatively minor extent of the modelled impacts as described above, there is a negligible risk that coal dust deposition from Project activities would impact downstream marine habitats, including those associated with the GBR. Increased sediment and water quality parameter loads are a significant issue for nearshore environments within the GBRMP. In the context of the Project, without the appropriate controls, additional sediment/water quality parameters could enter the marine environment either as a result of increased instream erosion and/or directly within mine site runoff and discharges. This may in turn, adversely impact biodiversity, ecological health or integrity or social amenity or human health. However, a mine site water management system and water release operating rules have been designed to ensure that the quality of water releases are within acceptable levels (see Section 15.4.3.1)15.4.3. Erosion and sediment controls are also specified the Project ESCP (see Appendix 15a). As such inputs will be managed in a such as way as to ensure sediment and water quality parameter loads remain within acceptable levels at all times. In particular, the overall sediment budget for the Project is expected to decrease sediment discharges from the catchment into the downstream GBR by approximately 50% (Engeny 2020b – Appendix 15b), thereby delivering a net benefit from the Project.	No
An action is likely to have a significant impact on the environment of the Great Barrier Reef Marine Park if there is a real chance or possibility that the action will: • Result in a known or potential pest species being introduced or becoming established in the Great Barrier Reef Marine Park.	The GBRMP is greater than 10 km downstream from the Project. The estuarine and intertidal areas in this region are substantially different to the upstream habitat within and immediately surrounding the Project Site. The Project Site is highly modified (largely due to grazing of cattle) and weeds are commonly observed along the watercourses such as Deep Creek and Tooloombah Creek. Pest species present in the Project Site include feral pigs, cane toads, rabbits and cats. Given the differences in environment between the Project Site and nearshore GBRMP, many of the threats from weeds and pests are not relevant in the downstream areas. For those species that may be present in nearshore areas (e.g. feral pigs), local populations are likely already established and the presence of the Project will not increase the number or extent of individuals. The Project will not result in the introduction or establishment of a pest species in the GBRMP.	No

Significant impact criteria	Response	Significant impact?
An action is likely to have a significant impact on the environment of the Great Barrier Reef Marine Park if there is a real chance or possibility that the action will: • Result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, or social amenity or human health may be adversely affected.	If not managed properly, there is the potential for elevated concentrations of water quality parameters to enter the marine environment via mine site runoff and discharges of mine affected water, with both sources being potentially elevated in chemicals and heavy metals. This could, in turn, adversely impact biodiversity, ecological health or integrity or social amenity or human health. However, erosion and sediment controls will be in place, and a mine site water management system and water release operating rules have been designed to ensure that water quality parameter loads remain within acceptable levels at all times (see Section 15.4.3) Under the proposed release conditions, downstream water quality is expected to be within the range of natural variability, and hence is not expected to cause adverse impacts to the downstream environment. A number of mitigation and management measures will be in place to collect water with high concentrations of parameters from the Project, divert clean water around the site and reduce the likelihood of run-off containing high concentrations of parameters. Water with high concentrations of parameters will be stored on site in dams and will only be released if water quality release limits are met and at an appropriate time to allow dilution into the natural flows. Discharge of water will be controlled to reduce the likelihood of non-compliant discharges from overtopping. Any increase in the concentration of water quality parameters in the waterways as a result of discharge will be very short-lived and substantially diluted and will therefore be unlikely to result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment. Uncontrolled discharges are only expected during times of heavy rainfall, when there is also likely to be significant dilution of any water quality parameters at high concentrations. With these control measures in place, there is not considered to be a real chance or possibility that the action will result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, or social amenity or human health may be adversely affected.	No
An action is likely to have a significant impact on the environment of the Great Barrier Reef Marine Park if there is a real chance or possibility that the action will: • Have a substantial adverse impact on heritage values of the Great Barrier Reef Marine Park, including damage or destruction of an historic shipwreck.	The Project does not occur directly within the GBRMP and therefore any heritage values within the GBRMP such as Commonwealth heritage places, lighthouses or shipwrecks will not be directly or indirectly impacted by the Project.	No

15.6.4 Aquatic and Marine Flora

The protected marine plants, marine couch, as well as saltmarsh and mangrove species, have been recorded in the downstream environment, along the margins of the Styx River and in Broad Sound. Given the distance between the Project activities and the downstream environment, the Project will not result in direct disturbance to downstream values including aquatic and marine flora. However, due to the connectivity between the Project Site and downstream environment via the Styx River, aquatic and marine flora have the potential to be indirectly impacted by Project related activities including surface water changes, groundwater drawdown and erosion of stream banks.

The risk of indirect impact on aquatic and marine flora in the downstream environment is considered to be low. The Project will not impact water quality in the downstream environment. The ephemeral nature of the creeks and the current flow regime will remain unchanged, and connectivity along the creek systems and into the downstream environments will not be affected. There will be no substantial change to the number of no flow days in the system under a mining scenario. Downstream areas will continue to be primarily influenced by the tidal regime of the Styx River estuary and Broad Sound marine environment. There will be no change in the location of the freshwater – saltwater interface within surface waters of the Styx River. Groundwater drawdown is not predicted to occur beneath the Styx River and therefore loss of potential baseflow from groundwater sources in downstream areas is not considered to be a potential impact of the Project. In addition, the overall risk of rapid and significant geomorphic change in Tooloombah and Deep creeks and the Styx River due to the proposed mining activity is low.

15.6.4.1 Significant Impact Assessment

A significant impact assessment for impacts on marine plants has been undertaken in accordance with the QEOP Significant Residual Impact Guidelines (DEHP 2014a). The results of the assessment, as presented in Table 15-14, conclude that the Project will not result in a significant impact on marine plants in the downstream environment.

Table 15-14: Significant impact assessment – marine plants

Significant impact criteria	Response	Significant Impact?
Result in private infrastructure works impacting more than 17 m^2 of fish habitat or public infrastructure works impacting more than 25 m^2 of fish habitat; and	• Marine couch was identified along the edge of the Styx River approximately 2.5 km downstream of the Project. These sparse occurrences most likely represent the peak tide limit associated with king tides and storm surges. Marine couch was most abundant along the banks of the Styx River from approximately 4 km downstream of the Project, which is considered to represents the normal high tide limit. Extensive stands of saltmarsh and mangrove species occur downstream of the Project (14 km and 21 km downstream respectively) along the margins of the Styx River and Broad Sound. • The Project will not result in a direct impact on marine plants located in the downstream environment. • Indirect impacts to the receiving environment (incl. marine plants) are considered unlikely given the proposed erosion and sediment controls, mine site water management system and the water release operating rules, which have been designed to protect downstream waters (see Section 15.4.3.1).	No

Significant impact criteria	Response	Significant Impact?
Temporary impacts are expected to take 5 years or more for the impact area to be restored to its predevelopment condition; or	• Temporary impacts from the Project associated with construction of infrastructure will not result in any disturbance to marine plants. Works in aquatic environments will occur in the dry season, during no flow periods so will not impact upon downstream environments where marine plants are present. Temporary impacts will cease after the construction period.	No
A proposed reduction in the extent of marine plants through removal, destruction or damage of marine plants; or	• Marine Couch was identified downstream of the Project boundary, however this will not be directly impacted by the project. • Indirect impacts to the receiving environment (incl. marine plants) are considered unlikely given the proposed erosion and sediment controls, mine site water management system and the water release operating rules, which have been designed to protect downstream waters (see Section 15.4.3.1). As such, there will be no reduction in the extent of marine plants through removal, destruction or damage of marine plants as a result of the Project.	No
Fragmentation or increased fragmentation of a marine ecological community; or	• There are no marine ecological communities located in the direct disturbance footprint of the Project. Important marine ecological communities are associated with the Styx River, Broad Sound FHA and GBR, all located downstream of the Project. • Indirect impacts to the receiving environment (incl. marine plants) are considered unlikely given the proposed erosion and sediment controls, mine site water management system and the water release operating rules, which have been designed to protect downstream waters (see Section 15.4.3.1). As such, fragmentation or increased fragmentation of a marine ecological community as a result of the Project is considered highly unlikely.	No
Adverse changes affecting survival of marine plants through modifying or destroying abiotic (non-living) factors (such as water, nutrients, or soil) necessary for a marine plant's survival; or	• The Project has the potential to impact on marine plants located downstream of the Project through changes in in water quality (including increases in sedimentation). • However, such indirect impacts to the receiving environment (incl. marine plants) are considered unlikely given the proposed erosion and sediment controls, mine site water management system and the water release operating rules, which have been designed to protect downstream waters (see Section 15.4.3.1). Therefore, the Project is considered highly unlikely to create adverse changes to abiotic factors that would affect the survival of marine plants.	No
Alteration in the species composition of marine plants in an ecological community, that causes a decline or loss of functionally important species; or	• There are no marine ecological communities located in the direct disturbance footprint of the Project. Important marine ecological communities are associated with the Styx River, Broad Sound and GBR, all located downstream of the Project. • Indirect impacts to the receiving environment (incl. marine plants) are considered unlikely given the proposed erosion and sediment controls, mine site water management system and the water release operating rules, which have been designed to protect downstream waters (see Section 15.4.3.1). As such, the	No

Significant impact criteria	Response	Significant Impact?
	Project will not lead to any alteration in the species composition of marine plants in an ecological community, that causes a decline or loss of functionally important species.	
Interference with the natural recovery of marine plant communities	• The Project has the potential to impact on marine plants located downstream of the Project Site through changes in in water quality (including increases in sedimentation). • However, such indirect impacts to the receiving environment (incl. marine plants) are considered unlikely given the proposed erosion and sediment controls, mine site water management system and the water release operating rules, which have been designed to protect downstream waters (see Section 15.4.3.1). Given this, it is considered highly unlikely that the Project would lead to any changes to the marine environment that would interfere with the natural recovery of marine plant communities.	No

15.6.5 Aquatic and Marine Fauna

The assessment presented in Section 15.3.9 concludes that there are seven conservation significant species which are known or likely to occur in the waterways surrounding the Project Site and/or the downstream environments of the Styx River estuary and Broad Sound. These are the estuarine crocodile, green turtle, flatback turtle, Australian hump-back dolphin, Australian snubfin dolphin, dugong and humpback whale. With the exception of the estuarine crocodile, these species are not expected to occur close to the Project due to the very low water levels in the Styx River during the low tidal phase, the ephemeral nature of the creeks and the general lack of suitable habitat present. A range of native and common fish and turtles also utilise the waterways surrounding the Project. These species have the potential to be directly impacted by the Project through disturbance or removal of habitat for the establishment of Project infrastructure. Habitat may also be indirectly impacted as a result of surface water changes, erosion of stream banks, groundwater drawdown or the increased prevalence of dust, weeds and pests.

