Central Queensland Coal Project

Appendix 10f – Receiving Environment Monitoring Program

Central Queensland Coal

CQC SEIS, Version 3

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Receiving Environment Monitoring Program

Central Queensland Coal

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Contents

List of Figures

List of Tables

Abbreviations

Abbreviation	Description
ANC	Acid Neutralising Capacity
ANZG	Australian & New Zealand Guidelines for Fresh & Marine Water Quality
BACI	Before, After, Control, Impact
CHPP	Coal Handling and Preparation Plant
DES	Department of Environment and Science
DGV	Default Guideline Value
DIWA	Directory of Important Wetlands of Australia
EA	Environmental Authority
EC	Electrical Conductivity
ELA	Eco Logical Australia
EIS	Environmental Impact Statement
ERA	Environmentally Relevant Activity
GDEMMP	Groundwater Dependent Ecosystem Management and Monitoring Plan
GBR	Great Barrier Reef
GBRMP	Great Barrier Reef Marine Park
GBRWHA	Great Barrier Reef World Heritage Area
LOR	Limit of Reporting
ML	Mining Lease
REMP	Receiving Environment Monitoring Program

Abbreviation	Description
RPD	Relative Percent Difference
SEIS	Supplementary Environmental Impact Statement
SSTV	Site Specific Trigger Value
TOC	Total Organic Carbon
WQO	Water Quality Objective

1. Introduction

1.1 Background

Central Queensland Coal proposes to develop a new open cut coal mine and associated infrastructure in the Styx Coal Basin, located approximately 130 km northwest of Rockhampton, Queensland (**Figure 1-1**). The Project is located on Mining Lease (ML) 80187 and ML700022 with a disturbance area of approximately 1,373 ha. The two open cut mine operations will produce up to 10 million tonnes per annum of run-of-mine coal, comprising semi-soft coking coal and high-grade thermal coal.

The Project will include:

- Two open cut coal operations, associated mining activities and mining infrastructure (including waste rock stockpiles, water storage and environmental dams, mine industrial area coal handling and preparation plants (CHPPs) and conveyors)
- A train loadout facility to load coal onto trains and provide a new connection to the North Coast Rail Line, and
- A transport corridor to transport coal from the mine to the train load out facility.

The Project Area is bordered by Tooloombah Creek to the west and Deep Creek to the east. These waterways meet at a confluence downstream of the site (approximately 2.3 km North) which is the highest point of tidal influence. These flow into the Styx River which begins 1 km further downstream (**Figure 1-2**). The Queensland coastal zone begins approximately 8 km downstream from the Project Area and forms Broad Sound estuary, which is located approximately 32 km downstream of the Project (**Figure 1-2**). Broad Sound is listed in the Directory of Important Wetlands of Australia (DIWA) and is part of the Great Barrier Reef Marine Park (GBRMP) and Great Barrier Reef World Heritage Area (GBRWHA).

The receiving environment surrounding the proposed mine has been extensively studied as part of the Environmental Impact Statement (EIS) process for the Project. Impact assessments related to values of the receiving environment have focussed on potential Project-related changes to surface water and groundwater resources, and the associated impacts on ecological values. Key ecological values are associated with aquatic, groundwater dependent, terrestrial, estuarine and marine ecosystems located adjacent to and downstream from the proposed mine.

Central Queensland Coal has prepared a Receiving Environment Monitoring Program (REMP) as part of an amended Supplementary Environmental Impact Statement (SEIS v3; Central Queensland Coal), to be submitted to the Queensland Department of Environment and Science (DES) for assessment under the *Environmental Protection Act 1994*. Submission of the revised SEIS v3 is the final stage of the assessment process for Project, with the proponent having received comments from regulatory agencies on a previous version of the SEIS (v2) in June 2019.

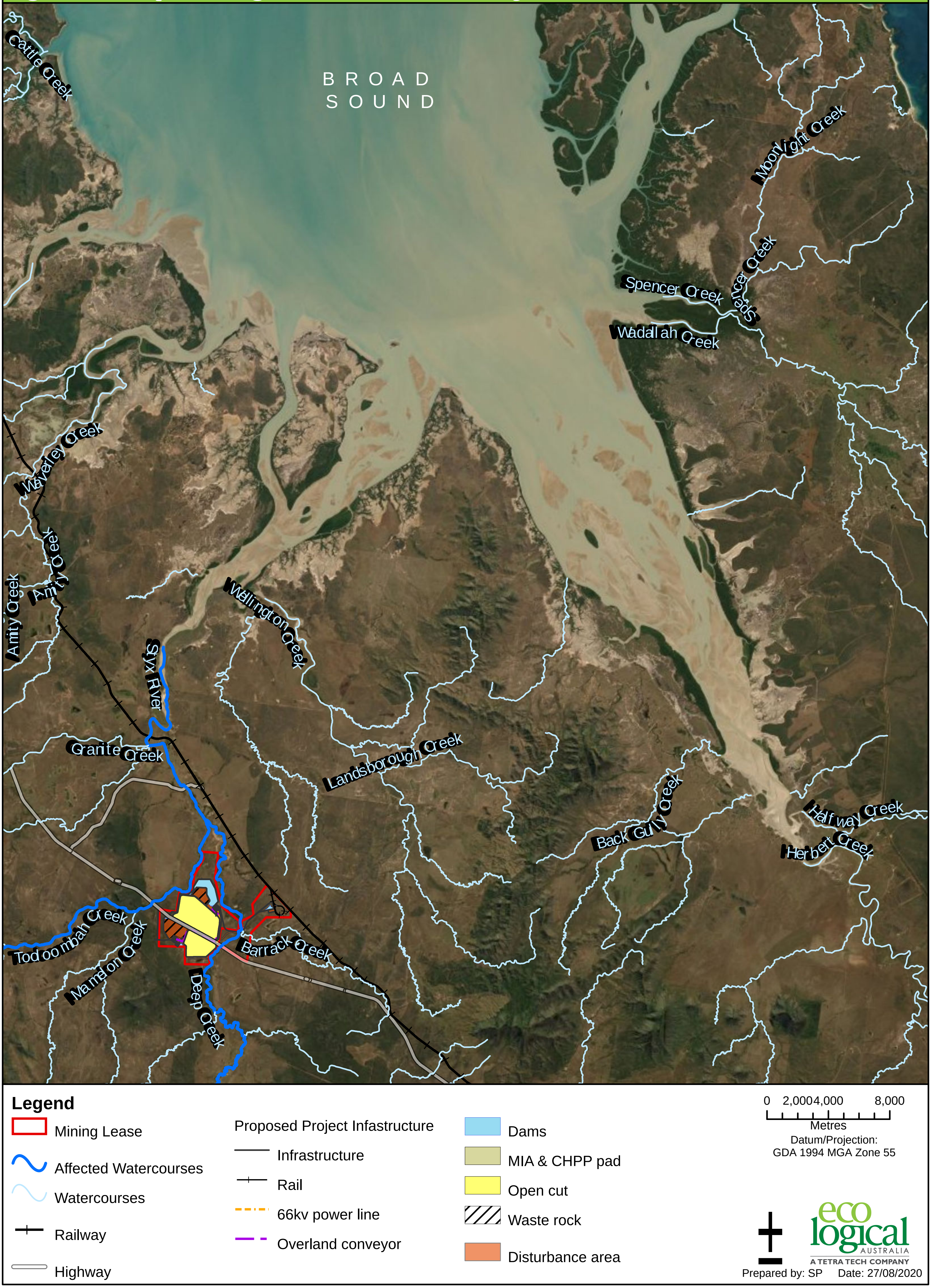
A separate Groundwater Dependent Ecosystem Management and Monitoring Plan (GDEMMP; ELA 2020a) has also been prepared for the Project, which describes the proposed monitoring of GDEs. Additionally, a groundwater monitoring program has been developed and included in the Project Environmental Management Plan. The groundwater monitoring program is based on the results and recommendations arising from a regional groundwater model developed for the Project (HydroAlgorithmics 2020).

Collectively, the REMP, GDEMMP and groundwater monitoring program provide a comprehensive description of the design and implementation of a rigorous scientific monitoring program and relevant indicators of the groundwater and surface water environment of the Project Area and surrounds. Some monitoring tasks described in the REMP and GDEMMP are the same (as the receiving environment contains Aquatic GDEs) and are described in full in each plan.

This REMP has been prepared as a draft, with further updates anticipated in the post-EIS phase of the Project, in accordance with any comments provided by regulatory agencies. Further refinements, review and implementation of the REMP will then be undertaken in accordance with relevant conditions of the Project Environmental Authority (EA) issued under the *Environmental Protection Act 1994*, and in consultation with DES. Future updates will include summary tables of water quality monitoring data and relevant guideline values for the protection of environmental values. During the EIS/SEIS assessment phase, this information is contained within the Surface Water Quality Technical Report of the SEIS v3 (OE 2020).

Figure 1-1: Map showing location of the Project

Figure 1-2: Map showing the location of waterways, basins, and Broad Sound



1.2 Purpose

A REMP is often required to be developed and implemented through the *Environmental Protection Act 1994* for Environmentally Relevant Activities (ERAs) that involve an actual or potential release of contaminants to waters. The requirements of a REMP are based on the nature of the proposed activity and are specified in the relevant EA issued for the ERA. In general, a REMP will describe a plan to monitor, identify and describe any adverse impacts to environmental values of the receiving environment as a result of controlled or uncontrolled releases of wastewater and associated contaminants to the environment, from a regulated activity (DES 2014).

The REMP has been developed in accordance with the Receiving Environment Monitoring Program guideline - For use with Environmental Relevant Activities under the *Environmental Protection Act 1994* (DES 2014). It has been developed with the following overall aim:

- Provide a program to detect potential impacts of mining activities on the environmental values of the receiving environment.

The objectives of this REMP are as follows:

- Assess the current condition of the receiving environment, and summarise the existing (baseline) monitoring data.
- Define additional data collection required to refine site-specific Guideline Values and triggers for further investigation or action prior to operations commencing.
- Outline the monitoring methods to be implemented, data analysis and reporting procedures.
- Apply appropriate design, sampling and data analysis methods (after ANZG 2018; Simpson & Batley 2016; and the *Monitoring and Sampling Manual*; DES 2018).
- Provide a program to detect, at a suitable level of confidence and for a suitable effect size, impacts of the Project on the receiving water environment.
- Collect data that will be used to drive continual improvement in management of the mine construction and operations.
- Utilise hydrological information including modelling and stream flow measurements to enable detailed interpretation of data collected.

The key environmental variables to be monitored as part of the REMP will be surface water quality, sediment quality and physical characteristics, aquatic habitat quality, in-stream macroinvertebrate assemblages, fish assemblages and mangrove distribution. The REMP will be implemented in freshwater streams adjacent to the Project, as well as estuarine and marine environments located downstream within the Styx River Estuary and Broad Sound.

1.3 Guidelines/Standards

A primary objective of the REMP is to assess the potential impacts of mining activities on the environmental values of the receiving environment. A key strategy to achieve this objective is the development and application of appropriate guideline values for the protection of environmental values.

The National Water Quality Management Strategy (NWQMS) presents the overarching national approach to improving and managing water quality in Australia's waterways. The Australian & New Zealand Guidelines for Fresh & Marine Water Quality (ANZG 2018; hereafter the Australian Water Quality Guidelines, or AWQG) are a key part of the NWQMS and provide authoritative guidance on the management of water quality in Australia and New Zealand. The AWQGs are implemented through the Water Quality Management Framework - a framework providing a logical process to be followed for the long-term management of receiving water/sediment quality.

The AWQGs provide guidance on developing monitoring programs, selecting relevant indicators, and adopting relevant guideline values to assess change in receiving environments, including a framework for developing locally derived guidelines.

Note that these newer ANZG (2018) guidelines adopt the term Default Guideline Values (DGVs) rather than trigger values or water quality objectives (WQOs). As such, DGVs are referred to herein in relation to guidelines for protecting receiving waters. WQOs are referred to where they are listed as such under legislative requirements, such as the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP Water and Wetland Biodiversity).

Site Specific Trigger Values (SSTVs) are used herein to denote values that have been selected as triggers, based on the 20^{th} and/or 80^{th} percentiles of reference site data (as described in the Queensland Water Quality Guidelines; QWQG EHP 2013).

In Queensland, the approach to adopting guideline values for receiving waters is:

- Scheduled environmental values (EVs) and water quality objectives (WQOs) under the EPP (Water and Wetland Biodiversity), unless sufficient local data is available to derive improved local SSTVs from appropriate reference sites
- End of catchment anthropogenic pollutant reduction targets in Great Barrier Reef catchments contained in the Great Barrier Reef River Basins, End-of-Basin Load Water Quality Objectives (DES 2019a), derived from the Reef 2050 Water Quality Improvement Plan 2017–2022 (Queensland Government, 2018)
- QWQG (EHP 2013) - in the absence of EPP (Water and Wetland Biodiversity) scheduled values
- AWQG DGVs.

The Styx River basin, including all waters of the basin, Broad Sound and adjacent coastal waters (basin 127 and adjacent to basin 127) are scheduled waters under Schedule 1 to the EPP (Water and Wetland Biodiversity). EVs and WQOs are described for these waters in the document *Styx River, Shoalwater Creek and Water Park Creek Basins Environmental Values and Water Quality Objectives* (DEHP 2014), made pursuant to the previous Environmental Protection (Water) Policy 2009.

The QWQGs provide regional guideline values for Queensland water types and regions, and approaches that complement the AWQGs for Queensland conditions, including a framework for deriving and applying local guideline values (SSTVs). Water monitoring protocols are contained in the Queensland Monitoring and Sampling Manual (DES 2018).

When deriving SSTVs, it is important to use an adequate amount of appropriate data. Ideally, they should be based on at least 2 years of monthly monitoring data from appropriate sites as outlined in the AWQGs. Sites also need to be from unimpacted areas; that is reference sites (commonly located upstream from potential Project impacts, or before Project impacts commence). Additionally, the AWQGs highlight that in systems where water quality is influenced by seasonal events (as are waterways surrounding the Project), monitoring data should include representative results from across various events (e.g. flood flow, no flow).

Further information on the development and application of SSTVs is provided in **Section 4.3**. SSTVs have been established to provide triggers for further investigation and action, with the local statistics generated on the baseline data to be used in the detection of longer term departures from baseline conditions (OE 2020; **Appendix A**). SSTVs have been defined for different waterways of the receiving environment, reflecting differences in baseline water quality conditions. Further information on the derivation of appropriate water quality guidelines for the identified EVs is provided in the Surface Water Quality Technical Report of SEIS v3 (OE 2020). Aquatic ecosystem guidelines are considered appropriate for the protection of other environmental values of relevance to the receiving environment (**Section 2.2**).

Sediments can act as a source or sink for parameters which can then impact water quality and environmental values within the receiving environment. The Interim Sediment Quality Guidelines for toxicants in sediment (ANZECC & ARMCANZ 2000) will be applied when assessing on-site sediment quality data (**Appendix B**). The sediment quality values provided in these guidelines are referred to as Default Guideline Values (DGVs) and 'upper' Guideline Values (GV-High). When assessing sediment quality, the total concentrations of parameters are compared with the DGVs. If the concentration of a parameter exceeds the DGV, tiered investigations should occur to determine whether there is a potential environmental risk associated with the exceedance.

The collection of biological data assists in determining the potential impacts of exceedances of water quality and/or sediment quality guidelines. For example, if relevant guidelines are exceeded at an impact site, then the potential effects on aquatic ecosystem environmental values can be assessed by reviewing the response of biological indicators (such as macroinvertebrates and fish) to the observed increased concentrations of contaminants.

1.4 Continuous improvement

This REMP provides a mechanism for continuous improvement of environmental management in the construction and operation of the Project. Data collected during implementation of the REMP will be used to make an assessment of the adequacy of management measures in place at the mine, and the potential impacts of the Project on the receiving environment. The REMP will be reviewed on an annual basis, with the monitoring design and management measures at the Project updated to address recommendations arising from the REMP findings.

2. Environmental Setting

This section summarises the environmental values of the receiving environment and describes how the Project may impact on these values. Information presented in this section has predominantly been sourced from the revised SEIS v3 (Central Queensland Coal 2020) and is referenced therein.

2.1 Catchment Areas

The Styx River catchment has a total area of approximately 3,013 km^2 and is bordered by coastal mountain ranges to the west, from which a number of waterways drain into the basin and discharge into the coastal waters of the GBR. The main waterway within the basin is the Styx River, which discharges into the Broad Sound estuary, part of the Broad Sound Wetland (listed in the DIWA), the GBRMP and the GBRWHA.

The Project is situated within two sub-catchments of the Styx River catchment; Tooloombah Creek and Deep Creek. Tooloombah Creek has a catchment area of 369.7 km^2 and flows in a north-easterly direction along the western boundary of the Project area. Deep Creek has a total catchment area of 298 km^2 and flows in a north-westerly direction along the eastern boundary of the Project area. The Styx River catchment, sub-catchments and relevant waterways are shown in **Figure 1-2**.

2.2 Environmental Values

Specific environmental values (EVs) and water quality objectives are provided for the Styx River Basin and adjacent coastal waters in the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019 - Styx River, Shoalwater Creek and Water Park Creek Basins Environmental Values and Water Quality Objectives* (DEHP 2014). These values and objectives cover all fresh and estuarine surface waters and groundwaters of the Styx River Basin. EVs for relevant waters within the Styx River Basin are provided in **Table 2-1** (DEHP 2014).

The water quality of waterways within the Project area and surrounding region is classified as high and the catchment is considered to be only slightly modified from its natural condition (ALS 2011). Given the predominantly modified grazing nature of the catchment, a slightly-moderately disturbed ecosystem type is adopted, both for fresh and estuarine waters.

Relevant WQOs from DEHP (2014) and ANZG (2018) for the Styx River Basin's fresh, estuarine, coastal and marine waters are provided in OE (2020).

Table 2-1: Environmental values for waters within the Styx River Basin and adjacent coastal waters

Water	Aquatic ecosystems (slightly to moderately disturbed)	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
SURFACE FRESH WATERS												
Southern Styx fresh waters (including Granite, Tooloombah and Wellington creeks)	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓
ESTUARIES / BAYS, COASTAL AND MARINE WATERS												
Styx River, St Lawrence, Waverly and other creeks (estuarine reaches)	✓		✓	✓		✓		✓	✓			✓
Broad Sound	✓				✓	✓		✓	✓			✓

Source: (DEHP 2014)

Waterways of the Styx River Basin are of value to a range of aquatic ecosystems. A total of 14% of the basin area consists of wetlands (estuarine 265.8 km^2, palustrine 89.7 km^2 and riverine 52.4 km^2; DES 2017).

The primary existing land use of the Styx River Catchment is agriculture (78%), predominantly consisting of cattle grazing. This has resulted in 80% of the land being cleared, leaving some areas prone to erosion. Trampling of waterway banks by cattle also results in impacts on existing aquatic ecology values and surface water quality. Turbidity within waterways can be high during significant flow events when eroded sediments enter the system.

Currently, 15% of the Project Area drains into Tooloombah Creek, with the remainder draining to Deep Creek. These creeks then meet approximately 2.3 km downstream of the Project Area and then flow into the Styx River a further 1km downstream. There are minimal developments along the Styx River, with adjacent lands generally managed for the purpose of cattle grazing. However, the Styx River and surrounding areas has a history of mining coal, minerals and semi-precious gems. Two small scale coal mines were operated in the Styx Basin between 1919 and 1963, but are no longer active.

Due to the minimal development and water use along waterways of the Project Area, potential impacts of the Project on water quality are unlikely to act cumulatively with other projects in the region. Project design, and the widespread cessation of cattle grazing across the site and associated offset areas will also minimise and likely reduce the amount of sediment and associated metals and nutrients entering the surrounding waterways, from what occurs currently under existing baseline conditions. Baseline information on water quality and biological values (**Section 3**) provides a sound understanding of the existing receiving environment, from which monitoring of any Project-related impacts in the future can be established.

2.3 Ecological values of the receiving environment

The receiving environment has a range of ecological values (ELA 2020b), which have been considered in the design of the REMP:

- Tooloombah Creek and Deep Creek are ephemeral waterways, which are supported to varying degrees by seasonal groundwater inflows. The creeks include Aquatic Groundwater Dependent Ecosystems (GDEs), which are supported by the surface expression of groundwater for at least some of the pools within the system. Aquatic GDEs include groundwater fed pools and their associated flora and fauna, as well as riparian vegetation with shallow root systems (e.g. Melaleucas). These trees meet their environmental water requirements in part from soil moisture contained within the creeks. Riparian corridors of the creeks also include groundwater dependent vegetation (Terrestrial GDEs) which utilise sub-surface groundwater held in bank storage or the alluvial groundwater layer. The key groundwater dependent species along the riparian corridors of the Project Area is the Forest Red Gum.
- During the dry season, surface water pools within Tooloombah Creek and Deep Creek persist to varying degrees, depending on their location, local geology and degree of groundwater inflow. Most pools in Tooloombah Creek are permanent or semi-permanent and some receive saline groundwater inputs during the dry season. In Deep Creek, the majority of pools are ephemeral, with minimal groundwater inputs. Pools in Deep Creek generally dry out at various stages during the dry season, with the exception of those in the lower reaches of the creek, which appear to have more consistent groundwater inflows.
- Existing aquatic habitats are subject to significant disturbance from cattle grazing. This includes trampling of stream banks and shallow stream bed habitats to access water from creeks, as well as the introduction of nutrients and bacteria from defecation. Riparian corridors are also subject to patchy and dense infestations of weeds and pests, which reduce their ecological condition.
- A range of aquatic fauna utilise local waterways and estuarine areas located downstream. These include freshwater turtles, macroinvertebrates and fish. Several species with a freshwater and saltwater phase to their life cycle occur in local waterways, including species of fisheries value, such as Barramundi.
- Estuarine and marine areas located downstream of the Project Area are of high conservation value, and include the GBRMP, GBRWHA, Broad Sound Fish Habitat Area and Broad Sound Wetland. These areas provide important habitat for a range of listed species including marine turtles, dolphins, whales and dugong.

The Project has the potential to impact on these aspects of the receiving environment to varying degrees, through both direct and indirect disturbance. In particular, groundwater drawdown in some locations has the potential to reduce the ecological condition of riparian zones, and cause some surface water pools to dry up faster than they do under baseline conditions. Water quality within ephemeral and permanent pools may also be affected by mining, particularly if inputs of saline groundwaters are reduced as a result of groundwater drawdown, by reducing salinity within these pools.

Several improvements in the condition of the receiving environment are also likely to be realised as a result of the Project. These include the cessation of cattle grazing across large parts of the Project area (approximately 2,000 ha), which will result in the rehabilitation of riparian zones impacted by grazing and their associated aquatic habitat features.

Sediment discharges to the receiving environment from currently grazed lands are also predicted to reduce by approximately 50% as a result of destocking, equivalent to a reduction of approximately 2,740 tonnes per year of sediment currently being introduced to local waterways (Engeny 2020). Other measures that are likely to improve the receiving environment include the implementation of weed and pest management measures in riparian zones, and revegetation of disturbed areas, including the widening of the existing riparian corridor through revegetation of a 10 m buffer on land either side of waterways owned by Central Queensland Coal.

The net effect of the above-mentioned Project-related changes to the receiving environment will be monitored through implementation of the REMP.

2.4 Activities with Potential to Impact on the Receiving Environment

2.4.1 Mine infrastructure

The location of key mine infrastructure and its overall layout in relation to the receiving environment is presented in **Figure 2-1**. Surface water runoff that comes in contact with mining infrastructure during the construction and operation of the mine has the potential to result in the release of metals, nutrients and other water quality parameters, and/or sediment, to the receiving environment, which supports a range of aquatic ecosystems and human uses including domestic supply, stock watering and irrigation.

Mining therefore has the potential to reduce the water quality of local waterways and downstream areas, and impact on associated environmental values. The specific infrastructure and mining activities that have the potential to be a source to the receiving environment include:

Coal Handling and Preparation Plant (CHPP):

- Two CHPPs are proposed: one south of the Bruce Highway along the southern boundary of Waste Rock Stockpile 1 and adjacent to Open Cut 1 (CHPP1); and the other north of Open Cut 2 at the south-eastern corner of Dam 1 (CHPP2; **Figure 2-1**).
- Processing of the mined coal occurs at the CHPP and produces reject material consisting of low-grade coal and particulates. The particulates range in size from fine to coarse rejects and are to be co-disposed with waste rock either within the waste rock stockpiles (early in the mine life) or in-pit (when space becomes available as mining progresses (this comprises approximately 1.3% of total waste material; RGS 2020).
- The coal rejects from the CHPP are expected to have a relatively low sulphide content and excess Acid Neutralising Capacity (ANC), which as a bulk mixed material, is expected to be non-acid forming (NAF) and present a low risk of generating acid drainage (RGS 2020).

Waste rock stockpiles:

- Excavated waste rock consists of material that overlies, underlies and sits between the target coal seams (overburden, underburden and interburden respectively). The excavated waste rock is proposed to be stockpiled in two main areas: Waste Rock Stockpile 1 and 2, located on the western boundary of Open Cut 1 and along the northern boundary of Open Cut 2 respectively, with additional waste rock deposited into the pit (**Figure 2-1**).

- Metals/metalloids can leach from the host rock (particularly where acidic conditions occur – see next bullet point) and impact surface water runoff flows that discharge into:
  - Dam 1 (and consequently Deep Creek through controlled releases) from Waste Rock Stockpile 2;
  - Environmental Dam 1B from Waste Rock Stockpile 1; and
  - The shallow alluvial aquifer via groundwater seepage (RGS 2020).
- Geochemical assessments undertaken by RGS (2020) indicate that a large portion of the excavated waste rock and potential coal reject materials is likely to show low sulphide content and are classified as NAF material, with a very low risk of acid generation or producing acid drainage.

Mine dams

- Dam 1 will be constructed immediately adjacent to CHPP 2 (**Figure 2-1**).
- Controlled releases of stored water from Dam 1 may be required over the life of the Project to prevent excessive accumulation of water within the site storages and to mitigate the risk of uncontrolled discharges to the receiving environment. The controlled release system will enable site water volumes to be effectively managed during wet periods when significant inflows to the site water management system are expected. Releases will only occur during flow events in Deep Creek (WRM 2020).
- The water balance model was used to assess the risk of uncontrolled offsite spills from the proposed water management system (WRM 2020). The mine-affected water dams that could potentially overflow directly to the receiving environment (Tooloombah Creek via a spillway) if rainfall exceeds the storage design criteria include:
  - Dam 1 – spilling to Tooloombah Creek;
  - Environmental Dams 2D, 1 and 2 – spilling to Deep Creek; and
  - Dam 4 – spilling to Deep Creek.

Haul road and access roads:

- The haul road and access road connect CHPP2 to the rail loadout area and rail loop (**Figure 2-1**).
- Contaminants from dust and spills that may occur during the transport of coal from the CHPP to the rail loadout area may potentially be transported to Environmental Dam 2D1 and Environmental Dam 2D2 located along the Haul Road, and Dam 4 at the rail loadout area.

Wastewater streams entering waterways:

- The following may be potentially transferred to water storage areas onsite and the Tooloombah Creek and Deep Creek waterways through surface runoff:
  - Oils from equipment cleaning.
  - Drainage from chemical, fuel and/or oil storage areas located at CHPP 2.
  - Washdown water from vehicle and equipment washdown bays.

Based on the assessment by RGS (2020), the initial and ongoing surface runoff and seepage from waste rock and coal reject materials is expected to be alkaline and have a low level of salinity (and low level of dissolved solids). Consequently, dissolved metal and metalloid concentrations in surface runoff and leachate from the potential coal rejects and bulk NAF waste rock are expected to be low and unlikely to pose a significant risk to surface water and groundwater at the mine storage facilities (RGS 2020). This subsequently applies to the mine dams, haul road and access roads, which may potentially receive overflows from the CHPP and waste rock stockpile areas.

2.4.2 Water discharge

Releases of mine affected water from the site could occur from three locations (**Table 2-2** and **Figure 2-1**):

- Dam 1, under controlled releases to Deep Creek via a constructed flow release structure (when sufficient flow is in the creek)
- Dam 1 as uncontrolled releases during larger events to Tooloombah Creek via a constructed spillway, and
- Dam 4 as uncontrolled releases to a tributary of Deep Creek.

In addition to these releases, there may be releases of water from sediment dams, which will be managed in accordance with the Erosion and Sediment Control Plan (the draft plan is included in the SEIS v3, Appendix A15a Central Queensland Coal 2020).

Controlled releases from Dam 1 will occur as part of the mine affected water release strategy. Water will be stored on site in Dam 1 and will be discharged from a specified release point to Deep Creek. Water discharged from this location has the potential to impact the receiving environment and will be required to be managed in accordance with EA conditions. Water quality will be monitored at the release point in accordance with the release strategy, and to assist in evaluating the effects of water discharges on the receiving environment.

Water will only be discharged from the release point during specified flow events (during and immediately after high rainfall events when creek flow is high), and only if the water quality parameters meet the water quality release limits outlined in the EA. The predicted controlled release volumes from Dam 1 are 2,790-2930 ML/a (very wet year 1%ile), 780-1430 ML/a (wet year 10%ile), up to 40 ML/a (average year 50%ile) and zero for dry years (WRM 2020).

The water balance model (WRM 2020) was used to assess the risk of uncontrolled releases from the mine water management system. For Dam 1, this would occur via a spillway to Tooloombah Creek. The risk of uncontrolled releases is very low (~1% for the life of the mine, increasing to 10% per year for Dam 1 after the first 10 years of mining). For the Environmental Dams and Dam 4, which are sediment dams and include settlement of sediments prior to release, there is a very low risk of overflow throughout the life of the Project (1%).

If controlled and uncontrolled releases do occur, modelling predictions indicate that the concentrations of key parameters at locations in Deep Creek, Tooloombah Creek and at the confluence of the two creeks will be well within the range of the typical historical receiving water concentrations for each parameter examined (WRM 2020).

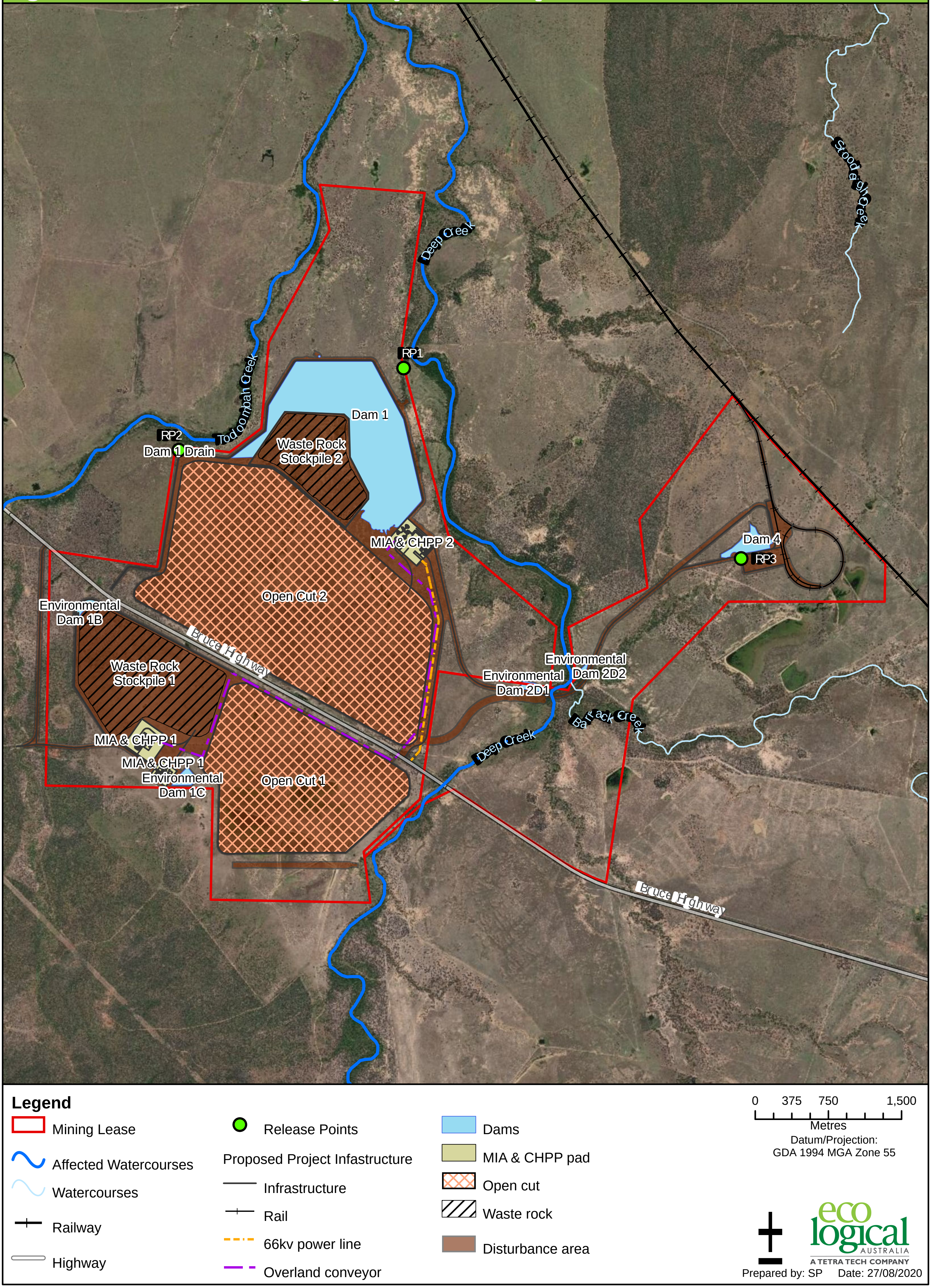
Runoff, wastewater and sediment released from the mine into the receiving environment has the potential to contain a number of parameters, depending on the source and storage arrangements of the water. Key water quality parameters potentially changed as a result of the Project include:

- pH
- Suspended solids and turbidity
- Sulphates
- Salinity (measured as electrical conductivity or total dissolved solids)
- Nutrients (from disturbance of soils, groundwater dewatering)
- Metals (from leaching from waste rock and disturbance and leaching of soils, groundwater dewatering), and
- Hydrocarbons (fuel).