15.6.5.1 Establishment of Project Infrastructure

There will be no direct disturbance of habitat for species located in the downstream environment. In addition, the Project footprint does not intersect any natural freshwater wetlands and consequently direct impacts on these wetlands and their aquatic ecology values are not anticipated. However, establishment of critical Project infrastructure will result in direct impacts to a number of waterways and riparian vegetation within the Project Site.

Both Deep and Tooloombah Creek are mapped as major risk waterways for barriers to fish passage. A number of smaller waterways are present within the Project Site and are mapped as low to moderate risk. Only one small section of waterway is mapped as high risk within the Project Site. Two unnamed tributaries of Deep Creek mapped as moderate and low risk waterways for fish passage will be permanently removed through the establishment of Dam 1 and the mine pits, resulting in the permanent loss of aquatic habitat and riparian vegetation[4] (Figure 15-5). Minor impacts will also occur to two low risk tributaries of Tooloombah Creek. Although these waterways are highly degraded and ephemeral and provide minimal value to aquatic species, their removal

[4] Impacts on remnant vegetation are addressed in Chapter 14 – Terrestrial Ecology

will reduce the potential for fish passage across 8.35 km of floodplain on the Project Site. Assuming an average stream width of 10 m, impacts to these waterways will result in the removal of 8.35 ha of waterway providing fish passage.

The haul road will cross Deep and Barrack Creek. Deep Creek is likely to be used for fish passage when flows occur. Barrack Creek is largely an ephemeral waterbody with highly intermittent flows. The works for the haul road will be undertaken in accordance with the DAF guidelines - Accepted development requirements for operational work that is constructing or raising waterway barrier works. With appropriate crossing design, including culverts, no barriers to fish passage are anticipated at these crossing points. Small areas of riparian vegetation will also be directly impacted through the construction of the haul road crossing[5] Riparian vegetation provides important ecological functions for aquatic ecosystems, such as providing shade to waterways which regulates temperature and enhancing bank stability. The small extent of watercourse vegetation[6]to be cleared (12.36 ha), limits the potential for significant impacts to aquatic ecology values to localised areas. Impacts on riparian vegetation are addressed in Chapter 14 – Terrestrial Ecology.

Impacts related to the mortality of aquatic wildlife from construction activities are expected to be minor. Construction works will be completed in the dry season, when in-stream aquatic ecology values are generally not present or are limited in geographic scale and abundance. Where required, spotter catchers will be present during all clearing activities and clearing procedures will be developed to relocate native wildlife to adjacent areas and rehabilitate any injured wildlife, noting that works will be undertaken in the dry season.

15.6.5.2 Surface Water Changes

The magnitude of Project-related change to the existing hydrological regime is minor and not expected to impact aquatic and marine fauna. As described in Section 15.4.3.1, under the proposed release conditions, downstream water quality is expected to be within the range of natural variability, and hence is not expected to cause adverse impacts to the downstream environment. In addition, the Project is not expected to result in any major changes to the natural hydrological conditions of Tooloombah and Deep Creeks, and therefore to the Styx River.

While some runoff within the creek catchments will be captured and retained on site within the mine footprint, the amount of water involved is minimal compared with that entering the creeks as runoff from the broader catchment during rain events. Surface water modelling shows that there will be no substantial change to the number of no flow days in the system under a mining scenario. Therefore, the ephemeral nature of the creeks and the current flow regime will remain unchanged, and connectivity along the creek systems and into the downstream environments will not be affected. Downstream areas will continue to be primarily influenced by the tidal regime of the Styx River estuary and Broad Sound marine environment. There will be no change in the location of the freshwater – saltwater interface within surface waters of the Styx River.

Risks associated with the erosion of stream banks will be managed through the engineering design of diversion channels, drains and spillways, and through minimising the disturbance to riparian vegetation. The removal of cattle grazing from large parts of the Project Site and adjacent offset areas will also assist in stabilising stream banks. In addition, the geomorphology assessment

[5] Impacts on remnant vegetation are addressed in Chapter 14 – Terrestrial Ecology
[6] Impacts on remnant vegetation are addressed in Chapter 14 – Terrestrial Ecology

concludes that while there could be isolated areas subject to somewhat higher risks of scour compared with the existing situation, the overall risk of rapid and significant geomorphic change in Tooloombah and Deep creeks and the Styx River due to the proposed mining activity is low.

Under average climatic conditions the Project will reduce the estimated baseline sediment generation rate of 5,037 t/year to approximately 2,297 t/year. Based on this assessment the Project will reduce the sediment load to the downstream environment by approximately 2,740 t/year. This equates to a reduction in the total Styx Basin sediment load of 2.74 % and a reduction in the total Fitzroy Basin sediment load of 0.15%. The assessment also considered non-average, very wet, climatic conditions when sediment might be expected to mobilise more readily and found that, even under non-average wet and very wet conditions, the sediment load from the Project will be less than that of current baseline conditions. An assessment against the Reef 2050 Water Quality Targets indicates that the Project will result in a positive contribution through the expected reduction in sediment load reporting to Tooloombah and Deep Creek.

15.6.5.3 Groundwater Drawdown

Groundwater drawdown is not predicted to occur beneath the Styx River and therefore loss of potential baseflow from groundwater sources in downstream areas is not considered to be a potential impact of the Project.

Groundwater drawdown will result in reduced groundwater inputs to some sections of Tooloombah and Deep Creek during the dry season. Pools along Tooloombah Creek, and to a lesser extent Deep Creek, may be affected by groundwater drawdown, drying up faster than they currently do in areas where groundwater inputs are reduced. Changes to water chemistry within pools is also likely to occur where the influence of saline groundwater inputs is reduced. Water quality within these pools is likely to be less salty over the dry season.

However, permanent pools are still likely to persist throughout most of the dry season, even under the worst-case scenario, with improvements in water quality (less variation in salinity). Whilst ephemeral pools are likely to dry up more quickly and for longer than under existing conditions, especially in the middle reaches of Deep Creek, these pools experience a natural cycle of drying under existing baseline conditions. The aquatic ecosystem is adapted to these cycles and most biota in these pools are adapted to living in ephemeral streams, reducing the risk of significant environmental impacts. In addition, recolonisation of pools will occur naturally as it currently does under existing conditions following rainfall, once the creeks begin flowing again. Flow currently occurs approximately 24% of the time and will not be affected by groundwater drawdown. The Styx River will remain an important source for recolonisation of ephemeral creeks located upstream during periods of flow and connectivity.

Potential impacts on riparian vegetation as a result of groundwater drawdown will be mitigated through the active management of vegetation within the riparian corridor of Deep Creek, including the implementation of a revegetation program. This will ensure that ecosystem processes relating to bank stability are retained, and risks of increased sedimentation in the downstream environments are low. See Chapter 14 – Terrestrial Ecology for more detailed discussion on the potential impacts of groundwater drawdown on riparian vegetation.

15.6.5.4 Dust, Weeds and Pests

As described in Section 15.4.7, impacts from dust on the aquatic and marine environment are considered to be minor. There is negligible potential for introduction of aquatic pest animals as a

result of construction or operation of the Project. Whilst there is potential for introduction and spread of weed species as a result of the Project, it is considered unlikely that the Project would contribute to a significant further change to existing threats given the current prevalence of weeds in the area and the land use history for the Project Site and surrounding area.

15.6.5.5 Significant Impact Assessments

15.6.5.5.1 Impacts on Fish Passage

Waterways providing fish passage are MSES and require consideration and assessment against the QEOP Significant Residual Impact Guidelines (DEHP 2014a). As described in the preceding sections impacts on fish passage will occur as a result of the establishment of critical Project infrastructure with direct impacts via the removal of 8.35 ha of waterway providing fish passage across the floodplain within the Project site. In terms of indirect impacts, a significant decrease in groundwater inputs or surface water runoff to waterways can reduce water levels and flows, impeding fish passage. However, changes to existing hydrology of the creeks are expected to be relatively minor, and similar to the variability that occurs from year to year under current conditions. As such, fish passage will not be impacted as a result of surface water changes or groundwater drawdown.

Responses to the significant residual impact criteria for waterways providing fish passage are provided in Table 15-15. Based on this assessment, the Project is expected to result in a significant residual impact to 8.35 ha of waterways providing fish passage.

Table 15-15: Significant impact assessment – waterways providing fish passage

Significant impact criteria	Response	Significant impact?
Result in mortality or injury of fish	A number of the waterways within the Project Site are ephemeral and highly modified, and while still meeting the definition of fish passage, are highly unlikely to regularly provide such function. This is particularly applicable for the waterways located within the footprint of the mine pits. However, in order to ensure there is no mortality or injury to fish construction will occur during the dry season when there is no water in the waterways to reduce the potential for injury or mortality to any species that may utilise Deep Creek during the wet season.	No
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	The waterways within the Project Site are ephemeral, highly modified and are unlikely to be regularly used by fish as a means of passage. The haul road will cross Deep and Barrack Creek and create waterway barriers, however, these will be designed to facilitate fish passage and to minimise the chances of entrapment and stranding. There is no evidence to suggest that the Project would increase predation risks for fish species.	No
Reduce the extent, frequency or duration of	The construction of critical Project infrastructure, including mine pits and dams, will occur directly over waterways mapped	Yes

Significant impact criteria	Response	Significant impact?
fish passage previously found at a site	as providing fish passage. Consequently, the extent of fish passage will be reduced.	
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	Construction of Project infrastructure will occur directly over waterways mapped as providing fish passage. However, these waterways are ephemeral, highly modified and consequently are unlikely to provide habitat necessary for the breeding and survival of fish. The waterway barriers associated with the haul road over Deep Creek and Barrack Creek will be designed and constructed to avoid significantly altering instream habitat and will not result in a reduction in fish passage.	No
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	Hydrological modelling for the SEIS found that the Project will not influence the existing hydrological conditions of local waterways. While some runoff will be captured on site in mine infrastructure, the small size of the water volumes involved, in relation to the surrounding catchment, means that no measurable changes to the hydrological conditions of the Project Area will occur. Waterways will continue to flow on average 24% of the time, consistent with baseline conditions.	No
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	No impacts to the water quality of the receiving environment are expected as a result of the Project. The receiving environment, including waterways of Tooloombah Creek and Deep Creek, will be managed in accordance with the Project EMP and a controlled release strategy for mine affected water. Controlled releases will also be regulated by the Mine EA. The effectiveness of these management measures will be determined by implementation of the REMP, which will include measures to monitor and record the effects of any release of mine-affected water on the receiving environment.	No

15.6.5.5.2 Threatened Aquatic and Marine Fauna

Threatened aquatic and marine fauna known, or considered likely, to occur in the downstream environment are the estuarine crocodile, green turtle, flatback turtle, Australian hump-back dolphin, Australian snubfin dolphin, dugong and humpback whale. These species are all exclusively marine and estuarine species except for the estuarine crocodile, which may also occur in freshwater environments, such as those that lie adjacent to the Project site. There are no threatened species that exclusively inhabit freshwater environments known, or considered likely, to occur.