Table 2-2: Project mine affected water release points

Release Point	Coordinates (Lat, Long)	Water source and location	Monitoring point	Receiving waterway
RP1	-22.675868, 149.669363	Dam 1 Controlled Release Waste Rock Stockpile 2, CHHP2 and associated MIA area, haul road, access road. Sources water from Open Cut 1 and 2, Environmental Dams 1B, 1C, 2D and Dam 4.	Sampling tap on riser pipe outlet	Deep Creek
RP2	-22.683835, 149.647105	Dam 1 Spillway As above	As close as practical to the spillway in Dam 1	Tooloombah Creek
RP3	-22.692928. 149.703360	Dam 4 Rail loadout and product stockpile pad, haul road	Sampling tap on riser pipe outlet	Deep Creek tributary

Figure 2-1: Mine water storage (dams) and release points



3. Existing data

Historical data relevant to the REMP is provided by a number of surveys that have been completed within the Project Area and surrounding environments as part of baseline studies for the EIS and SEIS. The following sections summarise the existing baseline data relevant to the design and implementation of the REMP.

3.1 Streamflow and hydrologic regime

The streamflow and hydrologic regime of waterways surrounding the Project varies substantially. Deep Creek is classified as a minor, non-perennial creek (BoM, 2011). The creek is responsive to rainfall and is highly turbid. During the dry season, the riverbed is mostly dry except for a series of disconnected pools (mostly temporary). Groundwater / bank storage inputs to pools are higher within increasing distance downstream (ELA 2020b). Bank storage is feasible, where bank storage within the alluvium is recharged through lateral flow of surface water within Deep Creek during the wet season. Return flow of bank storage back the creek occurs during dry periods. A fault line exists along the channel of Deep Creek in some locations. Stream reaches that are adjacent to the fault line may show a greater loss of groundwater than areas to the north and south – i.e. groundwater is less important in this area to maintenance of pools in the creek.

Available hydraulic conductivities of the Deep Creek alluvial sediments within the mining lease suggest that groundwater flow from bank storage may potentially flow away from the creek to the east. Hence, this is not considered a critical mechanism to sustain GDEs in the region. Therefore, soil moisture and surface water pools within Deep Creek are unlikely to be sustained during the dry season (ELA 2020c).

Tooloombah Creek is also classified as a minor, non-perennial creek (BoM, 2011). Typically, there are three flow events per year within the creek, during which the creek has an average depth of 4 m. These flows are short-lived and occur during larger rainfall events. Low-lying areas of the Tooloombah Creek catchment are subject to flooding and large pools of water occur along the creek during dry periods. Tooloombah Creek likely receives higher amounts of groundwater inflow compared with Deep Creek, and groundwater inputs are likely to maintain water in some of the pools. Both Deep Creek and Tooloombah Creek are ephemeral, with flows occurring for approximately 24% of the time (WRM 2020).

The Styx River is a tidally influenced stream that discharges into the Broad Sound estuary and meets the coast around 32 km downstream of the Project. With the exception of very high spring tides, the tidal influence extends to the Ogmore Bridge, at existing monitoring site St2 (approximately 4.8 km downstream). The peak tidal limit is at the confluence of Deep and Tooloombah creeks (approximately 2.3 km downstream of the Project), which also coincides with both highest astronomical tide, and the presence of marine couch (*Sporobolus virginicus*), indicative of tidal influence. A tidal transition zone is therefore identified between these two points.

During the 2011 aquatic ecology sampling event (ALS 2011), flow velocities were assessed to assist with the interpretation of water quality. Cross-channel flow measurements were originally planned to be taken in the main channel of the creeks sampled, but this was impractical due to a number of conditions including time available, low flow conditions, estuarine crocodiles and overhanging vegetation. Instead, flow measurements were taken where macroinvertebrates or fish were collected, and not necessarily where water measurements were taken. Nonetheless, this process provided some indication of the relative nature of flow conditions experienced at the time of sampling.

More recently, surface water pool level, stream flow and water quality (including pH, Electrical Conductivity (EC), temperature) have been continuously logged at the ALS Gauging Stations (No. 330451 and No. 330452) installed on Tooloombah Creek and Deep Creek, respectively, in October 2019. The first recorded flow event since installation of the gauging stations occurred in January 2020.

Streamflow monitoring results are important when interpreting water quality, sediment quality and aquatic ecology data collected in accordance with the REMP, and will be available through operation of the gauging stations on Tooloombah Creek and Deep Creek.

3.2 Water quality

Surface water quality data is available for a number of sites within the receiving environment between January 2008 to the present, from the following monitoring programs:

- January 2008 to March 2012 – 21 discrete monitoring events by the Fitzroy Basin Association covering mostly storm events
- June 2011 to July 2012 – 12 approximately monthly events by the proponent covering several storm events and otherwise mostly baseflow events, and
- February 2017 to the present – 37 approximately monthly events by the proponent up to 28 May 2020, predominantly 'no flow' events – that is, events with little to no discernible longitudinal flow along the creeks, due to the extended dry conditions.

A summary of the analytes relevant to each year of sampling is provided in **Table 3-1**.

Table 3-1 Water sample testing parameters and methods by year (OE 2020)

Parameter	2011	2012	2017	2018	2019	2020	ALS Method	LOR	Unit
Physico-chemical									
Electrical Conductivity @ 25°C	✓	✓	✓	✓	✓	✓	PC Titrator	1	µS/cm
Total Dissolved Solids (TDS)	✓	✓	✓	✓	✓	✓	EA015	10	mg/L
Total Suspended Solids (TSS)	✓	✓	✓	✓	×	✓	EA025	5	mg/L
Alkalinity (Hydroxide, Carbonate, Bicarbonate, Total) as $CaCO_3$	✓	✓	✓	✓	✓	✓	ED037P	1	mg/L
Nutrients and Major ions									
Sulphate	✓	✓	✓	✓	✓	✓	ED041G	1	mg/L
Chloride	✓	✓	✓	✓	✓	✓	ED045G	1	mg/L
Ammonia	✓	✓	✓	✓	✓	✓	EK055G	0.01	mg/L
Nitrite	✓	✓	✓	✓	✓	✓	EK057G	0.01	mg/L
Nitrate	✓	✓	✓	✓	✓	✓	EK058G	0.01	mg/L
Total Kjeldahl Nitrogen as N	✓	✓	✓	✓	✓	✓	EK061G	0.1	mg/L
Total Nitrogen	✓	✓	✓	✓	✓	✓	EK062G	0.1	mg/L
Total Phosphorus	✓	✓	✓	✓	✓	✓	EK067G	0.01	mg/L
Reactive Phosphorus	✓	✓	✓	✓	✓	✓	EK071G	0.01	mg/L
Fluoride	✓	✓	✓	✓	×	×	EK040P	0.1	mg/L
Dissolved Major Cations (Calcium, Magnesium, Sodium & Potassium)	✓	✓	✓	✓	✓	✓	ED093F	1	mg/L
Total Hardness as CaCO3	×	×	×	×	×	✓	EDO93F	1	mg/L
Total anions/Cations, Ionic Balance	✓	✓	✓	✓	✓	✓	EN055	0.01	mg/L
Dissolved metals and metalloids									
Aluminium	✓	✓	✓	✓	×	✓	EG020F Dissolved metals by ICP-MS	0.01	mg/L
Arsenic	✓	✓	✓	✓	✓	✓		0.001	mg/L
Cadmium	✓	✓	✓	✓	✓	✓		0.0001	mg/L
Chromium	✓	✓	✓	✓	✓	✓		0.001	mg/L
Copper	✓	✓	✓	✓	✓	✓		0.001	mg/L
Iron	✓	✓	×	✓	×	✓		0.05	mg/L
Lead	✓	✓	✓	✓	✓	✓		0.001	mg/L
Manganese	✓	✓	✓	✓	×	✓		0.001	mg/L

Parameter	2011	2012	2017	2018	2019	2020	ALS Method	LOR	Unit
Molybdenum	✓	✓	✓	✓	×	✓		0.001	mg/L
Nickel	✓	✓	✓	✓	✓	✓		0.001	mg/L
Selenium	✓	✓	✓	✓	×	✓		0.01	mg/L
Vanadium	✓	✓	✓	✓	×	✓		0.01	mg/L
Zinc	✓	✓	✓	✓	✓	✓		0.005	mg/L
Antimony	✓	✓	×	×	×	×	EG020F	0.01	mg/L
Barium	✓	✓	✓	✓	×	×		0.1	mg/L
Beryllium	✓	✓	×	×	×	×		0.01	mg/L
Boron	✓	✓	×	×	×	×		0.1	mg/L
Cobalt	✓	✓	✓	✓	×	×		0.01	mg/L
Silver	✓	✓	✓	✓	×	×		0.01	mg/L
Titanium	✓	✓	×	×	×	×		0.01	mg/L
Uranium	✓	✓	✓	✓	×	×		0.001	mg/L
Mercury	✓	✓	✓	✓	✓	✓	EG035F by FIMS	0.0001	mg/L
Total metals and metalloids (from March 2020)									
Aluminium	×	×	×	×	×	✓	1 EG020T: Total Metals by ICP-MS	0.01	mg/L
Arsenic	×	×	×	×	×	✓		0.001	mg/L
Copper	×	×	×	×	×	✓		0.0001	mg/L
Lead	×	×	×	×	×	✓		0.001	mg/L
Manganese	×	×	×	×	×	✓		0.001	mg/L
Molybdenum	×	×	×	×	×	✓		0.001	mg/L
Nickel	×	×	×	×	×	✓		0.001	mg/L
Selenium	×	×	×	×	×	✓		0.01	mg/L
Vanadium	×	×	×	×	×	✓		0.01	mg/L
Zinc	×	×	×	×	×	✓		0.005	mg/L
Iron	×	×	×	×	×	✓		0.05	mg/L
Mercury	×	×	×	×	×	✓	EG035T Total Recoverable Mercury by FIMS	0.0001	mg/L
Bacteriological									
Escherichia coli	×	✓	×	×	×	×	MW006 by MF	1	cfu/100ml
Total Recoverable Hydrocarbons (TRH)/ Total Petroleum Hydrocarbons (TRH/TPH), Aromatic hydrocarbons									
TPH/TRH	✓	×	✓	✓	✓	×	EP080/071	20/50/100	µg/L
Polynuclear Aromatic Hydrocarbons (PAH)	×	×	×	×	✓	×	EP075	1.0	µg/L
BTEXN									

Parameter	2011	2012	2017	2018	2019	2020	ALS Method	LOR	Unit
Benzene	✓	×	✓	✓	✓	×	EP080	1	µg/L
Toluene	✓	×	✓	✓	✓	×		2	µg/L
Ethylbenzene	✓	×	✓	✓	✓	×		2	µg/L
Xylene	✓	×	✓	✓	✓	×		2	µg/L
Naphthalene	✓	×	✓	✓	✓	×		5	µg/L

Surface water quality monitoring datasets have been collected in the Styx River catchment since 2008, at the locations shown in **Figure 3-1**. Water quality sampling events and monitoring sites are summarised in **Table 3-2**. Sampling encompasses a range of flow categories in the receiving environment, including dry, no flow (pooling), baseflow, no flow plus baseflow and stormflow.

Surface water monitoring, including the analytes tested, analytical methods, number of site observations by flow type (stormflow, baseflow, no flow, dry) and site statistics, including SSTVs, are detailed in OE (2020).

Sites De1, De2, De3, De4, De5, To1, To2, To3, St1 and St2 all have more than the 24 sampling events recommended by ANZG (2018) for derivation of SSTVs. While not a concurrent monthly program, the high number of monitoring events, many of which were on a monthly basis, make these data suitable for deriving SSTVs associated with baseline conditions (pre-mine) and the application of Before, After, Control, Impact (BACI) style assessments (**Section 4.3**). Several other sites have been sampled more than 18 times (which is denoted as a suitable number for setting SSTVs in the QWQGs): Gr1, Mo1 and Mo2, and provide good reference site data.

OE (2020) concluded that, based on the data, the sites for which there have been many sampling events are likely to be representative of overall variations in flow conditions within the receiving environment, without any particular bias towards any particular flow regime – i.e. the data is suitably representative of overall conditions. Coverage is deemed suitable to derive SSTVs for the waterways potentially impacted by the Project, and include locations immediately upstream of the Project, adjacent to and downstream of the mine.

Table 3-2 Surface water monitoring locations and sampling effort (OE 2020)

System	Site	Number of events[1]				Number of events by flow category				
		Jan-08 to Mar-11	Jun-11 to Jul-12	Feb-17 to May-20	Total	Dry	No flow (pooling)	Baseflow	No flow + Baseflow	Stormflow
Deep Creek	SW-WMP08	-	-	1	1	-	1 (100%)	-	1 (100%)	-
	De1	-	10 (6f)	36 (1f, 18c)	46	18 (39.1%)	18 (39.1%)	8 (17.4%)	26 (56.5%)	2 (4.3%)
	De2	-	12	36 (11c)	48	9 (18.8%)	27 (56.3%)	8 (16.7%)	35 (72.9%)	4 (8.3%)
	De2.1	-	1	-	1	-	-	1 (100%)	1 (100%)	-
	De3	-	8	37 (14c)	45	13 (28.9%)	24 (53.3%)	7 (15.6%)	31 (68.9%)	1 (2.2%)
	De4	-	-	36 (4c)	36	4 (11.1%)	27 (75%)	4 (11.1%)	31 (86.1%)	1 (2.8%)
	De5	-	-	32 (1f, 2c)	32	2 (6.3%)	25 (78.1%)	4 (12.5%)	29 (90.6%)	1 (3.1%)
	De5.1	-	1	-	1	-	-	1 (100%)	1 (100%)	-
Tooloombah Creek	St1	14	17 (3f)	31	62	-	23 (37.1%)	17 (27.4%)	40 (64.5%)	22 (35.5%)
	SW-WMP02	-	-	2	2	-	2 (100%)	-	2 (100%)	-
	To1	-	12 (1f)	38 (2c)	50	2 (4%)	30 (60%)	14 (28%)	44 (88%)	4 (8%)
	To2	-	6	35 (1c)	41		28 (68.3%)	12 (29.3%)	40 (97.6%)	1 (2.4%)
	To3	-	-	32 (2c)	32	1 (3.1%)	27 (84.4%)	4 (12.5%)	31 (96.9%)	-
	To4	-	-	7 (1c)	7	1 (14.3%)	3 (42.9%)	1 (14.3%)	4 (57.1%)	2 (28.6%)
	ToGS1	-	-	1	1	-	-	1 (100%)	1 (100%)	-
Styx River	St2	-	12	32 (3f)	44	-	-	1 (2.3%)	1 (2.3%)	-
Wetlands	Wet1	-	-	5	5	-	-	-	-	-
	Wet2	-	-	6	6	-	-	-	-	-
Amity Creek	Am1	-	2 (1f)	8 (3c)	10	3 (30%)	2 (20%)	2 (20%)	4 (40%)	3 (30%)