These species are listed as Vulnerable under the EPBC Act and/or NC Act. In addition, these species are all listed as Migratory under the EPBC Act. Impacts to these species have been assessed in accordance with the MNES Significant Impact Guidelines 1.1 (DE 2013) and the Queensland Environmental Offsets Policy Significant Residual Impact Guideline (DEHP 2014a). These two sets of guidelines are very similar, so have been presented together in Table 15-16. Based on this assessment, the Project is not expected to result in a significant residual impact to any threatened marine fauna.

Table 15-16: Significant impact assessment – threatened marine fauna

Significant impact criteria	Response	Significant impact?
Lead to a long-term decrease in the size of an important population ***(local population)***	The threatened species known, or considered likely to occur, in and around the Styx River estuary are the estuarine crocodile, green turtle, flatback turtle, Australian hump-back dolphin, Australian snubfin dolphin, dugong and humpback whale. In addition, the estuarine crocodile may also occur in the waterways adjacent to the Project site. No known important population of any of these species occurs in the Styx River estuary or adjacent marine environments. • Sightings of inshore dolphins are rare in the areas around the Styx River estuary. Given the shallow nature of the Styx River, particularly at low tides, suitable habitat for these species in the river is not expected to extend upstream beyond Rosewood Island. • Nesting for green and flatback turtles occurs at least 75 km to the north and foraging by these species in the areas near to the Styx River estuary is occasional. • Deeper waters at the northern entrance to Broad Sound are likely to be utilised by humpback whales for short periods during the southern migration, but Broad Sound itself is not ideal habitat for humpback whale, due to its large tidal range and associated turbid waters. • There is a Dugong Protection Area (DPA) in Broad Sound, associated with extensive seagrass beds extending from Carmilla Creek south to Clairview Bluff but this is approximately 55 km north of the Project so is far removed from the Styx River estuary. There are no known sightings of dugongs in the areas around the Styx River estuary and, given the lack of seagrass in most of Broad Sound it is unlikely the area immediately downstream provides suitable habitat for this species. • Suitable habitat for estuarine crocodile is prevalent along the Queensland coast, and there are no unique habitat features for this species present within and around the Project area, or downstream areas associated with the Styx River estuary. As any areas that may be ecologically significant, or be suitable to harbour important populations for these species, are well removed from the downstream environment of the Project, and there is low potential for impacts to downstream water quality as a result of Project discharges, it is considered highly unlikely that the Project would result in adverse effects to an important population. Extent of occurrence refers to the area bounded by an imaginary line around all known records of a species. Unless a development is near the edge of a species' distribution and the development is likely to contract that boundary, then it is very unlikely that a development will reduce the extent of occurrence of a species. As such, the Project will not note reduce the extent of occurrence of any of these species.	No
Reduce the area of occupancy of an important population ***(Reduce the extent of occurrence of the species)***		No
Fragment an existing important population into two or more populations		No
Disrupt the breeding cycle of an important population		No
Adversely affect habitat critical to the survival of a species ***(cause***	As described above (see dot points in above cell of this table), there is no habitat critical to the survival of any of the seven threatened species known, or considered likely, to occur in the areas within and around the Styx River estuary.	No

Significant impact criteria	Response	Significant impact?
disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species)	As any ecologically significant locations or areas of habitat critical to the survival of any of these species are well removed from the downstream environment of the Project, and there is low potential for impacts to downstream water quality as a result of Project discharges, it is considered highly unlikely that the Project would result in adverse effects to habitat critical to the survival of any of these species.	
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline ***(result in genetically distinct populations forming as a result of habitat isolation)***	As described above (see dot points in top cell of this column), the habitat in the areas within and around the Styx River estuary are considered marginal for all of the species except estuarine crocodile. Suitable habitat for estuarine crocodile is prevalent along the Queensland coast, and there are no unique habitat features for this species. As such, and given that there is low potential for impacts to downstream water quality as a result of Project discharges, it is considered highly unlikely that the Project would modify, destroy, remove, isolate or decrease the availability or quality of habitat for any species listed above, to the extent that the species is likely to decline. Furthermore, there will be no areas of habitat that become isolated as a result of the Project, hence there is no risk of any genetically distinct populations forming as a result of Project activities.	No
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	The Project is highly unlikely to result in the establishment of an invasive species in the marine environment.	No
Introduce disease that may cause the species to decline ***(that may cause the population to decline)***	The Project is highly unlikely to introduce disease into the marine environment.	No
Interfere with the recovery of the species	**Estuarine crocodile** There is no recovery plan for this species. In Australia, threats to this species include mortality due to fishing nets and habitat destruction. The Project will not contribute to these threats hence will not interfere with the recovery of this species. **Marine turtles - green turtle and flatback turtle** Interim recovery objectives for marine turtles are (DEE 2017b): • Current levels of legal and management protection for marine turtles are maintained or improved both domestically and throughout the migratory range of Australia's marine turtles. • The management of marine turtles is supported. • Anthropogenic threats are demonstrably minimised.	No

Significant impact criteria	Response	Significant impact?
	• Trends at index beaches, and population demographics at important foraging grounds are described. The Project will not interfere with these objectives. **Dolphins - Australian hump-back dolphin and Australian snubfin dolphin** There is no recovery plan for these species. Threats include habitat destruction and degradation; incidental capture in gillnets; traditional hunting by Indigenous Australian communities; live capture for oceanariums and competition with fisheries for prey species. The Project will not contribute to any of these threats, hence is unlikely to interfere with the recovery of these species. **Dugong** The Action Plan for Australian Mammals (Woinarski et al. 2014) identifies the following mitigation approaches for dugongs. • Ensure high levels of protection in important habitats. • Reduce incidental catch in nets from shark exclusion devices and fisheries. • Manage indigenous hunt to ensure it is sustainable. • Improve national coordinated planning and management of coastal development, port expansion, and vessel movements to reduce risks to dugongs and their seagrass habitats. • Enhance education programs to inform fishers and other users of marine environments of best practice codes of conduct for avoiding dugong injury or death, minimising seagrass loss, and ensuring future hunting is sustainable and that the cultural motivations for traditional hunting are understood by the wider community. The Project will not interfere with these objectives. **Humpback whale** The conservation advice prepared for the humpback whale (TSSC 2015) identifies the following actions to address threats and facilitate recovery: • maintain and improve existing legal and management protection • understand impacts of climate variability and change • assess and address anthropogenic noise; shipping, industrial and seismic surveys • address infrastructure and coastal development impacts and • reduce commercial fishing entanglements minimise vessel collisions. The Project will not interfere with these objectives.	

These items in italics are where the Queensland Environmental Offsets Policy Significant Residual Impact Guideline criteria differ slightly from the MNES Significant Impact Guidelines 1.1 (DE 2013) and the Queensland Environmental Offsets Policy Significant Residual Impact Guideline (DEHP 2014a).

15.6.5.5.3 Migratory Marine fauna

The migratory marine fauna known or likely to occur in waterways adjacent to the Project or in the downstream environment are the estuarine crocodile, green turtle, flatback turtle, Australian

hump-back dolphin, Australian snubfin dolphin, dugong and humpback whale. These species are all listed as Migratory under the EPBC Act and are also listed as Vulnerable under the EPBC Act and/or the NC Act. As such, impacts to these species have been assessed in accordance with the EPBC Act MNES Significant Impact Guidelines 1.1 (DE 2013) for Vulnerable species as presented in Table 15-16. Based on this assessment, the Project is not expected to result in a significant residual impact to migratory marine fauna. Impacts on migratory shorebirds and migratory birds which are known or likely to occur in the downstream environment are addressed separately in Chapter 14 - Terrestrial Ecology.

15.6.6 Coastal Environment

Potential impacts to the coastal environment, resources, values and processes may manifest as a result of direct disturbance from construction and operation, surface water changes, groundwater drawdown and increased bank erosion. However as described in the preceding sections there is a low risk of the Project resulting in a significant impact on the coastal environment. Under average climatic conditions, the Project will reduce the estimated baseline sediment generation rate of 5,037 t/year to approximately 2,297 t/year. The assessment of sediment loads from the Project Site under very wet climatic conditions also concluded that the total worst-case sediment generation rate for the Project would remain well below the baseline. An assessment against the Reef 2050 Water Quality Targets indicate that the Project will result in a positive contribution through the expected reduction in sediment load reporting to Tooloombah Creek and Deep Creek.

15.6.6.1 The Coastal Zone

As illustrated in Figure 15-19, the coastal zone is located to the west of the Project Site and extends downstream to Broad Sound. There will be no direct or indirect impacts to this area as a result of the Project.

15.6.6.2 Coastal Management District

The State's Development Assessment Mapping System (coastal protection) indicates that parts of the Styx River has been designated as part of the coastal management district as illustrated in Figure 15-19. This area pertains to the river itself and not adjacent properties. There is no proposal as part of the Project for development within or near this area, and the Project is not considered likely to exacerbate impacts resulting from storm tides or coastal erosion as discussed in the following sections.

15.6.6.3 Storm Tide Hazard Area

Storm surges are a condition associated with cyclonic weather whereby tidal levels are much higher than normal due to the piling up effect of wind upon the ocean. Little information is available about the potential magnitude of storm surge in the Styx River. It is a relatively small, ungauged catchment, so there is no history of flood heights or frequency and no local tidal data from which surge data could be inferred. However, according to the Livingstone Shire Council (2018) mapping the site is not a storm tide hazard area (OM14 Coastal Hazard - Area Storm Tide Area).

Downstream of the Project area, the State's Development Assessment Mapping System indicates sections of Deep Creek and Tooloombah Creek are potentially subject to 'medium' level impacts from storm tide inundation (Figure 15-19).

Fieldwork observations indicate the upstream extent of irregular (peak) tidal inundation, as evidenced by the presence of scattered patches of marine couch on lower banks, occurs downstream of the confluence of Deep Creek and Tooloombah Creek. Representative creek bed elevation at this location is approximately 5.5 m Australian Height Datum (AHD). This area lies upstream of the river crossings at Ogmore and the North Coast Rail line. At the Bruce Highway bridge over Deep Creek, the representative creek bed elevation is approximately 25 m AHD, almost 20 m higher than the peak tidal level. Whilst it is acknowledged that a storm surge creates tidal inundation (i.e. the storm tide) that travels further inland than regular tides, it would appear highly unlikely that cyclonic conditions could create a surge of this magnitude (Figure 15-18).

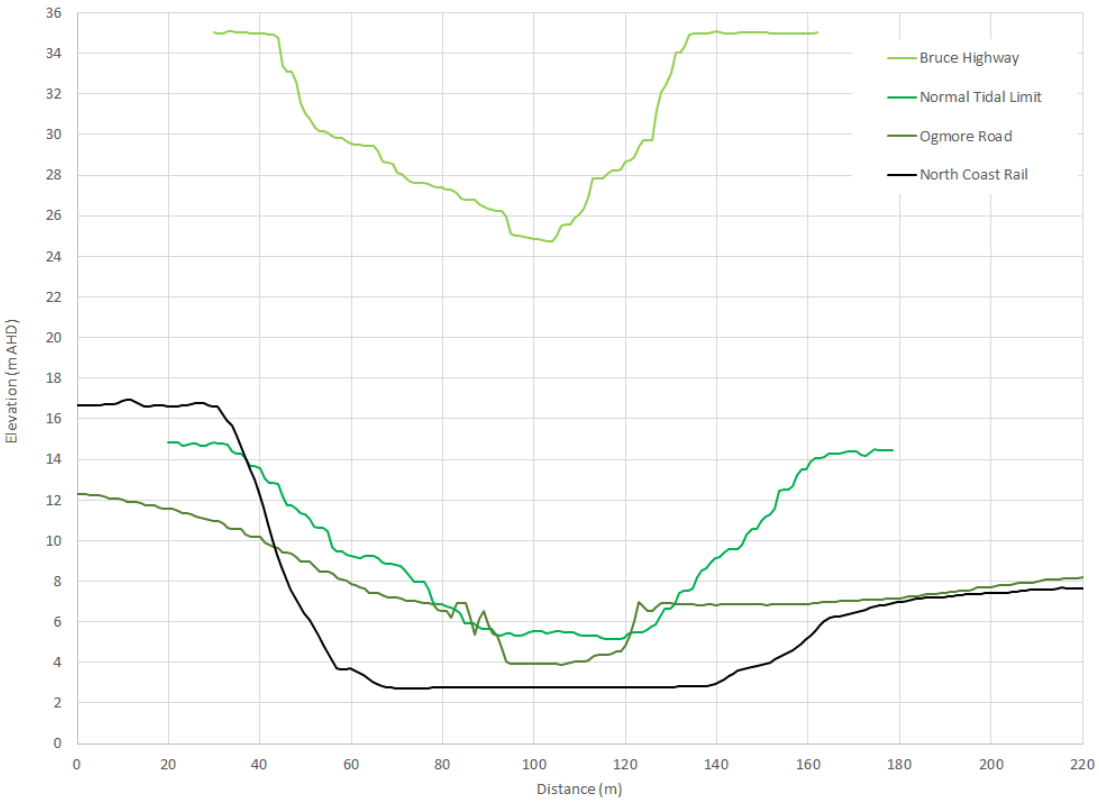

Figure 15-18: Comparative cross-section of watercourse crossings obtained from airborne laser survey

Flooding events occur during the wet season, with the Styx River containing most of the flow within the channel and overbank before overflowing into the floodplain areas downstream of the Project towards the township of Ogmore. In the (low likelihood) event of being coupled with a storm surge flooding events may be exacerbated. Within the vicinity of the Project, Deep Creek and Tooloombah Creek are incised with channel depths of more than 5 m. Tooloombah Creek is well-defined with little evidence of floodplain discharges while Deep Creek demonstrates several locations of floodplain discharges within the Project Area evident by the presence of erosion and lack of vegetation on the banks.

Hydrologic models have been developed for the Project and potential flooding has been depicted in both the current (undeveloped) scenario, and with development of the mine (see Chapter 9 – Surface Water), including the 0.1% Annual Exceedance Probability (AEP) rainfall event). In the undeveloped scenario the modelling indicates in a 0.1% AEP rain event minor flooding (up to 1.25 m depth) would occur through the centre of the ML with patches of deeper flooding associated with lower lying areas adjacent to Deep Creek to the north of the Bruce Highway.

To manage the risks from flooding, a mine water management system has been developed (see Chapter 9 – Surface Water). A system of flood protection levees and diversion drains has been developed to prevent ingress of clean water runoff to pits for up to and including the 1% annual exceedance probability (AEP) rainfall event. This provision reduces the volumes of water entering pits and becoming contaminated, and hence reduces the storage requirements of pit dewatering dams.

All regulated dams are conceptualised in accordance with EHP guidelines and include storage provisions to reduce the probability of non-controlled discharges of contaminated water from dam failure or overtopping during extreme rainfall events or wet seasons. Water held in pit dewater dams is prioritised for reuse in mine operations, which reduces the net raw water demand from external sources. Environmental dams are located downstream of stockpiles and disturbed areas to reduce sediment loads entering the watercourses and controlled discharges reduced to a contingency measure and subject to Environmental Authority conditions.

The Project is upstream of the State-mapped storm tide extent. The mine water management system has been developed to withstand the flooding impacts of a 0.1% AEP rainfall event. It is therefore considered unlikely that a storm-tide event will have any measurable impact upon concurrent riverine flood levels throughout the Project area.

15.6.6.4 Erosion Prone Area

According to the Livingstone Shire Council (2018) mapping the site is not an erosion prone area (OM13 Coastal Hazard Area – Erosion Prone Area mapping).

The State's Development Assessment Mapping System (coastal protection) indicates minor sections of Deep Creek and Tooloombah Creek downstream of the Project area are considered 'erosion prone areas' (Figure 15-19). This mapping is based on various factors including estimating potential erosion caused by extreme storm events, channel migration, sediment supply, and future sea level rise.

Based on the hydrological modelling described in Chapter 9 - Surface Water it is considered very unlikely that the Project activities would have any additive impact on background coastal erosion issues downstream of the Project.

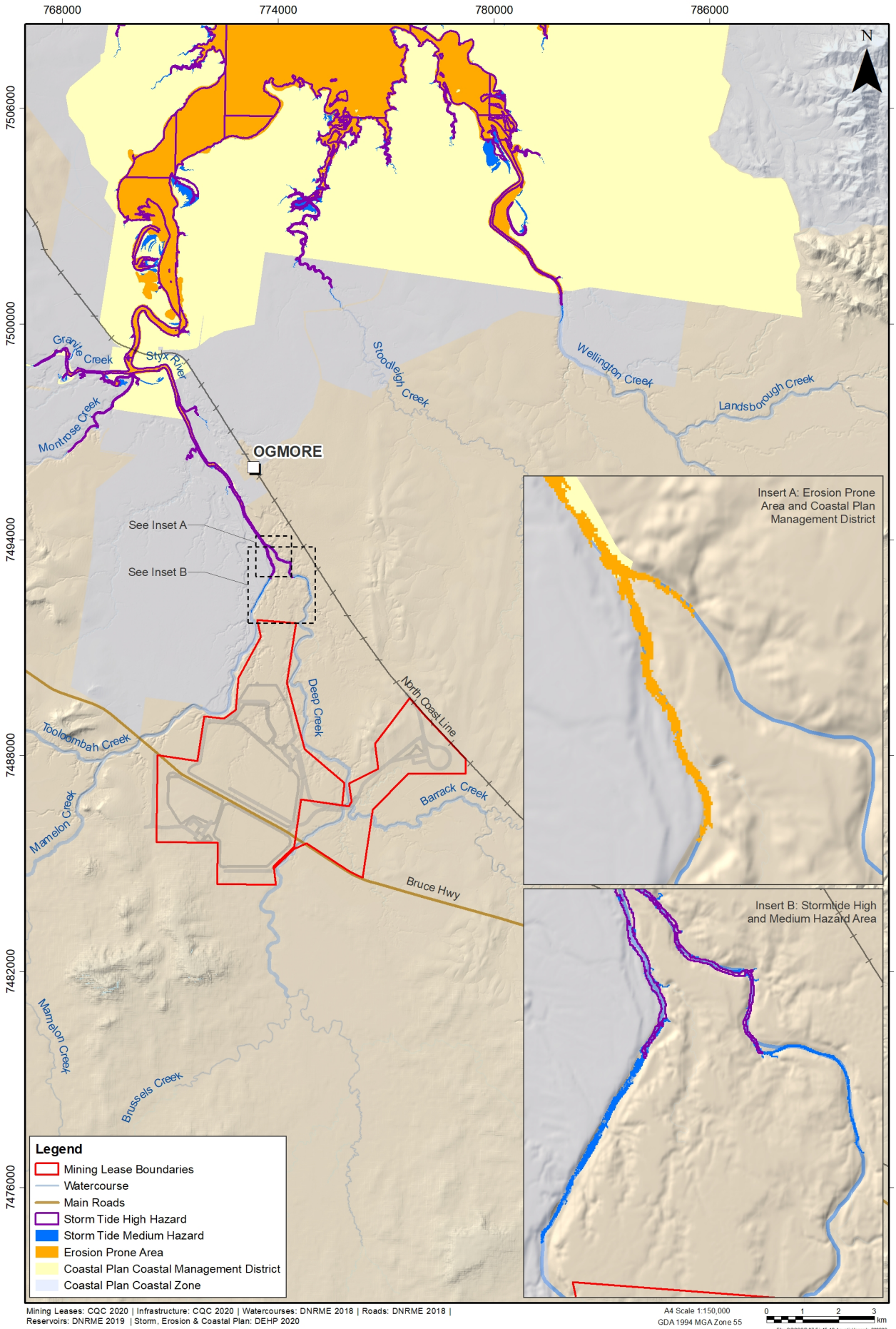

Figure 15-19: Coastal zone, management district, storm tides hazard and erosion prone area

15.6.7 MNES and MSES

As a result of the impact assessment presented in the preceding sections, the Project is expected to result in a significant residual impact on waterways providing for fish passage. As summarised in Table 15-17, no other significant residual impacts on aquatic or marine values are anticipated.