System		Site	Number of events[1]				Number of events by flow category				
			Jan-08 to Mar-11	Jun-11 to Jul-12	Feb-17 to May-20	Total	Dry	No flow (pooling)	Baseflow	No flow + Baseflow	Stormflow
Other Creeks	Barrack Creek	Ba1	-	-	14 (13c)	14	13 (92.9%)	1 (7.1%)	-	1 (7.1%)	-
		Ba1x	-	-	4 (2c)	4	2 (50%)	-	2 (50%)	2 (50%)	-
		Bar02	-	-	3	3	-	1 (33.3%)	-	1 (33.3%)	2 (66.7%)
	Granite Creek	Gr1	-	12	8 (3c)	20	3 (15%)	5 (25%)	8 (40%)	13 (65%)	4 (20%)
	Hefer Creek	Hf1	-	1 (1c)	-	1	-	1 (100%)	-	1 (100%)	-
	Mamelon Creek	Mam01	-	-	4	4	-	1 (25%)	1 (25%)	2 (50%)	2 (50%)
	Montrose Creek	Mo1	-	11	8 (3c)	19	2 (10.5%)	5 (26.3%)	9 (47.4%)	14 (73.7%)	3 (15.8%)
		Mo2	-	11 (1f)	8 (1c)	19	1 (5.3%)	8 (42.1%)	6 (31.6%)	14 (73.7%)	4 (21.1%)
	Neerim Creek	Nee1	-	-	5	5	-	2 (40%)	1 (20%)	3 (60%)	2 (40%)
	Prospectors Creek	Pr1	-	1 (1c)	-	1	-	1 (100%)	-	1 (100%)	-
	Sandy Creek	Sandy01	-	-	2	2	-	-	1 (50%)	1 (50%)	1 (50%)
Estuarine Sites		STL_DS	-	1	-	1	-	-	-		-
		STL_US	-	1	-	1	-	-	-		-
		STYX_DS1	-	1	-	1	-	-	-		-
		STYX_DS2	-	1	-	1	-	-	-		-
		STYX_MID	-	1	-	1	-	-	-		-
		STYX_US	-	1	-	1	-	-	-		-
		WAV_DS	-	1	-	1	-	-	-		-
		WAV_US	-	1	-	1	-	-	-		-
		WELL	-	1	-	1	-	-	-		-

System		Site	Number of events[1]				Number of events by flow category				
			Jan-08 to Mar-11	Jun-11 to Jul-12	Feb-17 to May-20	Total	Dry	No flow (pooling)	Baseflow	No flow + Baseflow	Stormflow
Dams		BPEast	-	-	3 (1c)	3	1 (33.3%)	-	-		-
		Ringtank	-	-	4	4	-	1 (25%)	-		-
		Surveyors	-	-	7	7	-	-	-		-
Other Pools	Tributary to Deep Ck	Dam PL	-	-	1	1	-	1 (100%)	-	1 (100%)	-
	Tributary to Barrack Ck	Pool 19	-	-	1	1	-	1 (100%)	-	1 (100%)	-
	Confluence Deep and Brussels Cks	De_Brussels Pool 7	-	-	1	1	-	1 (100%)	-	1 (100%)	-
	Tributary to Brussells Ck	Br Pool 15	-	-	1	1	-	1 (100%)	-	1 (100%)	-

Table notes:

1 Number refers to total number of sampling events, with the brackets providing, of the total, the number of (f) field only samples; (L) lab only samples; and (c) events where the site was visited, but no records taken (generally because it was dry)

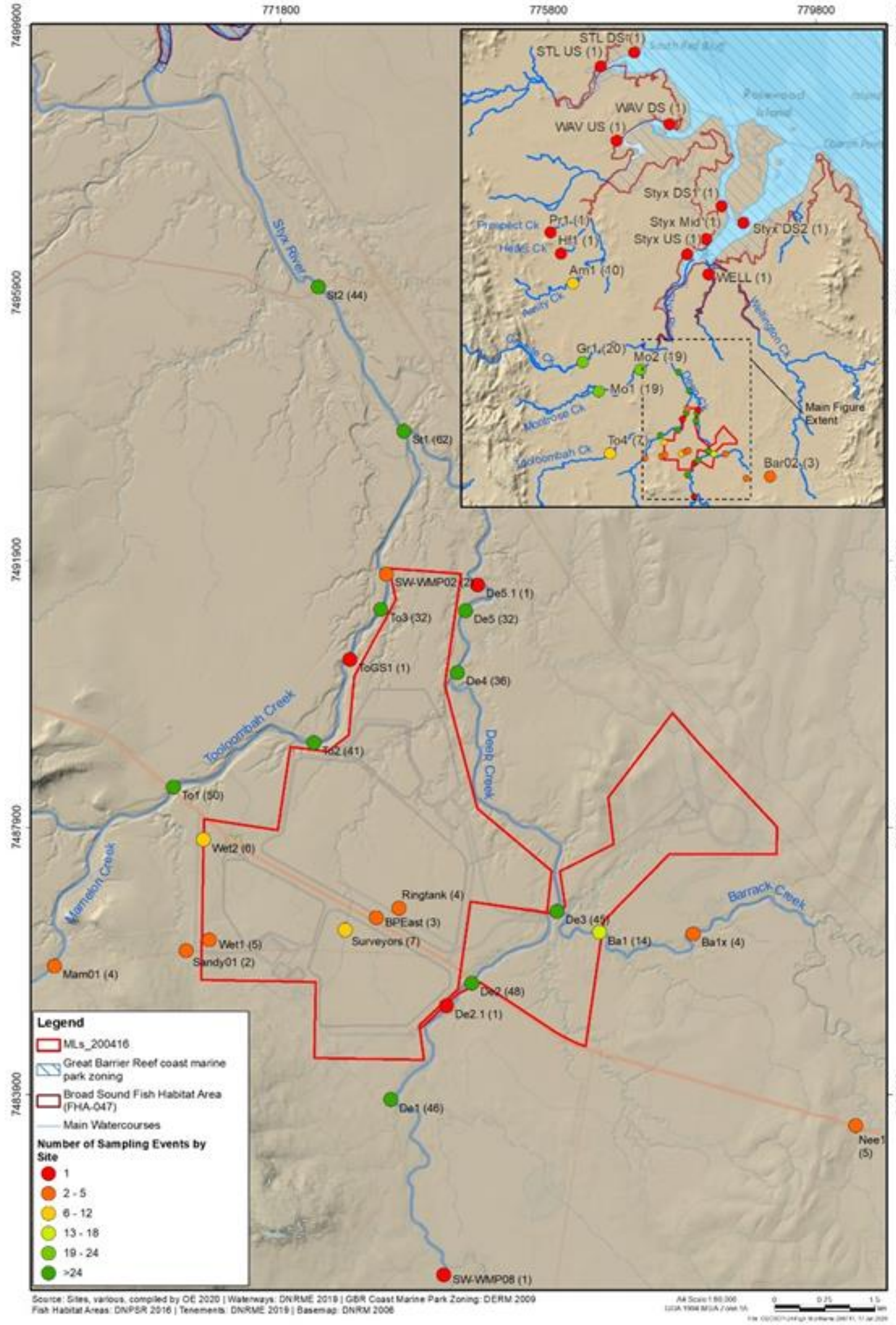


Figure 3-1: Sites where water quality monitoring has been undertaken previously during the Project EIS phase (Central Queensland Coal 2020)

The following sections summarise the water quality results for key waterways relevant to the REMP. Detailed water quality results are provided in the Surface Water Quality Technical Report of the SEIS v3 (OE 2020).

3.2.1 Turbidity

Turbidity within the surrounding waterways shows a seasonal response to rainfall, increasing during periods of residual flow (during the wet season). Deep Creek is typically more turbid than Tooloombah Creek, and is often recorded above the DGV of 50 NTU for the Styx River Basin (DEHP 2014). Turbidity within Tooloombah Creek has only occasionally been recorded to be elevated above the DGV. The difference in turbidity between the creeks is thought to be influenced by channel structure and surrounding land use. The creek bed in Deep Creek is comprised of fine-grained sediments (silts and clays) whereas Tooloombah Creek is mostly rocky (gravel and boulders). The banks of Deep Creek show greater levels of erosion and water flow is also slower than in Tooloombah Creek. Stock access to Tooloombah Creek is minimal compared with Deep Creek, potentially also influencing the level of sediment entering the waterways and being disturbed by cattle.

3.2.2 Electrical conductivity

The Styx River is within the tidally influenced area of the catchment where fresh surface waters from upstream mix with saline marine water, creating a brackish to saline environment. Salinity is highly variable at sampling locations in the Styx River, and varies among seasons due to the influence of tidal cycles and upstream runoff (EC commonly ranges from as low as 125 µS/cm to more than 40,000 µS/cm due to seawater).

Water within Deep Creek is generally fresh, with increases in salinity during and immediately after dry periods, due to evaporation. Salinity within Tooloombah Creek is generally higher than Deep Creek, (ranging from 170 to 2,700 µS/cm EC), and is also generally fresh during periods of flow. Tooloombah Creek likely receives higher amounts of saline groundwater inflow compared with Deep Creek, and groundwater inputs maintain water levels in several pools during the dry season. This groundwater input, paired with evaporation, is thought to be the primary cause of the higher salinity of Tooloombah Creek, when compared with Deep Creek. Overall, local waterways have a highly variable salinity regime with low EC during flow events and high EC within evaporating pools, particularly in Tooloombah Creek.

3.2.3 pH

The pH within the surrounding waterways has a broad range, but is generally between 7 and 8 (slightly alkaline). Elevated pH occurs in Tooloombah Creek during periods of low flow and is likely influenced by groundwater inflows.

3.2.4 Nutrients

Total Nitrogen within Deep Creek, Tooloombah Creek and the Styx River often exceeds the WQO (0.5 mg/L for the creeks and 0.3 mg/L for Styx river) during the dry season. Deep Creek typically has the highest concentrations (median of 2.4 mg/L during non-stormflow periods). Deep Creek also often exceeds the water quality objective for Phosphorus of 0.5 mg/L, as does the Styx River on some occasions.

Concentrations of Ammonia within the waterways are often elevated above the WQO and coincide with increased flows during the wet season. The highest concentrations of Ammonia are observed within Deep Creek and the Styx River.

The results for nutrients show a pattern of high nutrient levels in stormflow reflecting both runoff from the catchment and washout of stored nutrients in pool systems; lower total and ammonia levels in baseflows reflecting the system after this first flush, with nutrients retained in particulate form but loss of oxidised nitrogen stored up in the system during no flow periods (i.e. higher oxidised nitrogen in the water column); and finally elevated nutrients particularly ammonia when flows cease and particularly during extended dry periods in isolated pools, where organic matter is broken down, and altered sediment oxidation / reduction processes may release phosphorous into the water column. These no flow periods appear to be responsible for much of the nutrient processing within the catchment.

The source of these high nutrients are likely to reflect the dominance of cattle grazing in the local catchments, access to waterways by cattle, and both atmospheric deposition and uptake by aquatic organisms, particularly algae and more so when systems are in a no flow state with high temperatures.

3.2.5 Heavy metals

Concentrations of dissolved Aluminium, Copper and Zinc regularly exceed the respective guideline values in local waterways. Concentrations of dissolved Lead above the guideline values are also observed, particularly in the Styx River. This may be due to the interaction between Lead and Chloride in saline waters. Elevated heavy metal concentrations typically occur following rainfall events, although Deep Creek generally has higher Copper concentrations during the dry season. There have been no other significant concentrations of dissolved heavy metals recorded within local waterways. Total metals have not historically been monitored during baseline studies, with monitoring of unfiltered samples only commencing in 2020. While dissolved metals are the appropriate form to determine potential impacts of metals on biota, total metals assists in assessing the suitability of water quality in relation to stock drinking guidelines, as well as assisting with interpretation of dissolved metals results.

3.3 Sediment quality

ALS (2012) undertook estuarine and sediment sampling in local waterways in November 2011. Otherwise, no sediment sampling has been conducted. Monitoring of sediment quality prior to the commencement of the Project is important to understand the existing environment and baseline conditions, which can be compared with results once construction and operation of the Project begins. For this reason, sediment quality monitoring has been included in the REMP, which will include baseline monitoring prior to the commencement of the Project. **Section 5.2** provides further details of sediment monitoring.

3.4 Aquatic Ecology

A detailed aquatic ecology survey was undertaken within waterways of the Project Area from 1 to 6 June 2011. This survey was conducted by ALS Water Sciences and utilised the same sites that were surveyed as part of the water quality sampling in 2011/12. The site in Barrack Creek (Ba1) was not sampled due to a lack of water.

An additional survey was conducted by CDM Smith in 2017 with a focus on the previously surveyed sites. However, De4 was surveyed instead of De3 due to restricted access. **Figure 3-1** provides site locations and **Appendix C** provides detailed site descriptions.

Previous surveys have covered a range of aquatic ecology values including:

- Habitat assessment and water quality
- Aquatic macroinvertebrates, and
- Aquatic vertebrates focussing on fish as well as freshwater turtles in 2017 (additional species were opportunistically sighted or accidentally captured).

Targeted GDE assessments, including stygofauna sampling have also been undertaken, and these are described in the GDEMMP (ELA 2020a).

Macroinvertebrate and fish monitoring will be undertaken as part of the REMP to determine any impacts of the Project to aquatic ecology values in the receiving environment (**Sections 5.3** and **5.4**). The following sections summarise the results of previous monitoring for macroinvertebrates and fish.

3.4.1 Macroinvertebrates

Monitoring of macroinvertebrates has followed the approach detailed in *QLD Australian River Assessment System (AusRivAS) Sampling and Processing Manual* (DNRM 2001) and included sampling within both edge and riffle habitats.

A total of 46 taxa have been observed during site sampling: 31 were recorded within riffle habitats and 35 from edge habitats. Deep Creek had the highest diversity (De2, 24 taxa) within riffle habitats, and the Styx River had the highest diversity with edge habitats (St1, 26 taxa). Tooloombah Creek (To1) had the lowest overall diversity of taxa.

Within the creek sites, Diptera species (from Families Chironomidae and Simulidae) were the most abundant. These species can tolerate a wide range of water quality conditions. Other commonly observed macroinvertebrates included shrimps of the Family Palaeomonidae, Hydropsychidae (caddis flies - Trichoptera), and Caenidae (mayflies - Ephemeroptera). A full list of taxa recorded at each site is provided in the Project SEIS v3 (Central Queensland Coal 2020).

Macroinvertebrate community composition can provide information about habitat quality, stream health and the potential influence of disturbance. Analysis of the taxa observed within the waterways suggests that all of the edge habitats sampled represented minimally disturbed habitats, whereas the riffle habitats varied:

- De1, De2 and Gr1 were more biologically diverse than expected
- De3 and To2 were minimally disturbed and were consistent with the expected condition, and
- To1 was significantly impaired, indicating a decline in health of the river at this site.

It is important to note that results vary according to a range of factors and may not be a representative of the ongoing aquatic macroinvertebrate assemblages. These studies do however provide some level of baseline understanding (and data). This will be further expanded during pre-impact phases of the Project, to assist in identifying any changes to aquatic macroinvertebrate communities as a result of mining activities.

3.4.2 Fish

Fish were sampled using both electrofishing and baited traps during the 2011 (ALS) survey, while only baited traps were used in the 2017 (CDM Smith) survey. Some sites were not sampled (deep pools within Deep Creek) due to evidence of Estuarine crocodiles (*Crocodylus porosus*) being present, and associated safety risks for field personnel.

Fish provide a good indication of aquatic ecosystem function and are a recreational and commercial resource for people. Twenty-eight species of fish have been recorded in the surveyed waterways surrounding the Project, none of which were introduced species. Diversity was highest for sites within the Styx River (St2) and Tooloombah Creek (To1), with up to 15 species being recorded at individual sites. These sites also had large continuous pools of water, more so than the other waterways that were sampled. Fish abundance was highest within Deep Creek and Granite Creek. Overall, the Styx River had the highest diversity with up to 22 species being recorded, and Deep Creek had the lowest diversity (11 species). Such trends are likely to be associated with water availability (Styx River being a permanent waterway, while Deep Creek is highly ephemeral).

As the waterways range from fresh to marine, there were species recorded associated with all aquatic environments (fresh, estuarine and marine). The most abundant and widely distributed species were Eastern rainbowfish (*Melanotaenia splendida*) and Empire gudgeon (*Hypseleotris compressa*), which were recorded at all sites. Two commercially targeted fish species were also observed; Barramundi (*Lates calcarifer*) and Sea Mullet (*Mugil cephalus*). Data analysis identified that Deep Creek had a distinct fish community which is likely to be a result of its shallow stream habitat when compared with the deep and more permanent pool habitats of the other waterways.