Table 15-17: Summary of significant impacts on aquatic and marine MSES and MNES

MSES/MNES	Applicability to the Project	Significant Residual Impact?
MSES		
Wetlands and watercourses	Wetland 1 is both a wetland of HES and is a wetland in a WPA. It is mapped as RE 11.3.12. There are no wetlands or watercourses in HEV waters located near the Project.	No
Protected wildlife habitat	There are seven species which are listed as vulnerable under the NC Act and are known or likely to occur in the waterways surrounding the Project Site and/or the downstream environments. These species are: • Estuarine crocodile (Vulnerable - NC Act; Migratory – EPBC Act) • Green turtle (Vulnerable - NC Act; Vulnerable/Migratory - EPBC Act) • Flatback turtle (Vulnerable - NC Act; Vulnerable/Migratory - EPBC Act) • Australian hump-back dolphin (Vulnerable - NC Act; Migratory - EPBC Act) • Australian snubfin dolphin (Vulnerable - NC Act; Migratory EPBC Act) • Dugong (Vulnerable - NC Act; Migratory EPBC Act) and • Humpback whale (Vulnerable - NC Act; Vulnerable/Migratory - EPBC Act)	No
Highly protected zones of State Marine Parks	Only the areas of the GBRCMP zoned Marine National Park or Conservation Park Zone are considered MSES. The Marine National Park zone is located approximately 33 km northeast of the Project (or 40 km downstream).	No
Fish habitat areas	Broad Sound FHA boundary is located approximately 10 km downstream of the Project.	No
Waterway providing for fish passage	There are several watercourses of varying stream orders located within the Project area that have the potential to provide fish passage.	Yes
Marine Plants	Marine couch was identified along the edge of the Styx River approximately 2.5 km downstream of the Project, however, was most abundant along the banks of the Styx River from approximately 4 km downstream of the Project. Extensive stands of saltmarsh and mangrove species occur downstream of the Project (14 km and 21 km downstream respectively) along the margins of the Styx River and Broad Sound.	No
MNES		
World Heritage Properties	The GBRWHA is located approximately 10 km downstream of the northernmost Project boundary.	No

MSES/MNES	Applicability to the Project	Significant Residual Impact?
National Heritage Places	The GBR was placed on the National Heritage List in May 2007. It is located approximately 10 km downstream of the northernmost Project boundary.	No
Wetlands of international importance (listed under the Ramsar Convention)	No Ramsar Wetlands under the EPBC Act are located within the Project Area. The closest Ramsar wetlands are the Shoalwater and Corio Bays which are adjacent to the Broad Sound wetland.	No
Listed threatened species Listed Migratory Species	There are seven listed threatened and/or migratory species which are known or likely to occur in the waterways surrounding the Project Site and/or the downstream environments of the Styx River estuary and Broad Sound. These species are: • Estuarine crocodile (Vulnerable - NC Act; Migratory – EPBC Act) • Green turtle (Vulnerable - NC Act; Vulnerable/Migratory – EPBC Act) • Flatback turtle (Vulnerable - NC Act; Vulnerable/Migratory - EPBC Act) • Australian hump-back dolphin (Vulnerable - NC Act; Migratory - EPBC Act) • Australian snubfin dolphin (Vulnerable - NC Act; Migratory EPBC Act) • Dugong (Vulnerable - NC Act; Migratory EPBC Act) and • Humpback whale (Vulnerable - NC Act; Vulnerable/Migratory - EPBC Act)	No
Commonwealth marine areas	Coral Sea Marine Park is the closest Commonwealth marine area. It covers 989,836 square kilometres and lies off the coast of Queensland, and is one of the world's largest marine parks. The Coral Sea Marine Park boundary is located approximately 330 km north-east of the Project Area.	NA
Great Barrier Reef Marine Park	The GBRMP is located approximately 41 km downstream of the Project.	No

15.6.8 Cumulative Impacts

The Project may have impacts on environmental values that act cumulatively with those of other projects in the region. The contribution of past and present projects is inherent in the impact assessment, as these projects are influencing the environmental baseline upon which the impact assessment is based. However, reasonably foreseeable future projects should also be considered, in the context that these projects may have environmental impacts that act cumulatively with those of the Project.

The catchment and coastline surrounding the Project Area is relatively undeveloped, dominated by rural lands that are used for grazing. There are no known large-scale industrial or mining developments proposed within the catchment of the Project. The Commonwealth Department of Defence is currently developing an expansion of the existing Shoalwater Bay Defence Training Area. A future expansion of the existing Shoalwater Bay Defence Training Area is located partly in

the catchment of Broad Sound, approximately 50 km to the north-east of the Project. Therefore, there is some potential for the impacts of the Project to act cumulatively with those of the Defence project. Potential cumulative impacts relate to changes to water quality within Broad Sound and parts of the GBR, and associated disturbance to marine habitats such as seagrass communities. However, the potential for cumulative impacts is considered to be very low, because:

- Impacts of the Project on downstream values including water quality are not expected, particularly as far downstream as Broad Sound.
- Broad Sound and Shoalwater Bay are subject to a very large tidal influence, reducing the risk of cumulative impacts on water quality from both projects.
- The Defence project will be implemented in accordance with environmental guidelines to mitigate impacts on the environment, including local water quality values.
- The Project will result in a net reduction in sediment discharges to the GBR, reducing the risks of impacts from sediment discharges acting cumulatively with the Defence project.

15.7 Mitigation, Management and Monitoring

15.7.1 Environmental Management Framework

Central Queensland Coal have prepared a draft Environmental Management Plan (EMP) for construction and operation of the Project. The draft EMP is contained in Appendix 12 and has been developed to manage and mitigate potential environmental impacts, and to assist Central Queensland Coal to comply with relevant environmental approvals and permit conditions. The draft EMP has been prepared generally in accordance with the Commonwealth Environmental Management Plan Guidelines (Commonwealth of Australia 2014) and is modelled on the AS/NZS ISO 14001 (Standards Australia 2016) Plan-Do-Check-Act (PDCA) continual improvement model.

Appendix C of the draft EMP provides the specific, sub-plans for managing environmental impacts. The following sub plans are relevant to this chapter:

- General Acid Sulfate Soil Management Plan (ASSMP)
- Hazardous Materials Management Plan (including spill management) (HMMP)
- Land Use Management Plan (LUMP), including:
  - Biodiversity Management Strategies
  - Weed and Pest Management Plan (WPMP) and
  - Bushfire Management Plan (BfMP).
- Mineral Waste Management Plan (MWMP)
- Surface Water Management Plan (SWMP) and
- Groundwater Management and Monitoring Plan (GMMP).

The management plans in Appendix C of the draft EMP are high-level at this stage and will be updated following Project approval to reflect the final EA and EPBC Act Conditions.

In addition to the plans in Appendix C of the draft EMP, a number of more detailed management plans have been prepared in response to the government submissions on SEIS v2. These are referenced by the draft EMP and will form part of the final EMP system for the site. The following detailed plans are also relevant to this chapter:

- Draft Mine Site Water Management Plan (WMP – Appendix A5c) – The Draft WMP describes the procedures that will be implemented to manage water within the Project Site, to provide sufficient water for construction and operation of the mine, while also outlining how excess water will be managed, sourced from rainfall or from groundwater seepage into the mine pits.
- Draft Erosion and Sediment Control Plan (ESCP – Appendix A15a) – The Draft ESCP describes the approach to managing the risk of erosion at the site, and the methods that will be used to capture and manage sediment, to reduce discharges to the receiving environment.
- Draft Receiving Environment Monitoring Program (REMP – Appendix A10f) – The Draft REMP describes the rationale and salient aspects of a monitoring program for the receiving environment surrounding the Project Site, including the location of monitoring sites, monitoring frequency and parameters. The REMP is designed to evaluate changes in the quality of the receiving environment, with a focus on surface water quality, sediment quality, aquatic ecology habitat quality, marine ecology habitat quality, macroinvertebrates and fish. Several control and impact sites have been established upstream of, adjacent to, and downstream of the Project.
- Draft GDE Management and Monitoring Plan (GDEMMP – Appendix A10e) – The Draft GDEMMP describes the mitigation and monitoring measures that will be implemented to manage the impacts of the Project on GDEs. A series of triggers and corrective actions have been developed for each GDE, to facilitate an assessment of the impacts of the Project during various development stages, and to inform an assessment of the suitability of mitigation measures to manage impacts. An adaptive management approach will be implemented, with the results of monitoring relevant indicators for each GDE informing the ongoing re-evaluation of Project impacts and associated mitigation measures.
- Draft Significant Species Management Plan (SSMP – Appendix A9e) – The purpose of the Draft SSMP is to reduce the environmental impacts of the Project on listed species and their habitat, through the development of mitigation and monitoring measures for implementation prior to construction, during construction, during operations and as part of the decommissioning process. Although predominantly relevant to terrestrial species and birds, the measures implemented through the SSMP will also mitigate impacts on aquatic and marine species.
- Progressive Rehabilitation and Closure Strategy – A rehabilitation framework and strategy has been developed which will be developed into a PRCP. The strategy describes how final landforms associated with the Project will be rehabilitated after mining activities. Runoff from disturbed areas has the potential to reduce water quality in the receiving environment, with rehabilitation a key management measure to address this risk in the long term.

Measures to minimise, mitigate and monitor impacts on aquatic and marine values, as identified in this chapter, will be delivered through the implementation of the EMP and the sub-plans outlined above. It is important to note that the EMP and sub-plans are currently in draft form and will be finalised following Project approval to reflect the final EA and EPBC Act Conditions. This will involve consolidation of all mitigation, management and monitoring measures proposed throughout the SEIS chapters and plans into the EMP and sub-plans. Specific measures from the EMP and sub-plans to be implemented, and relevant to this chapter, are summarised below.

15.7.1.1 Vegetation Clearing

- Project design elements will ensure that the minimum amount of land required for construction and operation will be disturbed.

- Construction activities will be completed during the dry season where possible, to reduce the potential of construction-related erosion and scour, with areas stabilised as much as practicable prior to wet season rains.
- A detailed plan showing approved vegetation clearing areas is to be prepared prior to any works on the site, and the boundaries of 'no-go' areas drawn on construction plans.
- Prior to construction, boundaries of clearing and 'no-go' areas will be clearly pegged/flagged on the ground prior to clearing commencing. Training for all personnel will include information on identifying these marked areas.
- No lay down areas or materials storage will be located within wetland areas or areas of retained vegetation.
- Erosion and sediment controls outlined in the ESCP will be implemented.
- Records must be retained tracking the removal, stockpiling and movement of topsoil, particularly where the topsoil contains weed species.
- Where topsoil is not utilised in earthworks, it should be dispersed onto prepared landscaping and revegetation areas immediately to minimise deterioration of soils.
- Where topsoil is to be stockpiled:
  - Stockpiles should have a maximum height of 2 m.
  - Stockpiles should be revegetated to prevent soil erosion and weed invasion and to maintain soil microbes.
  - Stockpiles should be located well away from works areas, access paths and overland flow paths.
- Habitat areas to be cleared will be thoroughly checked by a fauna spotter-catcher prior to clearing.
- Fauna-spotter catcher will be present for all vegetation clearing activities. The spotter-catcher will be required to hold a Permit to Take or Interfere with Wildlife.
- Prior to construction at artificial dams, a qualified ecologist will inspect the area and if required, remove native aquatic fauna, which will be relocated to a suitable pre-determined area.
- Clearing activities must avoid damage to the roots, trunks and canopy of adjacent retained vegetation.
- Bank stabilisation will take place post-construction as necessary to allow for revegetation and to reduce scour potential.
- Regular inspections will be undertaken of cleared area extents to ensure retained vegetation is not being directly or indirectly impacted by construction activities.
- Weekly monitoring shall be conducted of retained vegetation to detect any damage or decline in the health and condition of retained vegetation within the construction site and adjacent sites.