A full list of species recorded at each site is provided in the Project SEIS v3 (Central Queensland Coal 2020).

3.5 Marine habitats

There have been some assessments of marine habitats in the estuarine waters of the Styx River Estuary and Broad Sound as part of the baseline studies to support the project EIS. These assessments were generally desktop in nature, supported by limited field studies to ground truth the presence of values. Given the proximity of the Project to coastal waters, marine habitats are considered to be part of the receiving environment and relevant to the REMP.

The Styx River Estuary and Broad Sound contain a variety of marine habitats, with mangroves being the dominant value within the estuary, providing important habitat to fish and other marine fauna. Saltmarsh also occurs in patches in the upper range the inter-tidal zone, but is not likely to be sensitive to Project-related impacts. There are no known seagrass beds in close proximity to the Project. This is most likely a consequence of the high turbidity of estuarine waters, and large tidal range of Broad Sound. The distribution and extent of mangrove habitats in the Styx River estuary and adjacent Waverley Creek estuary will be monitored as part of the REMP using satellite imagery, with details provided in **Section 5.5**.

3.6 Assimilative Capacity

The assimilative capacity of the receiving environment refers to the ability of the environment to receive wastewater and/or toxic substances without experiencing adverse effects to the environment and its users (both aquatic organisms and human). The assessment of the assimilative capacity of the receiving environment for the Project is based upon:

- The difference between current concentrations of water quality parameters and the relevant water quality objectives, whereby some parameters may already be elevated.
- Comparisons between concentrations of water quality parameters at sites currently impacted by human-use (e.g. cattle crazing) and control sites that are not currently (or minimally) impacted.
- The current health and sensitivity of ecological values that are present within the receiving environment.
- The potential for cumulative impacts, based upon current discharges of wastewater and/or toxic substances and the discharge that is to be expected from the Project.

Monitoring conducted as part of the REMP will allow the assimilative capacity of the receiving environment to be regularly assessed and updated based upon any changes to water quality following commencement of the Project.

Turbidity within Deep Creek already exceeds the freshwater GV of 50 NTU, while within Tooloombah Creek the GV is exceeded only occasionally (the median is below 50 NTU). Deep Creek is generally more turbid, particularly so during no-flow events in pools, which may indicate pugging by cattle and/or suspension of fine-grained sediments present within the creek bed. These are mobilised during flow events and cattle access, and do not readily settle. The banks of both creeks show evidence of erosion and the surrounding land use (cattle grazing) may result in high levels of sediment entering the waterways.

The Styx River is much less turbid than Tooloombah Creek and Deep Creeks, generally not exceeding 30 NTU during monitoring periods. This indicates that suspended sediment within Tooloombah Creek and Deep Creek is substantially diluted within the Styx River (or settles to the bed prior to reaching it), and any small increases in turbidity would be negligible at downstream locations such as Broad Sound and the GBR.

The natural seasonal variability in turbidity indicates that the receiving environment is tolerant of high turbidity, and the Project has the potential to improve turbidity within local waterways, with extensive areas to be destocked (approximately 2,000 ha). A sediment budget for the Project site estimated that existing sediment inputs to local waterways will be reduced by approximately 50%, resulting in a net reduction in sediment inputs of over 2,700 tonnes per year (Engeny 2020).

The sediment target for the Styx River Basin in the *Reef 2050 Water Quality Improvement Plan 2017–2022* (Queensland Government 2018) is to maintain the current load. Given the above, it appears there is no further assimilative capacity in the receiving environment for turbidity and sediments.

Although electrical conductivity often exceeds the freshwater ANZECC guideline value of 20 - 250 µS/cm within both Deep Creek and Tooloombah Creek, this does not suggest that the assimilative capacity is met or almost met. Within Tooloombah Creek, salinity ranges from 170 to 2,700 µS/cm EC and is considered to be a result of the natural saline groundwater inflows and evaporation. Salinity within Deep Creek is also highly variable, falling within the ANZECC guideline value after rainfall events before increasing as a result of evaporation during extended dry periods. Such patterns are commonly observed in ephemeral systems that experience extended dry periods (ANZECC & ARMCANZ 2000).

Nutrient concentrations within the receiving environment including Nitrogen, Phosphorus and Ammonia often exceed the respective GVs for the Styx River Basin. This is likely due to the high proportion of land that is subject to cattle grazing, including direct access by cattle to waterways. These concentrations suggest that the receiving environment is currently close to or at its assimilative capacity for nutrients, but that this could be reduced with proposed destocking of extensive parts of the Project Area.

Aluminium often exceeds the GV in all three waterways and may be close to the assimilative capacity of the receiving environment. Copper and Zinc concentrations peak following rainfall events, but then return to concentrations below GVs. Lead also follows this trend, except within the Styx River where it is often elevated above the GV. The receiving environment may be approaching assimilative capacity for these metals. However, if elevated concentrations are only short-lived after periods of heavy rainfall, the biological effects of these elevations are unlikely to be significant. In addition, the proposed water management system for the mine will result in the capture of runoff and treatment of water prior to release to the environment. Such treatment does not currently occur under baseline conditions.

Monitoring of biological indicators such as macroinvertebrates allows for a more detailed assessment of the receiving environment's assimilative capacity. The results of previous macroinvertebrate sampling indicate a higher than expected abundance and diversity of taxa for many of the sites within all three waterways. Some sites had low abundance and diversity during extended dry periods, but this is to be expected within ephemeral systems.

Overall, the results suggest that any current impacts to water quality of the receiving environment are not significantly impairing the environmental values of aquatic communities, and indicate that the receiving environment is tolerant of periods of reduced water quality. Existing stressors on the quality of the receiving environment include access by grazing cattle, and associated disturbance to aquatic habitats and water quality (high turbidity and nutrient concentrations).

4. Rationale of REMP design

This section explains the rationale for the monitoring program which has been designed in accordance with:

- *Receiving Environment Monitoring Program guideline - For use with Environmental Relevant Activities under the Environmental Protection Act 1994* (DES 2014)
- the Department of Environment and Science *Monitoring and Sampling Manual* (DES 2018)
- AWQGs (ANZG 2018, ANZECC & ARMCANZ 2000), and
- the Queensland Water Quality Guidelines (DEHP 2013)

The specific monitoring variables, indicators, frequencies and sites are described further in **Section 5**.

4.1 Selection of environmental variables to be monitored

When choosing parameters to monitor, it is important to select those which are likely to be sensitive to the potential impacts of the Project (DES 2014). It is important that monitoring has a clear link with water quality parameters that may be produced by the Project and impact the aquatic ecosystem values. **Table 4-1** provides a summary of the environmental variables to be monitored, and their link with project activities. This description is informed by the SEIS v3 for the Project and associated impact assessment (Central Queensland Coal 2020).

Table 4-1: Environmental monitoring parameters

Environmental variable	Summary of key indicators	Rationale for inclusion
Stream flow	Flow rate (cubic metres per second)	Allows for the description of flow conditions within the receiving environment during REMP monitoring. This assists with the interpretation of the results of other environmental variables, which may be influenced by the flow state of waterways.
Water quality	Turbidity, TSS, Temperature, DO, pH, EC Total metals, dissolved metals, various ions Nutrients Total recoverable hydrocarbons	The Project is located upstream of the Broad Sound Estuary, significant wetland areas, the GBR, and GDEs. Activities including controlled and uncontrolled surface water discharges to the receiving environment, coal dust and groundwater seepage may potentially influence water quality and impact the receiving environment and associated environmental values.
Sediment quality	Metals (<2 mm fraction), Particle size distribution	Sediments may act as a 'sink' for metals that are discharged to the receiving environment. The nature of sediment discharges is also likely to change as the land use transitions from cattle grazing to mining. Sediment data will support the interpretation of surface water quality data and assist in identifying impacts on the receiving environment that may result from the Project.
Macroinvertebrates	Species presence, abundance AusRivAS indicators	Macroinvertebrates are reliable indicators of aquatic ecology ecosystem values, as they are responsive to changes in water quality and flow. The AusRivAS system has been well-established for implementation in the assessment of impacts on the receiving environment and

Environmental variable	Summary of key indicators	Rationale for inclusion
		specifically, aquatic ecology values. In the event that water quality objectives are exceeded, macroinvertebrate data facilitates an assessment of whether biota in the receiving environment have been affected.
Fish	Species presence, abundance Assessment of body condition (e.g. presence of ulcers)	The receiving environment is habitat for several fish species that utilise the freshwater, estuarine and marine areas of local waterways. Many of these species are migratory during periods of flow. The presence and abundance of fish will assist in assessing impacts of the Project on aquatic ecology values, with body condition assessments providing insight into potential chronic effects of reduced water quality, if present.
Mangrove distribution	Area (ha) occupied by mangroves using aerial photography	The Project is located in close proximity to the tidal waters of the Styx Estuary, GBR and Broad Sound Fish Habitat Area. Activities of the mine may affect the condition of marine habitats downstream, through changes to water quality or sediment inputs. There are no seagrasses in close proximity to the Project. However, mangroves are widespread throughout the estuary, and may increase or decrease their distribution as a result of sediment accumulation or erosion. The extent of mangrove habitat will be mapped in the Styx River and Waverley Creek estuaries using satellite imagery. This will be undertaken to determine whether changes are occurring that may be related to the Project.

4.2 Location of sampling sites

Receiving environment monitoring locations need to include both receiving water reference sites (located upstream of any Project-related impacts or in nearby catchments) and impact sites (located downstream of the influence of Project-related activities), to allow for an adequate assessment of Project impacts on the receiving environment. It is also important to take into account that sites well suited for monitoring of water and sediment quality, may not be appropriate for biological monitoring.

As Deep Creek and Tooloombah Creek are both ephemeral waterways, sites should preferably be located where there are pools so that water is more likely to be present during sampling events year-round, and seasonal variances in water quality can be determined. Such an approach also allows interpretation of water quality under varying waterway flow states (e.g. flowing waterway vs evaporating pools).

As discussed in **Section 3**, historical monitoring of water quality and aquatic ecology has occurred at a several sites within the receiving environment, with information recorded on the flow state of each site at the time of monitoring. It is preferable to continue monitoring at these historical sites where extensive baseline data exists. This approach will allow ongoing comparisons of water quality within the receiving environment with baseline data, as well as conditions in reference sites. The application of Before, After, Control, Impact (BACI) statistical approaches is also facilitated by utilising extensive baseline data (**Section 3**).

Not all historical sites will be utilised for monitoring as part of the REMP. These historical sites were used when collecting data for the EIS, and may not be necessary or practical for ongoing monitoring as part of the REMP. A subset of these sites has been chosen for monitoring during implementation of the REMP, to achieve monitoring objectives. The monitoring sites were determined to be the best-available, based on the following criteria:

- Optimal location as either a reference or impact site for determining potential impacts of the mine on the receiving environment
- Availability of extensive baseline monitoring data (sites with the most historical records)
- The likely presence of surface water throughout most parts of the seasonal cycle, and
- Provide safe and reliable access for monitoring teams.

Monitoring sites are listed in **Table 4-2** and their locations are shown in **Figure 4-1**.

To provide robust data for each waterway, eight reference sites and eight impact sites (plus one streamflow monitoring site) have been selected for the receiving waterways of Tooloombah and Deep Creek and three impact sites have been selected for the Styx River and downstream estuary. In addition, two sites have been selected within a nearby estuarine creek within Broad Sound Estuary (Waverley Creek), downstream of reference sites in the Waverley Creek catchment. The Waverley Creek estuarine sites have been classified as ‘adjacent estuarine sites’ rather than reference sites, as they are influenced by tidal waters of Broad Sound. The Waverley Creek estuarine sites will provide data on the receiving environment in a nearby estuarine creek, which is located much further from the Project than other estuarine sites. In addition, two mangrove areas have been established for long term monitoring of their area and extent using satellite imagery. In total, there are 24 monitoring sites (**Table 4-2**).

Table 4-2: REMP monitoring sites

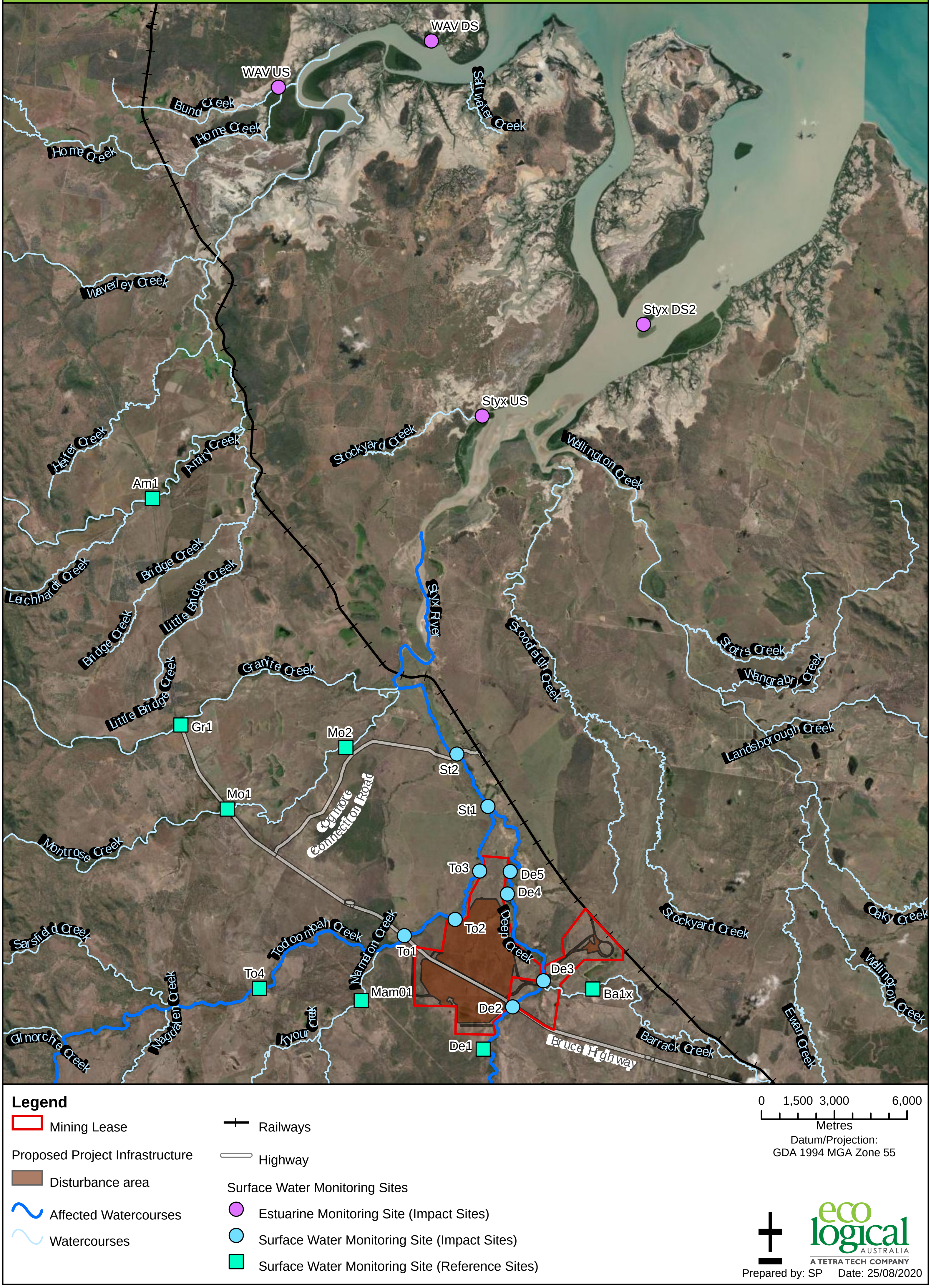
Monitoring points	Receiving waters location description	Latitude (DD, WGS1984)	Longitude (DD, WGS1984)	Flow	Water quality	Sediment quality	Macroinvertebrates	Fish	Mangroves
REFERENCE SITES									
Deep Creek – De1	Deep Creek; located outside the ML boundary, upstream of mine releases.	-22.730855	149.662329		X	X	X	X	
Mamelon Creek - Mam01	Mamelon Creek, located outside the ML boundary, upstream of mine releases	-22.713587	149.613052		X	X			
Tooloombah Creek – To4	Tooloombah Creek - located outside the ML boundary, upstream of mine releases	-22.709663	149.572218		X	X	X	X	
Montrose Creek - Mo1	Montrose Creek – in neighbouring catchment to the north. Outside of ML boundary and not influenced by mine	-22.643217	149.558003		X	X	X	X	
Montrose Creek – Mo2	Downstream of Mo1 – in neighbouring catchment to the north. Outside of ML boundary and not influenced by mine	-22.619549	149.605151		X	X			
Granite Creek – Gr1	Granite Creek - in neighbouring catchment to the north. Outside of ML boundary and not influenced by mine	-22.612223	149.538864		X	X	X	X	
Barrack Creek – Ba1x	Barrack Creek – located outside of the ML boundary, upstream of mine releases	-22.707751	149.705870		X	X			
Amity Creek – Am1	Amity Creek – in separate catchment to the north. Outside	-22.528043	149.525899		X	X			

Monitoring points	Receiving waters location description	Latitude (DD, WGS1984)	Longitude (DD, WGS1984)	Flow	Water quality	Sediment quality	Macroinvertebrates	Fish	Mangroves
	of ML boundary and not influenced by mine.								
IMPACT SITES									
Tooloombah Creek – To1	Tooloombah Creek; located outside the ML boundary, adjacent to mining influences	22. 689145	149. 629895		X	X	X	X	
Tooloombah Creek – To2	Tooloombah Creek; located outside the ML boundary, adjacent to mining influences in close proximity to uncontrolled release discharge point	-22.682790	149.650164		X	X	X	X	
Tooloombah Creek – ToGS1	Tooloombah Creek gauging station; located outside the ML, adjacent to mining influences in downstream of uncontrolled release point	-22.671494	149.655248	X					
Tooloombah Creek – To3	Tooloombah Creek; located outside the ML boundary, downstream of mining influences and uncontrolled release discharge point	-22.664615	149.659619		X	X	X	X	
Tooloombah Creek – St1	Tooloombah Creek; located outside the ML boundary, downstream of the mine discharge point, at the confluence of Deep and Tooloombah Creeks. At the point of the peak tidal limit.	-22.640529	149.662461		X	X	X	X	

Monitoring points	Receiving waters location description	Latitude (DD, WGS1984)	Longitude (DD, WGS1984)	Flow	Water quality	Sediment quality	Macroinvertebrates	Fish	Mangroves
Deep Creek – De2	Deep Creek, located within mining lease adjacent to mining influences	-22.714938	149.673824		X	X	X	X	
Deep Creek – De3	Deep Creek and Barrack Creek junction, located within mining lease adjacent to mining influences	-22.705021	149.685977		X	X	X	X	
Deep Creek – De4	Deep Creek, located outside the ML immediately downstream of controlled discharge location	-22.672976	149.670908	X	X	X	X	X	
Deep Creek – De5	Deep Creek; located outside the ML boundary, downstream of controlled discharge location.	-22.664591	149.671887		X	X	X	X	
Styx River – St2	Styx River at the Ogmore bridge; located outside the ML boundary, downstream of the mine discharge point, past the confluence of Deep and Tooloombah Creeks, and the normal tidal limit.	-22.621245	149.649665		X	X		X	
Styx River - Styx US	Styx River Estuary, located where the river widens before flowing to Broad Sound	-22.495319	149.657414		X (Quarterly)	X			
Styx River – Styx DS2	Styx River Estuary, located at the entrance to the Styx River upstream of where it meets Broad Sound	-22.460139	149.721296		X (Quarterly)	X			

Monitoring points	Receiving waters location description	Latitude (DD, WGS1984)	Longitude (DD, WGS1984)	Flow	Water quality	Sediment quality	Macroinvertebrates	Fish	Mangroves
NEARBY ESTUARINE SITES									
Waverley Creek - WAV US	Waverley Creek, where the creek broadens and meets the estuary	-22.374336	149.573557		X (Quarterly)	X			
Waverley Creek - WAV DS	Waverley Creek, where the creek meets Broad Sound	-22.356136	149.634410		X (Quarterly)	X			
MANGROVE ANALYSIS									
Styx Mangrove area	Styx River Estuary, near the entrance to Broad Sound	**Section 5.5**							X
Waverley Creek Mangrove area	Waverley Creek Estuary, north of the Styx River Estuary	**Section 5.5**							X

Figure 4-1: REMP monitoring sites



4.3 Application of BACI Approach and Development of SSTVs

As there are extensive baseline data established prior to the commencement of mining activities, there is an opportunity to utilise BACI approaches for the statistical analysis of water quality data. BACI statistical approaches have the benefit of considering water quality conditions prior to establishment of the mine, and how these might have changed in response to mining, compared with suitable reference locations.

As noted above, the relevant DGVs for the Project area are contained in the *Styx River, Shoalwater Creek and Water Park Creek Basins Environmental Values and Water Quality Objectives* (DEHP 2014), made pursuant to the previous Environmental Protection (Water) Policy 2009. As also discussed above, many of the DGVs in that document are not directly applicable to the immediate receiving waters of Deep and Tooloombah Creeks, the St1 confluence or St2 Styx River sites, nor to some of the other reference creek sites. As such, SSTVs are relevant to the Project and have been derived.

The relevant SSTVs adopt the 80^{th} percentile of reference site data for upper limits, and the 20^{th} percentile for lower limits. Non-compliance with the SSTVs is determined where the median at an impact site exceeds the 80^{th} percentile of reference site data (or is lower than the 20^{th} percentile for those parameters with a lower range), as recommended by the AWQGs. For toxicants where the 80^{th} percentile of reference site data is lower than the DGV, the approach adopted by the AWQGs is to instead compare the 95^{th} percentile of monitored data with the DGV, since action is often required sooner for parameters with potential biological effects.

These approaches have the effect of testing for a specific change in the receiving waterways using pre-operational data to set SSTVs (the 'before' component of the BACI approach). When combined with reference sites, this provides for the 'control' sites, and comparing the results of monitoring at impact sites with those of reference sites provides the 'after' and 'impact' components of the BACI approach, allowing the influence of mining activities to be determined. In the event that impacts are detected, the degree to which these extend downstream to the Styx River and Broad Sound can also be determined from sites in the estuarine receiving environment. Measurement along stream reaches also provides a gradient type approach to detecting changes at different distances along the creeks beside the Project.

Ephemeral systems can be highly variable in their environmental conditions, depending on the season and recent rainfall. Other factors influencing water quality, sediment quality and aquatic ecology values in the receiving environment for this Project include natural groundwater inflows, surrounding land uses of cattle grazing and associated erosion of drainage lines, gullies and streams. Deriving SSTVs for local conditions assists in neutralising the effects of these factors, which may not be related to the Project.

Sites De1, De2, De3, De4, De5, To1, To2, To3, St1 and St2 all have more than the 24 sampling events recommended by ANZG (2018) for derivation of SSTVs. While not a concurrent monthly program, the high number of monitoring events, many of which were on a monthly basis, make these data suitable for deriving SSTVs associated with baseline conditions (pre-mine) and the application of Before, After, Control, Impact (BACI) style assessments. Several other sites have been sampled more than 18 times (which is denoted as a suitable number for setting local guidelines in the QWQGs), including Gr1, Mo1 and Mo2, and provide good reference site data.

The results of the REMP will be compared with relevant DGVs and SSTVs as follows:

- Physicochemical stressors: median site concentration for a given parameter will be compared with the 80th percentile value for that parameter from the Reference site(s). While the QWQG specify use of the 75th percentile for EC, the 80th percentile has been adopted, due to the high variability in salinity in the receiving environment and the ephemeral nature of the systems (OE 2020). Being highly ephemeral, the natural systems are acclimated to relatively large changes in EC.
- Toxicants: the 80th percentile of reference site data exceeds the relevant DGV for a given parameter, the median concentration will be compared with the 80th percentile value for that parameter from the reference site(s). Where the 80th percentile of reference site data is lower than the relevant DGV for a given parameter, the 95th percentile value at a site will be compared with the DGV.

The analysis and additional BACI statistical methods to be applied are described in **Section 6**. The process of guideline development, a description of its application and the conclusions arising from BACI statistical methods will be included within the annual REMP report (**Section 7**).

4.4 Timing and frequency of sampling

The timing and frequency of sampling will vary for each environmental variable of the monitoring program. Sampling will be undertaken in accordance with the program shown in **Table 4-3**. This program has been designed to capture variability associated with the seasonality of flow events. Due to the ephemeral nature of the surrounding creeks, sampling may not always be possible at all sites during dry periods, particularly in Deep Creek where most surface water pools do not receive groundwater inflow (ELA 2020b).

Stream flow gauges were installed as part of the EIS investigations and monitor stream flow continuously. This will remain in effect during implementation of the REMP, allowing for variations in stream flow to be recorded. Such approaches are particularly important when monitoring ephemeral watercourses which are subject to sudden changes in stream flow during and following periods of rainfall.

Water quality monitoring will be conducted monthly, with sampling undertaken during or immediately following flow events in a month where flow occurs. Monitoring of water discharged to the receiving environment will also occur daily while discharge is occurring. The high frequency (monthly) of water quality monitoring reflects the variability in this aspect of the receiving environment, which can change rapidly in response to changing conditions in the receiving environment.

Sediments are often a ‘sink’ for metals and other parameters that settle out of the water column and accumulate in areas of low flow. Sediments can also be a source of high concentrations of some parameters if disturbed through flooding or other disturbance processes. Sediment quality is expected to be less variable than water quality, with key periods prioritised for sampling being the start and end of the wet season, when sediments are wet and may have accumulated parameters from surrounding land uses over the previous six months.

Biological sampling requires special consideration in ephemeral systems. Both the *Monitoring and Sampling Manual* (DES 2018) and REMP guidelines (DES 2014) state that macroinvertebrate sampling should not be conducted during high flow conditions or when waterways are dry. Rather, sampling should occur between 4 – 6 weeks after high flow has subsided to allow enough time for populations to recover and stabilise. The Macroinvertebrate sampling will therefore take place at the start of the wet season approximately 4-6 weeks after the first flush (most likely between October-November). Additional sampling will take place at the end of the wet season before semi-permanent water dries up during the dry season (May-June). This approach is consistent with recommendations in the Queensland AusRivAS manual (DNRM 2001), and will provide insight into the aquatic ecology assemblages of Aquatic GDEs (groundwater fed pools).

Fish monitoring will follow the same monitoring protocol as macroinvertebrates, with the addition of a targeted sampling of surface water pools within Tooloombah Creek and Deep Creek. This will occur prior to the wet season (first flows), to determine how the fish assemblages of pools persist through the dry season (August-September).

Table 4-3: Monitoring timing and frequency

Environmental variable	Frequency	Timing
Stream flow	Continuous	Collected continuously
Water quality	Monthly at freshwater sites, timed to coincide with flows in months when creeks flow Quarterly at marine / estuarine sites After release from mine	All year (when water is present) • Sampling will be undertaken on a monthly basis for freshwater sites, the St1 confluence and St2 site within the Styx River • Sampling will be undertaken on a quarterly basis for marine sites (Styx US, Styx DS2, WAV US and WAV DS) • During flow events, sampling of freshwater sites will be timed to occur 1 – 2 days after the first flush during wet season • Sampling of freshwater sites will occur during and/or in the days immediately following releases from the mine, provided safety and logistical constraints can be satisfied (it may not be safe to conduct sampling at all sites during and immediately after flood events)
Sediment quality	Twice per year	At the start of the wet season approximately 4-6 weeks after the first flush (October-November) Post wet season when flows have ceased (June-July)
Macroinvertebrates	Twice per year	At the start of the wet season approximately 4-6 weeks after the first flush (October-November) Post wet season when flows have ceased (May-June)
Fish	Twice per year. A third survey will occur at selected pool sites.	At the start of the wet season approximately 4-6 weeks after the first flush (October-November) Post wet season when flows have ceased (May-June)

Environmental variable	Frequency	Timing
		A targeted sampling of surface water pools within Tooloombah Creek and Deep Creek will occur prior to the wet season, to determine how the fish assemblages of pools persist through the dry season (August-September)
Mangrove area and location	Once every three years	A desktop assessment of the size and location of mangrove areas in the Styx River Estuary and adjacent Waverley Creek Estuary will be completed every three years, as part of the annual report. The timing of the assessment will be determined once the annual reporting cycle has been established, and a program of acquiring satellite imagery on this basis has also been secured.

Where possible, environmental variables will be sampled at a similar time to assist with data interpretation. In particular, water and sediment sample collection should occur at the same time as macroinvertebrate and fish sampling (where monitoring occurs at the same sites).

5. Monitoring Program

5.1 Water quality

5.1.1 Monitoring Sites

Water quality monitoring sites are described in **Table 4-2** and shown in **Figure 4-1**. Reference sites have been selected to allow for the development of SSTVs.

5.1.2 Parameters

Table 5-1 provides the parameters to be measured.

Table 5-1 Water quality parameters to be measured

Characteristic of Water Quality	Type of Testing	Parameter
Physico-chemical	Field EC to be also analysed at the laboratory	Electrical Conductivity, pH, Dissolved Oxygen, Temperature, Turbidity, Oxidation-Reduction potential (Redox)
Major Cations and Anions	Laboratory	Alkalinity (Hydroxide, Carbonate, Bicarbonate, Total) as $CaCO_3$, Hardness, Sulphate, Chloride, Fluoride, Dissolved major cations (calcium, magnesium, sodium and potassium)
Total and dissolved (field filtered) metals and metalloids	Laboratory	Aluminium, Antimony, Arsenic, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Mercury, Molybdenum, Nickel, Selenium, Vanadium and Zinc
Nutrients	Laboratory	Ammonia, Nitrite, Nitrate, Oxidised Nitrogen (Nitrate + Nitrite), Total Kjeldahl Nitrogen, Total Nitrogen, Total Phosphorus, Reactive Phosphorus
Organics	Laboratory	Total Recoverable Hydrocarbons
Flow	Field Gauging station data portal	An estimate of flow during each sampling event at each site, and collection of quantitative flow data from the Deep and Tooloombah Creek gauging stations

5.1.3 Field sampling procedures

Water quality will be sampled at each site as described in **Section 4.4**. *In situ* monitoring will be undertaken for pH, EC, Turbidity, Dissolved Oxygen, Temperature and Redox, using a calibrated water quality meter. Water samples for laboratory analysis will be collected and stored in appropriately preserved and labelled containers provided by a National Association of Testing Authorities (NATA) accredited laboratory, and placed on ice for storage before being transported to the laboratory for analysis within laboratory specified holding times.

Containers will be labelled with the Project ID, monitoring site, initials of the personnel collecting the sample and time/date. Sample numbers, dates and analytical requirements will be recorded on Chain of Custody forms. Field-filtered water samples (e.g. for dissolved metals/metalloids) will be collected using disposable syringes and 0.45 µm filters.

The collection of water samples will be completed during various flow periods: dry, no flow (pooling), baseflow, no flow plus baseflow and stormflow. The flow characteristics at each site at the time of sampling will be recorded on the field data sheet and with the results, once received from the laboratory. Notes of other field conditions such as oil sheens, odour and weather conditions, will be recorded on the field data sheet and in a photo. Stream flow monitoring gauges will assist in the interpretation of results obtained from no flow periods.

5.1.4 Laboratory Analysis

Water samples will be processed by a NATA accredited laboratory for the parameters listed as such in **Table 5-1** (including EC, which will be tested in the field and by the lab, as a quality assurance method). The limit of reporting will be sufficiently low to determine whether water quality is above or below the guideline values and an assessment of potential impacts will be made on environmental values of the receiving environment.

5.1.5 Quality Assurance and Quality Control

In accordance with the QWQGs, additional Quality Assurance / Quality Control (QA/QC) samples will be collected, at a rate of 10% of the primary samples collected. This will comprise:

- A duplicate sample, collected by splitting the collection between two sets of bottles, to obtain as close to identical samples as practicable (when decanting, sample bottles are filled incrementally switching between each so that the water is as close as possible in both bottles) – this provides the primary sample, and the duplicate sample. The duplicate sample will be labelled 'DupA' or similar and recorded on the field sheet as a duplicate of that site (the site of the duplicate will be unknown to the laboratory). This sample will assist in determining the level of variation in the analysis of samples from the same location by minimising sample differences
- A replicate sample, collected by first collecting the primary sample and filling sample bottles, and then collecting a second sample (the replicate). The replicate should be subject to *in-situ* field testing as well as laboratory analysis, and should be collected from the same location as the above duplicate sample if practicable. The replicate sample will be labelled 'DupB' or similar and recorded on the field sheet as a replicate of that site (the site of the replicate will be unknown to the laboratory). This aims to test the variation in sampling plus laboratory analysis in samples from the same location.