15.7.1.2 Construction of Creek Crossings

To ensure aquatic habitat connectivity is maintained, Central Queensland Coal commits to undertaking detailed design and construction of the haul road crossing of Deep and Barrack Creek in compliance with:

- State Code 18: Constructing or raising waterway barrier works in fish habitats.
- DAF guidelines - Accepted development requirements for operational work that is constructing or raising waterway barrier works.
- Austroads – Guide to Road Design Part 5B – Open Channels, Culverts and Floodways.
- Design detail requirements of the Code for Self-Assessable Development; Minor Waterway Barrier Works Part 3: Culvert Crossings, Code number: WWWBW01 (April 2013), Department of Agriculture and Fisheries.

In all cases the following specific conditions will be applied:

- Project design elements will ensure that surface water flows into creeks represent natural conditions as much as possible.
- The design of the haul road crossings will maintain aquatic habitat connectivity.
- Works will be completed during the dry season in periods of no-flow.
- Minimum culvert aperture width will be 2.4 m or span the entire channel width, reducing impacts on flow and aquatic fauna passage.
- All new and replacement culvert cells will be installed at or below bed level.
- The internal roof of the culverts will be >3 m above the 'commence of flow' water level.
- If culvert cells are installed < 3m below bed level, the culvert floor will have a rough surface to simulate natural bed form.
- Where possible, box culverts will be used to facilitate fish passage at low flow depths.
- Footings over the base slabs may be used to maintain the natural bed channel through the culverts.
- Apron and stream bed scour protection will be provided.
- The culvert gradient will be no steeper than natural waterway bed gradient.
- Any fish that become trapped during construction will be salvaged in accordance with the DAF *Guidelines for fish salvage* (DAF 2020). In the event of a fish kill, the appropriate steps provided in the guidelines will be followed.
- Stabilisation of the banks will be done post construction to allow revegetation and reduce scour potential.

15.7.1.3 Groundwater Drawdown

A draft GMMP has been developed as part of the Project's EMP. The monitoring program will be implemented to ensure that adequate groundwater monitoring and data analysis is undertaken to establish changes to groundwater levels and quality associated with the Project.

A draft GDEMMP has also been prepared with the aim of minimising and managing the environmental impacts of the Project on GDEs through the development of mitigation and monitoring measures for implementation prior to construction, during construction, during operations and post operations. As part of the draft GDEMMP a monitoring program has been developed for GDEs, to determine whether mitigation and management measures are adequate and successfully implemented. This work will build upon the baseline studies completed during the EIS and SEIS.

In addition, a revegetation program will be implemented in areas within the riparian corridor expected to be affected by groundwater drawdown with the aim of building ecological resilience.

Revegetation will include expansion of the existing riparian corridor by a width of 10 m. A revegetation program will be designed to ensure the planting of drought tolerant, and non-groundwater dependent, species of similar ecological function as those with the potential to be impacted. This will ensure that existing habitat for terrestrial species is maintained, as well as reducing the potential for consequential impacts such as erosion and sedimentation which may be associated with vegetation loss. The revegetation program will be implemented from Project commencement ensuring sufficient timeframes for establishment of vegetation, given potential impacts as a result of changes to groundwater are not expected to commence until at least 10 years after Project commencement.

15.7.1.4 Surface Water and Erosion Management

- Changes to surface water quality from controlled releases will be managed via the WMP.
- Water quality release limits will be set for mine-affected water as outlined in Chapter 9 – Surface Water. Water will only be discharged from the mine dam during flow trigger events (during/immediately after high rainfall events when the creek is flowing) and only if the flow and water quality parameters meet the water quality release limits outlined in the Environmental Authority (which will set to ensure appropriate dilution of any elevated water quality parameters).
- Water storages will be managed to reduce the likelihood of non-compliant discharges due to overtopping.
- Mine dams will be constructed to contain potentially contaminated mine groundwater pumped from the open cut pit throughout the life of the project.
- Early construction of the mine dams and water storage facilities will allow for the collection of water from disturbed areas from an early stage in development.
- Environmental dams will collect run-off which will be transferred to the main site dam.
- A water catchment system will be in place to capture rainfall runoff from the mine site including the Train Loadout Facility and waste rock stockpile areas.
- Roads will be designed and located to minimise the amount of run-off into waterways.
- Captured water will be treated to minimise the amount of sediment and concentration of contaminants or treated through settlement prior to release.
- Baseline water quality will be monitored at the mine dams, discharge locations and locations both upstream and downstream of the Project Site in accordance with the draft WMP and REMP.
- Landforms such as waste rock stockpiles will be constructed using erosion-resistant materials to reduce the level of erosion.
- Site infrastructure includine waste rock stockpiles are immune from the 0.1% AEP (1 in 1000-year average recurrence interval) flood event.
- Removed topsoil will be placed in designated soil stockpile zones and seeded to minimise erosion.
- Erosion and sediment controls will be installed and maintained in accordance with the ESCP.
- Clean water will be diverted around disturbed areas to avoid the mobilisation of additional sediment and contaminants.

- Earthmoving activities will be minimised during rainfall events to limit sediment and contaminant runoff.
- Regeneration of the vegetation and restoration of habitat on the property will create vegetation buffers to reduce sediment and nutrient run-off in a number of ways:
  - increased capture of sediment and nutrient run-off from the property and
  - reduction of erosion as a result of vegetation restoration reducing the amount of sediment entering waterways during surface water flows.
- Removal of cattle (destocking) will reduce the level of erosion and land degradation, as well as removing a source of nutrient in-put into surrounding waterways.
- Vegetation regeneration and stock exclusion will continue post-operation, resulting in a permanent reduction of sediment run-off.
- Storage and handling of oil and chemicals will be in accordance with relevant Australian Standards to minimise the risk of accidental spills and leaks.
- Spill control materials will be retained on site for use in the event that a substance is spilled into a surrounding waterway.

15.7.1.5 Weed and Pest Management

Weeds and Pests will be managed onsite in accordance with the WPMP. Key measures to be implemented under this plan include:

- Prior to construction commencing, a baseline weed and pest survey will be conducted in the Project footprint plus a 200m buffer. This will be used to prepare a digital weed map of the site identifying the distribution and density of weed infestations and will enable tracking changes over time. In addition, a register of pertinent information in relation to weed and pest distribution, numbers and control requirements will be established.
- Following the baseline survey, ongoing weed and pest monitoring surveys will be undertaken every two years, consisting of a survey during the dry season and a survey post-wet season.

Preventative methods proposed to reduce the risk of weeds being introduced into the area include:

- For shipped plant and machinery, a thorough washdown procedure will be required for all plant and machinery prior to it being shipped to site.
- All contractors bringing vehicles/plant onto the site will be required to complete a Weed Declaration Form, in which they formally declare that all required weed hygiene measures have been taken and that their vehicles/plant are free of weed material (in particular, weed seeds).
- Establish a weed wash-down facility at or near the entrance to the Project Site for any vehicles that do enter / leave the mining lease areas.
- For vehicles and plant that are unable to provide a Weed Declaration Form wash down will be required.
- All weed washes will be documented and evidence maintained of weed wash-downs on or off-site.
- Clearing will be minimised to the area directly required for mining operations.

- Removal, stockpiling and movement of topsoil on the site will be tracked, particularly where the topsoil contains weed species. Top-soil from weed infestation areas (as identified in the pre-construction mapping) will be carefully stockpiled and if moved, not stored or reused in areas where those weeds are not present.
- Any weeds that are identified within the Project area will require appropriate treatment to reduce the potential for these species to spread to new areas. Should weed infestations occur, the treatment applications will be selected relevant to the species, the size and growth stage of each infestation and the timing of application.

15.7.1.6 Dust Management

Dust suppression measures primarily include the application of water to control dust emissions. The following dust suppression measures will be considered:

- Minimising topsoil and vegetation removal and revegetation of disturbed areas as soon as possible.
- Minimise pre-strip to a maximum of one block ahead.
- Pave areas where practical around offices, carparks, maintenance and storage areas.
- Visual monitoring of dust daily with ramping down of activities in the instance of high dust emissions.
- Watering of haul roads to suppress dust emissions.
- Minimising speed of on-site traffic, where applicable, to minimise wheel generated dust.
- Watering of Run of Mine stockpiles using water sprays and/or water cannons that are operated on timers.
- Fogging system on outlets from transfer points and sizing stations with the potential to generate dust.
- Maintain appropriate moisture content of product coal and reject material as they leave the CHPP which avoids the need for supplementary watering.
- Implement an Integrated Coal Moisture Regulating System to minimise dust emissions from the product coal stockpile and to ensure that product coal delivered for train-loading has a coal -surface water content at the optimum level to ensure the effectiveness of veneering of loaded coal. The Integrated Coal Moisture Regulating System will use a water spray or fogging systems to apply optimum levels of supplementary coal watering.
- Use of benign adhesives if water suppression methods are not effective. Should chemical suppressants be required to control dust, a risk assessment will be undertaken to assess potential for adverse impacts to water quality.
- Installing an overhead bin and train loading facility from the start of the operations to minimise coal dust and the potential loss of coal during train transit.

If adverse conditions are encountered during operation of the Project, additional dust suppression measures will be implemented.

15.7.1.7 Rehabilitation

Where impacts do occur, environmental values will be restored if possible, through the following measures:

- The Project Site will be destocked in the northern part during operations years 1 to 9, comprising an area of over 2,000 ha, and in the southern parts, during years 10 to 19 (674 ha).
- Management of destocked land on the property (presently mostly cleared) to allow for regeneration of the vegetation and restoration of habitat, focussing on riparian zones along Deep Creek and Tooloombah Creek.
- Cattle will also be removed from offset areas (approximately 2,800 ha), except where light grazing is required for fuel load and weed management.
- Progressive rehabilitation of disturbed areas will occur where possible to reduce the time between disturbance and rehabilitation.
- Removed topsoil will be placed and seeded in designated soil stockpile areas throughout the life of the Project.
- Removal of mine infrastructure and rehabilitation of all disturbed land to a stable, non-polluting and self-sustaining condition suitable for low-intensity cattle grazing.
- Any riparian vegetation that is damaged during construction will be rehabilitated.
- Any areas of vegetation impacted by hydrological changes will be revegetated and actively managed. Species representative of the REs affected will be used in this revegetation.