The Relative Percent Difference (RPD) will be calculated for each parameter, to compare how similar the results of the duplicate are with the site sample. If values are less than 10 times the LOR, there is no RPD limit. If values are between 10 and 20 times the LOR, then the acceptable RPD range is 0-50%. If values are 20+ times the LOR, then the acceptable RPD range is 0-20%. If the RPD thresholds are not met, further investigation and assessment is required to determine if the sample should be retested, resampled, discarded or if the result is still valid and instead reflects inherent high variability of the parameter in the receiving environment.

A field blank will also be collected during each round of water quality sampling. This involves filling sampling containers with deionised water while in the field, using the protocols applied to the collection of water samples from waterways (e.g. deionised water is field filtered for dissolved metal/metalloid analysis). The blank samples are labelled 'blank' and stored with the other samples for monitoring sites.

If contamination of the blank sample is indicated by the results (concentrations above the LOR), then the results of other samples should be interpreted cautiously and further investigation undertaken.

5.2 Sediment Quality

5.2.1 Monitoring Sites

Sediment quality monitoring sites are described in **Table 4-2** and shown in **Figure 4-1**. Preferred sampling locations are areas where there is a low flow and pooled water, as these areas provide conditions for contaminants or fines in sediment-laden water to deposit under low flow velocities.

5.2.2 Parameters

The following sediment contaminants will be measured:

- Metals (Total digest on <2 mm fraction): Aluminium, Antimony, Arsenic, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Molybdenum, Mercury, Nickel, Selenium, , Vanadium and Zinc
- Particle size distribution (PSD), and
- Total Organic Carbon (TOC).

5.2.3 Field sampling procedures

Sediment samples will be collected once during the wet season after the creeks have been flushed at least once by rainfall, and once at the end of the wet season when flows have ceased, but where water remains present.

At each sampling site, a total of 10 sub-samples will be collected from the vicinity of the site, to ensure appropriate characterisation of the sediment. The sub-samples will be collected from the surface sediments (0-50 mm below surface), and target the sediments likely to mobilise during flow events. Samples will be collected using a suitable sampling device such as a food grade plastic spoon, trowel or Van Veen grab (from a vessel), taking care to avoid potential sources of contamination from sampling equipment. For sites where vessel-based sampling is required using a Van-veen grab, three grab samples (sub-samples) will be collected for at site.

Each sub-sample will be placed in a suitable container (e.g. glass or food grade plastic bowl) so collected sediment samples can be homogenised using a food grade plastic spoon. The composite sample will be placed into laboratory-prepared sampling containers for sample transportation. Sampling containers will be supplied by laboratories accredited by NATA for the analyses to be undertaken.

Containers will be labelled with the Project ID, site location, initials of personnel collecting the sample and the time and date. Containers will then be sealed and stored in a chilled insulated box for transport to the laboratories for analysis within the laboratory specified holding time. Sample numbers, dates and analytical requirements will be recorded on Chain of Custody forms.

As the collected samples are to be sieved in the laboratory for analysis of the <2 mm fraction, as well as being subject to particle size distribution analysis, a minimum of one 250 g laboratory grade sediment sampling jar, plus two food-grade 500 g zip lock bags, will be collected at each sampling location.

The sampler will record the following at each site:

- Sampling conditions (e.g. the sediment is wet / dry, flow state)
- Soil description (moisture, grain, colour etc.) of each sample collected, with the aim of collecting representative samples from each site, and
- GPS coordinates of each sampling site.

5.2.4 Laboratory Analysis

Sediment samples will be processed by a NATA accredited laboratory for parameters listed in **Section 5.2.2**. The laboratory will sieve whole sediment samples to the <2 mm fraction, with the sieved fraction analysed for metals. The laboratory limit of reporting will be sufficiently low to determine whether sediment quality is above or below the sediment quality guidelines (**Appendix A**), and make an assessment of potential impacts on environmental values. PSD and TOC for each sample will also be determined to assist in the interpretation of results, and allow for the assessment of changes in sediment characteristics for each site over time.

5.2.5 Quality Assurance and Quality Control

Cleaning of sediment sampling equipment will be undertaken between collection at each site. This will involve cleaning of the equipment (e.g. Van-veen grab, trowel, bowl) using phosphate-free detergent. Disposable gloves will also be used throughout sampling events.

A duplicate sediment sample (split sample) will be collected at one monitoring site during each round of sampling. This will be used to assess analytical precision (level of variation) of the samples. Duplicates will be unknown to the assessing laboratory. The RPD will be calculated for each parameter, to compare how similar the results of the duplicate are with the site sample. If values are less than 10 times the LOR, there is no RPD limit. If values are between 10 and 20 times the LOR, then the acceptable RPD range is 0-50%. If values are 20+ times the LOR, then the acceptable RPD range is 0-20%. If the RPD thresholds are not met, then the sample should be retested by the laboratory. If the result is the same (outside of the acceptable RPD range), then the result will be discarded.

5.3 Macroinvertebrates

5.3.1 Monitoring sites

Macroinvertebrate monitoring sites are described in **Table 4-2** and shown in **Figure 4-1**.

5.3.2 Field Sampling procedures

Monitoring will follow the approach detailed in AusRivAS (DNRM 2001). Macroinvertebrate samples will be collected twice per year from freshwater sites as described in **Section 4.4**. Sites will be sampled at least four weeks after the first flush to allow for colonisation of stream habitats. The timing of sampling at each site after the first flush should remain consistent from year to year.

Three replicate macroinvertebrate samples will be collected from both the edge habitat and riffle habitat at each site (if both habitats are present). A 250 µm mesh net will be used to perform a standardised 10 m sweep of edge habitats. The net will be washed with clean water between each sample collection. Samples will be field picked and placed into sorting trays. The samples will be preserved in 80% ethanol for later identification.

Field observations (including photographs) and a physical habitat assessment will be performed at each site in accordance with AusRivAS procedures. The habitat assessment will include assessment of riparian vegetation composition and integrity, as well as bed and bank features.

5.3.3 Laboratory Analysis

Samples will be identified to family level (or to a level recommended by AusRivAS; Chironomids will be identified to sub-family) in a laboratory by appropriately qualified personal. The abundance of each taxon will be calculated.

5.3.4 Quality Assurance and Quality Control

Sample collection and picking should be overseen by qualified personnel (AusRivAS-accredited) whom should remain consistent throughout the duration of each monitoring event. A residual sample will be collected during each survey for each field pick operator. Quality assurance/quality control checks will be undertaken by an AusRivAS-accredited ecologist at each stage of laboratory processing.

5.4 Fish Monitoring

5.4.1 Monitoring sites

Fish monitoring sites are described in **Table 4-2** and shown in **Figure 4-1**.

5.4.2 Field Sampling procedures

Two fish surveys will be completed at each site per year, during and following wet season flows as described in **Section 4.4**. The wet season survey will be undertaken when waterways are flowing and there is connectivity along the waterways. The post-wet season survey will be completed in the early stages of the dry season, and focus on describing the fish assemblages of pools (for freshwater reaches). A third fish survey will be completed at the end of the dry season, only at sites containing pools of water. This survey will determine the extent to which fish persist through the dry season within ephemeral reaches of the creek (which is relevant when assessing the impacts of groundwater drawdown on fish habitat values).

Survey methods will be adapted to suit the local conditions (freshwater or estuarine), and also to address the risk to field teams for estuarine crocodiles. It is anticipated that survey methods will be refined once regular monitoring commences, and a suitable combination of techniques can be established for each site.

The following methods will be used in accordance with the conditions of animal ethics and general fisheries permits:

- Baited traps and cast nets targeting small fish
- Gill nets from vessels targeting large fish (gill nets to be attended and/or checked on an hourly basis)
- Electrofishing from a vessel or using backpacks (where the risk of crocodiles can be managed in shallow water)

- Angling targeting large fish such as Barramundi.

Baited traps will be set opportunistically at sites and include both sides of the waterway/pool. The traps will be set overnight and any species captured will be identified and released. Electrofishing will be undertaken using either back-pack electrofishing units for shallow sites or from an electrofishing boat at deeper sites. Up to two hours will be spent at each site, sampling suitable habitats.

Cast netting will be used as a supplement to baited trapping, targeting small fish. Gill nets will be used if site conditions permit (sufficient water depth and minimal to no water flow), and subject to restrictions of regulatory agencies. Angling will also be used as an alternative method to target large fish.

All captured fish will be identified to species level and then released at the same site from which they were captured. Up to 20 individuals of each species should be measured (total length) and given a general health assessment (identify the presence of deformities, parasites, tissue/fin damage).

Water quality monitoring should occur at the same time as fish monitoring. If this is not possible, a minimum of *in-situ* water quality sampling should be undertaken at each site as per procedures in **Section 5.1.3** to assist with interpretation of the results. Field observations and conditions will also be recorded at each site and photographs of the site will be taken.

5.4.3 Quality Assurance and Quality Control

Sampling will be performed by qualified aquatic ecologists in accordance with the conditions of animal ethics and fisheries permits.

5.5 Mangrove habitat

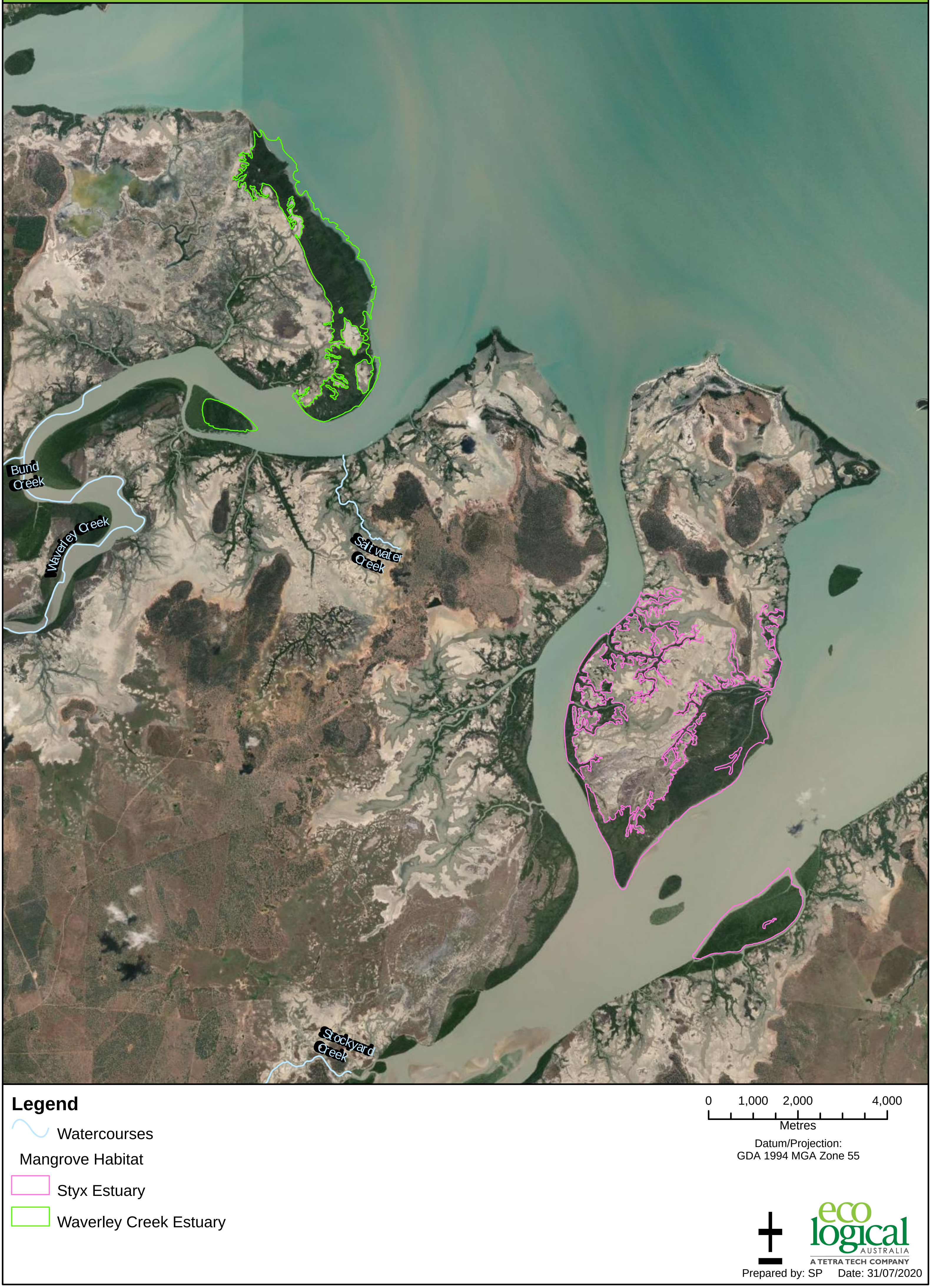
A desktop assessment will be completed of the size and extent of mangrove habitats at the entrance of the Styx River Estuary and Waverley Creek Estuary to Broad Sound. The assessment will utilise recent satellite imagery, and involve the following key steps:

- A recent satellite image for the area will be acquired, as close as possible to the period 3 months prior to the annual report being submitted.
- The image will be opened in a GIS software program, with the boundary of the mangrove forests shown in **Figure 5-1** traced into a polygon. The monitoring locations were chosen on the basis of their large and intact boundaries which can be easily measured from satellite imagery, and their varying locations in receiving waters downstream from the mine.
- The polygon will be overlaid with polygons from previous assessments with the following calculated:
    - Area of mangrove habitat within each polygon
    - Relative differences in the extent of each polygon from the previous assessment and baseline assessments

Results of the study will provide an ongoing assessment of whether there are changes in the spatial extent of mangroves in the lower estuary. The Waverley Creek Estuary has been chosen as a comparable site in a similar location, where water and sediment quality information are available. Monitoring of this estuary will assist in determining whether any changes in the Styx River Estuary are more widespread.

In the event that a significant change occurs (increase or decreases in mangrove area or extent), then on site ground truthing will be undertaken to investigate the potential causes and evaluate mangrove tree health indices.

Figure 5-1: The location of mangrove habitats to be assessed annually for spatial extent and area



6. Data Analysis

6.1 Water quality

The program design and the data analysis is based on a BACI type design, where before-after data is compared, and control-impact data offers the ability to determine whether changes are likely due to Project operations, or wider changes in the aquatic environment. A two-stage approach to analysis is adopted for water quality:

1. Comparison of the results of each sampling event and the median of the previous year's results against guideline values, using control charting approaches as outlined in the AWQG.
2. Where guideline values are exceeded, comparison of the deviation from the median for control sites vs impact sites, aiming to identify trending departure from baseline indicative of Project impacts.

The control charting approaches outlined in the AWQG for both comparison to guideline values and control-impact sites are to be adopted. An example of such an approach is shown in **Figure 6-1** for total nitrogen, where the impact site is the Deep Creek De3 site, and the control site is the upstream site De1. As can be seen, exceedances occur in some individual events, but overall the median remains below the trigger value. As a departure from median, the changes are mirrored at both sites and it can be seen that the changes reflect changes within the overall system rather than any particular site impacts (which are not present).

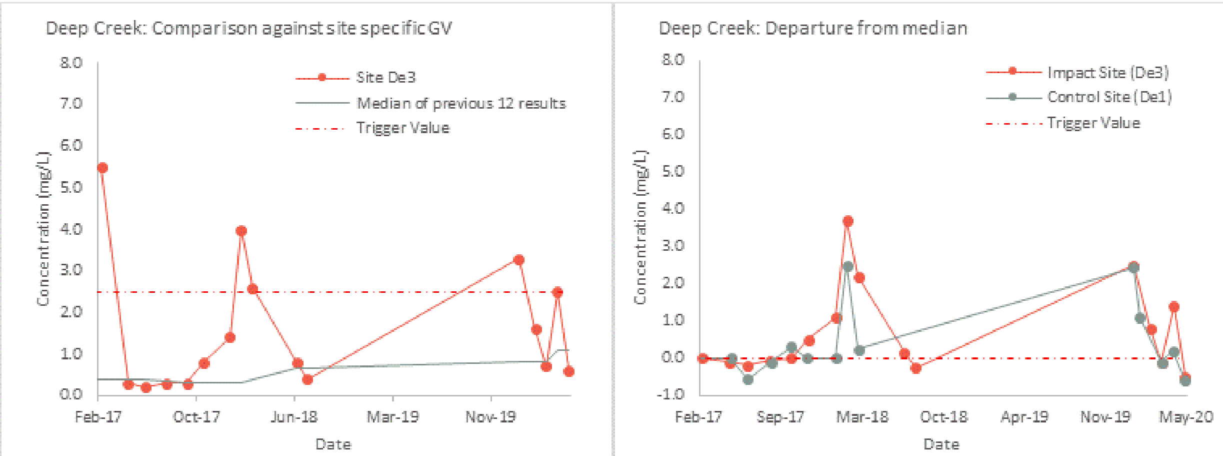


Figure 6-1 Example of Control Charts – Total Nitrogen

Dissolved metals results will be used to interpret water quality results in relation to the protection of aquatic ecosystem environmental values at the 95% level of protection (slightly to moderately disturbed). As the toxicity of some metals to biota varies according to hardness concentrations, hardness corrected guideline values will also be used in accordance with the AWQGs. Total metals results will be used in relation to the protection of livestock drinking values, using the livestock drinking guidelines provided in the AWQGs.