15.8 Offsets

Central Queensland Coal is committed to providing offsets to compensate for the unavoidable direct and indirect significant residual impacts on MNES and MSES. A Biodiversity Offset Strategy (BOS) has been prepared to outline how the Project's offset requirements will be acquitted. The BOS and the Project's Draft Offset Delivery Plan (ODP) is presented in Appendix 11 – Offsets.

In relation to aquatic and marine values the Project will result in a significant residual impact on 8.35 ha of waterway providing fish passage as illustrated in Figure 15-5. To acquit this offset requirement a financial settlement offsets is proposed to be made in accordance with the QEOP (Version 1.8; DES 2020b). In accordance with this policy, the financial settlement offset calculator has been used to calculate the cost of this offset. The total cost of the financial settlement for impacts on fish passage is $208,750.00[7]. The details of the financial settlement offset are provided in the Project's Offset Delivery Plan (ODP, Attachment B) and following DES approval, payment will be made to the Queensland Government's Offset Fund prior to Project commencement.

15.9 Qualitative Risk Assessment

The risk of impact on the aquatic and marine environment from Project activities has been assessed based on a qualitative risk assessment using risk levels defined as follows:

- Extreme – Works must not proceed until suitable mitigation measures have been adopted to minimise the risk.
- High – Works should not proceed until suitable mitigation measures have been adopted to minimise the risk.
- Medium – Acceptable with formal review. Documented action plan to manage risk is required.

[7] This amount is based on a combined financial settlement payment for all MSES as presented in Chapter 14 – Terrestrial Ecology. The total payment for all combined MSES offsets is $874,585.65.

- Low - Acceptable with review.

Table 15-18 summarises the results of the risk assessment including the initial risk rating and residual risk rating once mitigation measures are implemented. All impacts receive a residual risk of either Medium or Low through the implementation of mitigation measures. Key risks to the aquatic and marine environment identified through this process include:

- drawdown in alluvium from aquifer dewatering, resulting in direct disturbance to stygofauna habitat
- groundwater drawdown reducing or eliminating groundwater inflows to pools within Tooloombah Creek and Deep Creek, causing them to dry up faster than usual during the dry season
- direct disturbance to riparian vegetation
- direct disturbance to aquatic habitat, affecting connectivity and
- water quality impacts including increased sedimentation in downstream areas resulting from:
  - erosion of streambanks from riparian vegetation dieback
  - mine site runoff and
  - water releases from mine site (controlled and uncontrolled).

Table 15-18: Qualitative risk assessment

Issue	Potential Impacts	Initial Risk	Mitigation Measures	Residual Risk
Subterranean GDEs				
Drawdown in alluvium from aquifer dewatering, resulting in direct disturbance to stygofauna habitat	• Stygofauna will be lost from the area of impact around the mine, and communities upslope of the mine will be isolated from downstream communities. It is the lower reaches of the Styx alluvium, and areas adjacent to the main creeks where stygofauna diversity is likely to be highest. Any taxa living in the area modelled for drawdown are likely to also occur in the downstream reaches.	High	• Project design to minimise the area of alluvial aquifer drawdown. • Apply an adaptive monitoring approach through the GDEMMP, involving the monitoring of groundwater and stygofauna in the alluvium. Target shallow bores that sample fresh groundwater overlying saline deeper water.	Medium
Depressurisation of lower aquifers causing change in groundwater flux and direction	• Changes in the volume and quality of alluvium groundwater caused by depressurisation of deeper aquifers, which could impact stygofauna communities.	Low	• Project design to minimise the area of alluvial aquifer drawdown. • Apply an adaptive monitoring approach through the GDEMMP, involving the monitoring of groundwater and stygofauna in the alluvium. Target shallow bores that sample fresh groundwater overlying saline deeper water.	Low
Alteration of recharge patterns for alluvial aquifers	• Reduced infiltration from rainfall at impermeable surfaces such as roads, and an increase in infiltration along creeks during periods of drawdown.	Medium	• Project design to minimise the area where water will be captured and not infiltrate to the creeks. • Minimal enhanced leakage estimated from the regional groundwater model.	Low
Leachate from waste rock stockpiles percolating into aquifers	• Leachates could percolate into aquifer, then into creeks. Change to water quality post-mining.	High	• Proper sealing of stockpile base and bunding.	Low

Issue	Potential Impacts	Initial Risk	Mitigation Measures	Residual Risk
Seepage from storage dams	• Local changes to groundwater quality around dam.	Low	• Dam design to reduce the risk of seepage, including use of low permeability clay as a foundation or a liner to prevent migration of contaminants.	Low
Change in surface water flows	• Changes to the hydrology of surface water resources, affecting recharge of alluvial aquifers	Low	• Design has minimised changes of surface water flows to negligible levels.	Low
Discharge of mine water to creeks	• Change of water quality in creeks, which may infiltrate shallow aquifers during periods of no rainfall. Released water may lack key elements if water is treated with reverse osmosis, could be low in dissolved oxygen, may cause erosion.	Medium	• Water management strategy implemented to result in minimal change to water chemistry in downstream waters. • Fit energy dissipation structures and release water at low velocity, and over rocky substrate. Spray water to aerate. Add supplementary minerals or elements, if necessary.	Low
Erosion of sediments	• Not relevant to Subterranean GDEs.	Low	• Erosion and sediment control plan will be implemented at the Project site.	Low
Change in location of freshwater – saltwater interface	• Changes in the water chemistry of alluvial aquifers providing habitat for stygofauna.	Low	• Design to minimise changes in the location of the freshwater – saltwater interface as a result of Project activities.	Low
Aquatic GDEs				
Direct disturbance to vegetation and habitat	• There may be some disturbance to pools/vegetation within Deep Creek which are associated with infrastructure such as bridges, revetments or spillway construction. These will be small in scale, if they occur at all in areas of GDEs.	Low	• Design of project to minimise number of instances where works are required. • Construction will be undertaken in the dry season in periods of no-flow.	Low

Issue	Potential Impacts	Initial Risk	Mitigation Measures	Residual Risk
Groundwater drawdown reducing or eliminating groundwater sources to pools within Tooloombah Creek and Deep Creek	• Evaporation of pools during the dry season more quickly than under baseline condition. • Reduced distribution and persistence of aquatic habitat during dry season. • Reduction in habitat connectivity. • Changes in the water chemistry of surface water pools.	High	• Design of mine to minimise area affected by groundwater drawdown.	Medium
Change in surface water flows	• Changes to the hydrology of surface water resources, affecting recharge of alluvial aquifers which sustain pools during dry season.	Low	• Design has been completed to minimise changes to surface water flows, which are negligible.	Low
Change in surface water quality Change in groundwater quality Discharge of mine water to creeks	• Change of water quality in creeks, which may in turn affect the water quality of pools within creeks. • Change of water quality in groundwater-fed pools, due to changes in groundwater quality. • Cessation or reduction in saline groundwater inputs to pools, resulting in lower salinity.	Medium	• Implement Water Management Plan to minimise the frequency and volume of discharges and resultant changes to water quality of the receiving environment. • Fit energy dissipation structures and release water at low velocity, and over rocky substrate. Spray water to aerate. Add supplementary minerals or elements, if necessary. • Changes to surface water quality in pools are likely to be suited to a wider range of aquatic fauna (i.e., less variability in salinity).	Low
Erosion	• Degradation of bank and other habitat types within pools of creeks. • Sedimentation of aquatic habitats.	Medium	• Design has ensured minimal risk of erosion, with removal of cattle grazing likely to reduce erosion and sediment input to streams. • Revegetation of riparian vegetation along Deep Creek. • Implementation of the ESCP.	Low

Issue	Potential Impacts	Initial Risk	Mitigation Measures	Residual Risk
	• Increase in turbidity of water in pools.			
Change in location of freshwater – saltwater interface	• Changes in the water chemistry of pools within creeks.	Low	• Design to minimise changes in the location of the freshwater – saltwater interface as a result of Project activities.	Low
Aquatic Ecology Values				
Direct disturbance to vegetation (clearing)	• Clearing of riparian vegetation, wetlands and associated aquatic habitat. • Degradation of receiving water quality and adverse effect on supported ecosystems. • Bank instability and associated follow-on impacts including riparian degradation.	Extreme	• Project design has been optimised to reduce the need to clear remnant vegetation, particularly in riparian zones and wetlands. • Retained vegetation will be clearly marked to avoid damage or accidental clearing. • Bank stabilisation will take place post-construction to allow for revegetation and reduce scour potential. • Apron and stream bed scour protection will be provided • Regeneration of vegetation on the property during construction and operation will reduce erosion. • Vegetation buffers will be created to reduce sediment and nutrient run-off to waterways. • Offsets will be provided for significant residual impacts on watercourse vegtation. • Post-operation mine infrastructure will be removed and rehabilitation of all disturbed land will occur. This will be to a minimum of pre-existing vegetation and habitat condition.	Medium
Direct disturbance to aquatic habitat, affecting connectivity	• Creek crossings causing loss of connectivity in waterways that provide fish passage. • Increased flow velocities in creeks due to Project related	High	• Project design ensures surface water flows into creeks represent natural conditions as much as possible. • Construction of creek crossings will be completed during the dry season to eliminate the need to divert water around the construction area.	Medium

Issue	Potential Impacts	Initial Risk	Mitigation Measures	Residual Risk
	infrastructure (crossings and diversion bunds). • Reduced waterway flows, due to capture of catchment runoff in mine water storage dams.		• Minimum culvert aperture width will be 2.4 m or span the entire channel width. • Culvert design and installation will be optimised to represent natural conditions and facilitate fish passage. • Water will only be discharged from the mine dam during flow trigger events (during/immediately after high rainfall events when creek flow is high) and only if the water quality parameters meet the water quality release limits. • Discharge of water will be controlled to reduce the likelihood of discharges from overtopping.	
Changes to groundwater level	• Reduction in groundwater flows to pools, causing them to dry up faster than usual during the dry season.	High	• Project design to minimise the areas of creeks that are subject to groundwater drawdown.	Medium
Change in groundwater quality	• Change of water quality in groundwater-fed pools, due to changes in groundwater quality.	Medium	• Project design to minimise the risk of changes to groundwater quality.	Low
Changes to hydrology and surface water flows	• Reduction of inflows to creek lines and consequent reduction in long-term habitat persistence (waterholes).	Medium	• Project design will ensure that surface water flows into creeks represent natural conditions as much as possible. • Water from upstream of the catchment will be diverted around disturbed areas and into the creeks. • Tooloombah Creek and Deep Creek have naturally deep channels that confine the majority of flow within the banks. There will be minor changes to flood levels as a result of the Project, with most flow remaining contained within the system. There will be no significant increase in creek flow velocity as a result of the Project. • Water will be discharged from the mine dam during flow trigger events.	Low