If an exceedance of an aquatic ecosystem guideline value occurs, results of macroinvertebrate and fish monitoring will be used to determine if the change in water quality has impacted biological values within the receiving environment. Assessment will occur over an annual cycle to account for seasonal differences in water quality. The assimilative capacity of the receiving environment will be assessed and updated annually, based on the water quality data.

Monitoring data collected in accordance with EA conditions during and after the release of mine affected water to the receiving environment will also be collated and analysed. The purpose of this assessment will be to determine the impact of discharge events on the receiving environment. These will be considered individually in the annual REMP report.

The existing monitoring database will be used as a continuous record of historical water quality data and new data as it is collected, as well as flow conditions and site data from field observations. This will allow the site and hydrological conditions at the time of sampling to be considered when analysing water quality data. Guideline values will be refined based on the results of monitoring data collected from the reference sites (see **Section 4.3**), and will be calculated for a variety of flow states, to assist in interpretation of monitoring results.

6.2 Sediment Quality and Physical Characteristics

Sediment metals results (<2 mm fraction) will be compared with relevant guideline values as described in the sediment quality guidelines of ANZECC (2018) and Simpson and Batley (2016; **Appendix B**). Particle size distribution results will be used for interpretation and analysed to determine if there are long term trends or changes in the composition of sediment fractions in the receiving environment.

As sediment quality has not been previously monitored in the receiving environment, initial monitoring will focus on establishing a baseline data set. This will assist in describing the type and nature of sediments of the receiving environment, and inform future updates of the REMP, which may involve the collection of additional sediment for analysis of <63 µm grain sizes, and application of the dilute acid extraction laboratory methods, if sediments regularly exceed the guidelines values for the <2 mm fraction. Results of sediment quality at reference and impact sites will be compared with guideline values to assess the potential impacts of mining on environmental values of the receiving environment.

Assessment will occur annually to account for seasonal differences in sediment quality. If an exceedance above DGV occurs, assessment via the decision tree process described in the guidelines will be followed (ANZG 2018; Simpson and Batley 2016). This process will incorporate water quality, macroinvertebrate and fish monitoring data to assist with interpretation and to determine if sediment quality is impacting biological values in the receiving environment.

Particle size distribution results will assist in the interpretation of sediment quality data. This will include providing insight into the type of sediments present in the receiving environment (e.g. clay, silt, sand, gravel) and whether grain size is an important influence on sediment quality. The Project has the potential to change the composition of sediments in parts of the receiving environment, through discharges of mine affected water, and from the cessation of cattle grazing across large parts of the Project Area (a known source of sediment inputs to the GBR).

Total Organic Carbon measurement can be used to understand the movement and storage of organic matter within sediments, and also in normalising results where required (refer Simpson and Batley 2016).

The existing monitoring database will record sediment data as it is collected, as well as flow conditions and site data from field observations. This will allow the site and hydrological conditions at the time of sampling to be considered when analysing the sediment quality data.

6.3 Macroinvertebrates

Macroinvertebrate data will be assessed based on the methods provided in AusRivAS (DNRM 2001). Several statistical analytical methods will be used to compare macroinvertebrate assemblages between sites and assess what may be driving these differences. These analyses include:

- Taxonomic richness: calculated from the number of taxa present in each sample, providing an indication of community diversity at the site, with richness typically increasing with ecological condition
- PET taxa richness: derives a value based on the number of taxa from three orders of aquatic macroinvertebrates; Plecoptera (stone flies), Ephemeroptera (may flies) and Thrichoptera (caddis flies). These taxa are considered to be sensitive to poor water quality.
- Stream Invertebrate Grade Number – Average Level (SIGNAL2): provides an index score based upon the taxa that are present. Taxa are assigned a grade between 1 and 10 based on their tolerance to poor environmental conditions (lower grades = more tolerance). The index score provided indicates the condition of the environment at a particular site/waterway for a given time (time of sampling).
- Tolerant taxa: the percentage of tolerant taxa is calculated using the SIGNAL2 sensitivity grades derived from aquatic macroinvertebrate taxa at the Family level. Tolerant taxa are those with a SIGNAL2 score of 3 or less. Macroinvertebrate families in this group are expected to be able to tolerate changes to their environment, including habitat degradation and some pollution. An absence of the more sensitive taxa suggests environmental conditions may be too harsh for more sensitive taxa (those with SIGNAL2 score above 3) to tolerate.

Results will be compared with the freshwater macroinvertebrate guideline values for slightly to moderately disturbed waters in the Central Region provided in the QWQG.

Multi-dimensional scaling (MDS) will also be used to assess the spatial variation in community composition and abundance. This process groups different sampling sites based on their similarities. Water quality and sediment quality data can then be used to interpret these results, identifying whether water and sediment quality conditions of the receiving environment may be influencing the diversity and abundance of macroinvertebrates.

6.4 Fish

There are currently no prescribed guideline values for the three fish indices described in the DES *Monitoring and Sampling Manual* (DES, 2018) for the Styx River Basin. Therefore, these indices cannot currently be used to assess the fish monitoring data.

The abundance and diversity of each fish species observed at each site will be described. Community composition for each site/waterway will also be determined and size data will be used to assess community age structure. Health indicator observations will be collated to calculate the percentage of unhealthy fish.

Water quality, sediment quality and macroinvertebrate monitoring data will assist with interpretation of the results and help identify any impacts to aquatic ecosystems within the receiving environment. Results will be compared over time to identify any changes throughout the life of the Project. Key indicators that will be followed are:

- The continued absence of fish species at sites where they have previously been recorded
- An increase in the prevalence of ulcers, fin damage and/or disease in fish

6.5 Mangrove area

A series of discrete mangrove habitats located downstream from the Project in the Styx River Estuary and Waverley Creek Estuary have been selected for desktop monitoring using satellite imagery (as described in **Section 5.5**). The purpose of the monitoring is to identify any changes to the size and location of the mangrove habitats, which are likely to contribute to the conservation values of the Broad Sound region and to local fisheries productivity.

Satellite imagery dated as close as practicable to when the REMP annual report is due for submission will be acquired for the sites, and the location of the boundary will be traced along the mangrove fringe (where it meets the water) using GIS software. An assessment of changes in the area and boundary of the mangrove wetlands will be completed, comparing the results with baseline conditions (prior to the mine) and with previous years. The method will assist in identifying incremental changes in the location of mangrove habitats (either accretion or erosion), which may occur as a result of the project. Historical satellite images are also likely to be available if an extended baseline is required to examine long term trends prior the mine commencing operations.

7. Reporting

The REMP will be updated post approval of the Project in accordance with conditions of the EA and to address comments on the draft REMP received from regulatory agencies. Once finalised, the REMP will be implemented immediately, to continue the collection of baseline data, prior to mine construction works commencing.

Once Project construction begins, the REMP will be reviewed annually to allow for continual improvement as outlined in **Section 1.4**. As part of this process, a REMP results report will be produced annually (or as specified in the EA) and will be submitted to DES upon request.

The annual report will highlight the key findings of the REMP overall, with a focus on the previous 12 months of monitoring data, and will:

- Provide an assessment of water quality and sediment quality results, including pre-mining (baseline conditions), results at upstream and other reference sites and results at impact sites (freshwater and estuarine)
- Provide a summary and interpretation of biological monitoring results, associated macroinvertebrates and fish
- Describe any changes to the area and extent of mangrove habitats in the Styx River Estuary and Waverley Creek Estuary
- Describe the current assimilative capacity of the receiving environment and any changes that may need to be made to current environmental management practices, water release limits or guideline values in response to the results of REMP implementation.
- Provide an update of SSTVs and associated calculations, based on reference site data collected during the previous 12 months.
- Describe any effects of the release of mine affected water on the receiving environment.
- Recommend improvements to the REMP design and implementation based on the monitoring findings. This may include updated environmental values or water quality objectives, the relocation of unsuitable monitoring sites, or the establishment of additional monitoring sites or data collection methods.

Any revisions to the REMP will be made in consultation with DES.

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Appendix A Summary of Adopted Site Specific Trigger Values (OE 2020)

General water quality and nutrients

Parameter	Deep Creek	Tooloombah Creek	Deep and Tooloombah Creek Confluence (St1)	Styx River at Ogmore Bridge (St2)
pH			6.5 - 8.3	
Dissolved Oxygen (%Sat)			65 – 110	
EC (µS/cm)	740	1,640	-	-
Sulfate (mg/L)	25	54	-	-
Total Suspended Solids (mg/L)	26	11	15	30
Turbidity (NTU)			50	
Ammonia – as N (mg/L)	0.088	0.055	0.060	0.130
Oxidised Nitrogen – as N (mg/L)	0.023	0.014	0.020	0.028
Total Nitrogen – as N (mg/L)	2.48	0.69	0.60	0.74
Filterable Reactive Phosphorous – as P (mg/L)			<0.010	
Total Phosphorous – as P (mg/L)	0.484	0.065	0.090	0.180

Metals and metalloids

Parameter	Trigger Level (mg/L)	
	Deep Creek	Tooloombah Creek
Aluminium (dissolved)	0.24	0.055
Arsenic (dissolved)	0.013	0.002
Boron (dissolved)	0.37	
Cadmium (dissolved)	0.0002	
Chromium (dissolved)	0.001	
Cobalt (dissolved)	0.090	
Copper (dissolved)	0.003	0.002
Iron (dissolved)	0.3	
Lead (dissolved)	0.004	
Manganese (dissolved)	1.9	
Mercury (dissolved)	0.0002	
Molybdenum (dissolved)	0.034	
Nickel (dissolved)	0.011	
Selenium (dissolved)	0.010	
Silver (dissolved)	0.001	
Uranium (dissolved)	0.001	
Vanadium (dissolved)	0.010	
Zinc (dissolved)	0.008	

Appendix B Sediment Quality Guidelines

Analyte	DGV	GV-High
Antimony (mg/kg)	2	25
Arsenic (mg/kg)	20	70
Cadmium (mg/kg)	1.5	10
Chromium (mg/kg)	80	370
Copper (mg/kg)	65	270
Lead (mg/kg)	50	220
Mercury (mg/kg)	0.15	1
Nickel (mg/kg)	21	52
Silver (mg/kg)	1	4
Zinc (mg/kg)	200	410

Source: ANZECC Guidelines (2018)

Appendix C Monitoring site descriptions and photographs

Photo	Site Description
Reference Sites	
	**Deep Creek – De1** Located south of the mine area, with a stream bed width of 8 m (50° bank slope) and slow / minimal flow. *Eucalyptus tereticornis* (Forest Red Gum) and *Melaleuca leucadendra* (Weeping Tea-Tree) open forest is present in addition to *M. viminalis* (Weeping Bottlebrush).
	**Mamelon Creek - Mam01** Located along Mamelon Creek approximately 2 – 3 km upstream of the Tooloombah Creek confluence and west of the CQC Project.
	**Tooloombah Creek – T04** To4 is the furthest upstream of all the Tooloombah Creek monitoring sites and is located upstream of the confluence with Mamelon Creek (west of the CQC Project).

Photo	Site Description
	**Montrose Creek – Mo1** Mo1 is the most upstream monitoring site along Montrose Creek, located north of the CQC Project. Flow from Mo1 travels downstream towards Mo2 before reaching the Styx River.
	**Montrose Creek – Mo2** Mo1 is the most downstream monitoring site along Montrose Creek, located north of the CQC Project. Flow from Mo2 travels downstream to the Styx River.
	**Granite Creek – Gr1** Located north-west of the CQC Project along Granite Creek for monitoring of surface water upstream of the Styx River.

Photo	Site Description
	**Barrack Creek – Ba1x** The Ba1x site is 10 m wide with a maximum water depth of 0.3 m and slow flow. Bank slope is approximately 45°. Vegetation present at the site includes *Eucalyptus tereticornis* (Forest Red Gum) and *Melaleuca leucadendra* (Weeping Tea-Tree) open forest, in addition to *M. viminalis* (Weeping Bottlebrush).
	**Amity Creek – Am1** Located to the north of the Project, being the northernmost freshwater reference site, flowing into Waverley Creek and Estuary.
Impact sites	
	**Tooloombah Creek – To1** To1 is located to the west of the Project. The creek bed is between 5 m and 10 m wide at this location with the bank slope estimated between 25° and 45°. *Eucalyptus tereticornis* (Forest Red Gum) and *Melaleuca leucadendra* (Weeping Tea-Tree) open forest is present in addition to *M. viminalis* (Weeping Bottlebrush).

Photo	Site Description
	**Tooloombah Creek – To2** Located north of the mine, with slow flow within a 15 – 20 m wide stream bed. The water depth is described as 'deep' and bank slope is approximately 60°. *Eucalyptus tereticornis* (Forest Red Gum) and *Melaleuca leucadendra* (Weeping Tea-Tree) open forest is present in addition to *M. viminalis* (Weeping Bottlebrush).
	**Tooloombah Creek – To3** To3 is located north of the mine. The creek is 5 – 10 m wide, with bank slope at 45° and flow is very slow to none. Vegetation present includes *Eucalyptus tereticornis* (Forest Red Gum) and *Melaleuca leucadendra* (Weeping Tea-Tree) open forest, in addition to *M. viminalis* (Weeping Bottlebrush).
	**Deep Creek – De2** Located east of the mine area and south of the Bruce Highway. The site contains slow flow, stream bed width is 5 – 10 m and bank slope is 45°. *Eucalyptus tereticornis* (Forest Red Gum) and *Melaleuca leucadendra* (Weeping Tea-Tree) open forest is present in addition to *M. viminalis* (Weeping Bottlebrush).
	**Deep Creek – De3** De3 is located to the east of the mine adjacent to the proposed Haul Road. The creek is 3 – 4 m wide with a bank slope of approximately 60° at this location. *Eucalyptus tereticornis* (Forest Red Gum) and *Melaleuca leucadendra* (Weeping Tea-Tree) open forest is present in addition to *M. viminalis* (Weeping Bottlebrush).

Photo	Site Description
	**Deep Creek – De4** De4 is located north of the mine. The creek is approximately 3 m wide with a bank slope of approximately 30 - 45° at this location and slow flow observed. *Eucalyptus tereticornis* (Forest Red Gum) and *Melaleuca leucadendra* (Weeping Tea-Tree) open forest is present in addition to *M. viminalis* (Weeping Bottlebrush).
	**Deep Creek – De5** Located towards the north-eastern corner of ML80187, approximately 3 – 4 km upstream (south) of the confluence with Tooloombah Creek.
	**Styx River – St1** Located to the north of the CQC Project area and west of the North Coast railway line. The site has a 20 m wide stream bed with bank slope at approximately 45°. *Eucalyptus tereticornis* (Forest Red Gum) and *Melaleuca leucadendra* (Weeping Tea-Tree) open forest is present in addition to *M. viminalis* (Weeping Bottlebrush).

Photo	Site Description
	**Styx River – St2** Located north of St1 and west of the town of Ogmore in the vicinity of Ogmore Bridge.
	Styx River - Styx US The upstream monitoring point where the Styx River meets the coast, at Broad Sound Estuary, located approximately 32 km north of the Project.
	Styx River – Styx DS2 The downstream monitoring point where the Styx River meets the Broad Sound Estuary, located approximately 35 km north of the Project.
	WAV US Waverly Creek monitoring site upstream of the Broad Sound Estuary and located north-west of the CQC Project. Amity Creek, and subsequently the Am1 monitoring site, is a tributary to Waverly Creek.
	WAV DS Waverly Creek downstream monitoring site located at the river mouth at Broad Sound Estuary at the coast.

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