Issue	Potential Impacts	Initial Risk	Mitigation Measures	Residual Risk
Erosion of streambanks, sedimentation of waterways and sediment runoff	• Bank instability and associated follow-on impacts including degradation of the riparian zone. • Degradation of instream habitat / water quality including downstream estuarine habitat in the Styx River. • Degradation of important downstream habitat and values associated with Broad Sound FHA and GBR	Extreme	• Construction will be completed during the dry season where possible, to reduce the potential of construction related erosion and scour. • Bank stabilisation will take place post-construction to allow for revegetation and reduce scour potential. • A water catchment system and environmental dams (sediment basins) will collect run-off from the development area which will be transferred to the main site dams. • Captured water will be treated to minimise the amount of sediment. • Water will only be discharged from the mine dam during flow trigger events (during/immediately after high rainfall events when creek flow is high). • Discharge of water will be controlled to reduce the likelihood of non-compliant discharges from overtopping. • Landforms such as waste rock stockpiles will be constructed using erosion-resistant materials and with low batter slope angles to reduce the level of erosion. • Removed topsoil will be placed in designated rehabilitation zones and seeded to minimise erosion. • Installation of sediment fences on the downslope of disturbed areas, erosion control devices and diversion drains. • Clean water will be diverted around disturbed areas to avoid additional sediment and contamination. • Earthmoving activities will be minimised during high rainfall events to limit sediment runoff. • Regeneration of the vegetation and restoration of habitat on the property will create vegetation buffers to reduce sediment and nutrient runoff into waterways.	**Medium**

Issue	Potential Impacts	Initial Risk	Mitigation Measures	Residual Risk
Changes to the location of the SW – FW interface	• Reductions in surface water flows causing the interface between salt water and freshwater to move upstream. • Reduction in habitat for freshwater species.	Low	• Project design, to minimise the potential impacts on freshwater flows from surface water and groundwater sources. • No changes to the current flow regime are expected.	Low
Direct fauna mortality	• Mortality of aquatic fauna during clearing of habitat and instream works.	High	• Instream construction works will be carried out during the dry season and permanent water sources within creeks (permanent pools) are not present in the vicinity of instream construction works. • Prior to emptying wetlands or dams, a qualified ecologist will inspect the area and if required, remove aquatic fauna. Any fish that become trapped during construction will be salvaged in accordance with the guidelines for fish salvage (DAF 2020). In the event of a fish kill, the appropriate steps provided in the guidelines will be followed.	Low
Increase in dust, pests and weeds as a result of mining construction and operations	• Reduction in the condition of vegetation and habitats due to an increase in dust from construction and mining operations. • Introduction of pests and weeds.	Medium	• All works will be undertaken in accordance with an EMP, which has extensive controls to minimise the creation of dust and the introduction of new pests and weeds. • A weed and pest management program will be implemented to keep existing pests and weeds at low levels throughout the Project Site.	Low
Downstream Values: Marine Environment and Great Barrier Reef				
Direct disturbance to marine habitat	• Not applicable	-	-	-
Changes to groundwater level and quality	• Reduction in groundwater in flows to estuarine and marine areas.	Medium	• Project design to minimise the areas of creeks that are subject to groundwater drawdown. • Implementation of groundwater monitoring and management plan with appropriate triggers and corrective actions if	Low

Issue	Potential Impacts	Initial Risk	Mitigation Measures	Residual Risk
	• Changes in the quality of groundwater flowing to estuarine and marine areas.		groundwater drawdown exceeds predicted levels and/or extents.	
Changes to hydrology and surface water flows	• Reduction of inflows to creeks and changes to the hydrological dynamics of estuarine areas.	Medium	• Ensure water regime for the Project is designed such that impacts to hydrological regime are minimised. • Implementation of REMP to detect and respond to any unexpected downstream changes.	Low
Increased sedimentation in downstream areas resulting from: • Erosion of streambanks from riparian vegetation dieback • Mine site runoff and • Water releases from mine site (controlled and uncontrolled).	• Bank instability and associated follow-on impacts including degradation of the riparian zone. • Degradation of instream habitat / water quality including downstream estuarine habitat in the Styx River. • Degradation of important downstream habitat and values associated with Broad Sound e.g. FHA and GBR.	Extreme	• Construction will be completed during the dry season where possible, to reduce the potential of construction related erosion and scour. • Implementation of the site ESCP. • Bank stabilisation will take place post-construction to allow for revegetation and reduce scour potential. • A water catchment system and environmental dams (sediment basins) will collect run-off from the development area which will be transferred to the main site dams. • Captured water will be treated to minimise the amount of sediment. • Water will only be discharged from the mine dam during flow trigger events (during/immediately after high rainfall events when creek flow is high). • Discharge of water will be controlled to reduce the likelihood of non-compliant discharges from overtopping. • Landforms such as waste rock stockpiles will be constructed using erosion-resistant materials and with low batter slope angles to reduce the level of erosion. • Removed topsoil will be placed in designated rehabilitation zones and seeded to minimise erosion. • Installation of sediment fences on the downslope of disturbed areas, erosion control devices and diversion drains.	Low

Issue	Potential Impacts	Initial Risk	Mitigation Measures	Residual Risk
			• Clean water will be diverted around disturbed areas to avoid additional sediment and contamination. • Earthmoving activities will be minimised during high rainfall events to limit sediment runoff. • Implementation of the Deep Creek Revegetation Program. • Destocking and grazing reduction will occur both within the mining lease and upstream offset property.	
Release of mine affected water into downstream areas	• Degradation of water quality including downstream estuarine habitat in the Styx River. • Degradation of important downstream habitat and values associated with Broad Sound e.g. FHA and GBR.	Extreme	• A water catchment system and environmental dams (sediment basins) will collect run-off from the development area which will be transferred to the main site dams. • Captured water will be treated to minimise the amount of contamination. • Water will only be discharged from the mine dam during flow trigger events (during/immediately after high rainfall events when creek flow is high). • Discharge of water will be controlled to reduce the likelihood of non-compliant discharges from overtopping. • Clean water will be diverted around disturbed areas to avoid increases in the concentration of suspended sediment and water quality parameters.	Medium
Changes to the location of the SW – FW interface	• Reductions in surface water flows causing the interface between salt water and freshwater to move upstream. • Reduction in habitat for freshwater species. • Movement of saline wedge in groundwater aquifers impacting groundwater quality.	Low	• Implementation of groundwater monitoring and management plan with appropriate triggers and corrective actions as required. • Implementation of REMP to detect and respond to any unexpected downstream changes.	Low

15.10 Conclusion

This chapter presents the result of the aquatic and marine ecology assessment for the Central Queensland Coal Project. Aquatic and marine ecology values identified within the Project Area through this assessment include:

- Wetland 1 – a GBR wetland of HES located in a GBR WPA
- Wetland 2 – a wetland of GES
- Subterranean, Aquatic and Terrestrial GDEs
- Broad Sound DIWA and FHA
- the GBRWHA, GBRMP and GBRCMP
- marine plants located downstream along the margins of the Styx River and Broad Sound including marine couch, stands of saltmarsh and mangrove species and
- seven conservation significant species including estuarine crocodile, green turtle, flatback turtle, Australian hump-back dolphin, Australian snubfin dolphin, dugong and humpback whale.

The Project has the potential to result in direct and indirect impacts on these values as a result of the establishment of Project infrastructure, groundwater drawdown, surface water changes, increased erosion and sedimentation (including erosion of stream banks), increased abundance or diversity of pest and weeds, and increased dust.

The impact assessment demonstrates that the primary impact of the Project on these values is the establishment of Project infrastructure which will result in the direct removal of aquatic habitat within the Project Site. Specifically, 8.35 ha of waterways providing fish passage will be significantly impacted.

Overall, impacts on stygofauna are considered to be acceptable, as they will result in the localised loss of assemblages that are likely to be well represented in adjacent areas.

Impacts to downstream values are considered to be acceptable as there will be no change to the existing hydrological regime, water quality or groundwater inflows. There will be no change in the location of the freshwater – saltwater interface within surface waters of the Styx River. In addition, the Project will reduce the estimated baseline sediment generation rate of 5,037 t/year to approximately 2,297 t/year under average climatic conditions. Based on this assessment the Project will reduce the sediment load to the downstream environment by approximately 2,740 t/year. This equates to a reduction in the total Styx Basin sediment load of 2.74 % and a reduction in the total Fitzroy Basin sediment load of 0.15%. The assessment also considered non-average, very wet, climatic conditions when sediment might be expected to mobilise more readily and found that, even under non-average wet and very wet conditions, the sediment load from the Project will be less than that of current baseline conditions. An assessment against the Reef 2050 Water Quality Targets indicate that the Project will result in a positive contribution through the expected reduction in sediment load reporting to Tooloombah Creek and Deep Creek.

Measures to minimise, mitigate and monitor impacts on aquatic and marine values will be delivered through the implementation of the EMP and the sub-plans including the WMP, ESCP, REMP, GDEMMP, SSMP and PRCP. In addition, Central Queensland Coal is committed to providing offsets to compensate for the unavoidable direct significant residual impacts on waterways providing fish passage. To acquit this offset requirement a financial settlement offset is proposed to be made in

accordance with the QEOP (Version 1.8; DES 2020b). In accordance with this policy, the financial settlement offset for impacts on fish passage is $208,750.00. The details of the financial settlement offset are provided in the Project's Offset Delivery Plan (ODP, Attachment B) and following DES approval, payment will be made to the Queensland Government's Offset Fund prior to Project commencement.

15.11 Commitments

Central Queensland Coal's commitments in relation to the Project's aquatic and marine ecology assessment are provided in Table 15-19.

Table 15-19: Commitments – Aquatic and Marine Ecology

Commitment
Finalise and implement the EMP including mitigation and monitoring measures, triggers and corrective actions.
Finalise and implement the WMP including operational rules and procedures to manage water within the Project Site.
Finalise and implement the ESCP to be certified by a suitably qualified person, prior to construction.
Finalise and implement the REMP detailing the monitoring and management measures for surface water in accordance with relevant guidelines including triggers and corrective actions.
Finalise and implement the GDEMMP for monitoring all identified GDEs including stygofauna and watercourse pools in the Project Area including triggers which will be evaluated, with corrective actions identified for implementation in response to the monitoring results.
Finalise and implement the SSMP including the development of mitigation and monitoring measures for implementation prior to construction, during construction, during operations and as part of the decommissioning process.
Develop and implement the PRCP describing how final landforms associated with the Project will be rehabilitated after mining activities.
Prior to Project commencement deliver the QEOP financial settlement offset for impacts on fish passage - $208,750.00.